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The impact of a model-based clinical regional registry for attention-deficit hyperactivity disorder

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Abstract
This article describes the development and clinical impact of the Italian Regional ADHD Registry, aimed at collecting and monitoring diagnostic and therapeutic pathways of care for attention-deficit hyperactivity disorder children and adolescents, launched by the Italian Lombardy Region in June 2011. In particular, the model-based software used to run the registry and manage clinical care data acquisition and monitoring, is described. This software was developed using the PROSAFE programme, which is already used for data collection in many Italian intensive care units, as a stand-alone interface case report form. The use of the attention-deficit hyperactivity disorder regional registry led to an increase in the appropriateness of the clinical management of all patients included in the registry, proving to be an important instrument in ensuring an appropriate healthcare strategy for children and adolescents with attention-deficit/hyperactivity disorder.

Keywords
adolescent, attention deficit disorder with hyperactivity, child, health information systems, registries

Introduction

Attention-deficit hyperactivity disorder (ADHD) is a neurobehavioral disorder characterized by maladaptive, and inappropriate, levels of inattention and/or hyperactivity and impulsivity in early childhood that can persist through adolescence, pervade across settings and lead to notable impairments in adulthood.[1] Current evidence defines ADHD as a disorder resulting from complex interactions between genetic and environmental factors. ADHD is diagnosed by the severity and persistence of symptoms, which are associated with high levels of impairment in family and social relationships and with a higher risk of developing co-occurring psychiatric disorders during the lifetime, such as mood, conduct and substance abuse disorders.[2]

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In recent years, there has been an increase in the clinical recognition of ADHD, with a corresponding increase in the number of children diagnosed and treated.[3] Worldwide, the prevalence of ADHD is estimated at 5.3 per cent, although there is wide variability between geographic locations.[4]

In the Italian Lombardy region (the most populated and economically important region in Italy), the estimated prevalence was 9.5 per 1000 children and adolescents aged between 6 and 17 years, and less than a quarter of them received drug therapy.[5]

Although there is growing evidence that stimulants for the treatment of ADHD both improve 'core' ADHD symptomatology and reduce the risk of developing psychiatric co-morbidities, psychosocial treatments such as psychoeducation, cognitive-behavioural therapy (CBT) and supportive training to help with organizing daily activities are also the first choice, alone or in combination with pharmacological therapy, according to clinical and environmental evaluation. Psychosocial treatments have been shown to be more effective than pharmacological therapy alone, in particular when both parents and teachers are involved.[6] According to the Italian guidelines on ADHD treatment (defined in 2003 through a consensus conference),[7] drug treatment should only be started after a child psychiatrist, who is an expert in ADHD, has thoroughly assessed the child or adolescent and confirmed the diagnosis. Moreover, once treatment has been initiated, the effectiveness and adverse effects need to be assessed carefully and regularly, and reported, by each reference centre's team of clinicians.

Because of the large concern about the safety and rational use of psychotropic drugs in children, a national initiative was launched in Italy in 2007 to monitor the prevalence and appropriateness of drug therapy in the ADHD paediatric population: the National ADHD Registry. The registry was set up under the auspices of the Italian Medicines Agency (AIFA) and coordinated by the Italian National Institute of Health, following the reintroduction of methylphenidate on the market (as immediate-release tablets) and the registration of atomoxetine. These are the only two drugs with a specific indication for ADHD available in Italy, and are registered for use only in children aged 6–17 years. The Italian registry is a unique tool internationally; it is able to ensure the monitoring and evaluation of the safety and tolerability of methylphenidate and atomoxetine in children and adolescents with ADHD.[8]

To create shared and feasible diagnostic and therapeutic pathways, however, an analysis of currently existing clinical and socio-anamnestic variables, such as type of ADHD or specific environmental life contexts, is a key step. This analysis then needs to be followed by a final evaluation of the process outcomes, including user satisfaction in relation to the health services provided and the quality of life of families. The data collected through the National ADHD Registry made it possible to clarify certain critical issues, but not to perform a finalized epidemiological analysis, nor to best plan effective strategies for improvement. In particular, few data concerning the families' anamnesis are collected and no information about ADHD patients receiving psychological treatment or other psychotropic agents are collected.

In this context, the need to create a new database to monitor the diagnostic and treatment pathways for all children and adolescents with ADHD, not only those already receiving drug treatment, was apparent. This article describes the development and clinical impact of the Italian Regional ADHD Registry, an initiative aimed at ensuring an appropriate management plan for children and adolescents with ADHD and set up as part of the project 'Sharing of diagnostic and therapeutic pathways for ADHD'.[9]

Methods

The new ADHD database, the 'Italian Regional ADHD Registry powered by PROSAFE', allowed, through a flexible interface, the collection of information relating to

- Anamnestic data;
- Clinical assessment;
- Diagnosis;
- Therapeutic interventions, both pharmacological and non-pharmacological;
- Follow-up visits.

The information collected was analysed monthly, and the results were presented and discussed at regular meetings between the participating centres and the coordinating centre (IRCCS – Istituto di Ricerche Farmacologiche Mario Negri), in order to assess whether any improvements were achievable.[9] The coordinating centre published all results in a monthly summary report sent to each participating centre and posted it on the ADHD project website (adhd.marionegri.it).

Before the project started one of the 18 centres was selected as a pilot site to test the system and to resolve emerging technical problems. After a 3-month running period, a technical support service was established through a dedicated phone number and monthly meetings with all clinician participants were organized for feedback.

PROSAFE

The 'Italian Regional ADHD Registry powered by PROSAFE' originated from the development of an already-existing model-based software called 'PROSAFE', a programme used for data collection in many Italian intensive care units (ICUs).[10] The modular structure and features of the software have made it possible to create a stand-alone Case Report Form (CRF) interface to collect data on the Italian Regional ADHD Registry, while continuing to use the skills and technical characteristics that distinguish PROSAFE.

The software architecture used is PROSAFE CLIENT-SERVER, which allows more software to be installed on the same network, according to the needs of each individual centre. In addition, each centre may use and store data even offline without an internet connection – an option that would have been impossible with a web-based software. The software is free of charge for the ADHD centres.

Eligibility of centres and users

Italian healthcare is provided free or at a nominal charge through a network of 148 local health units (LHUs). Child and adolescent neuropsychiatric services (CANPS) are part of the LHU and provide care at the hospital and community level for children and adolescents with neurologic and/or psychiatric and/or neuropsychological disorders (including developmental disabilities and intellectual disabilities), and for their families. CANPS are multi-professional, comprehensive community services providing diagnosis, treatment, and rehabilitation. In order to prescribe methylphenidate or atomoxetine to ADHD patients, Italian regulatory rules require a strict clinical assessment for the diagnosis of the disorder and a systematic patient's monitoring during treatment. Since September 2007, local reference centres have been required to send patient information to the Italian National Registry dedicated to collecting data only on pharmacological treatment of ADHD patients aged less than 18 years. Regional health authorities are responsible for the accreditation of the reference centres in regional hospitals, which are linked to the CANPS located in the local communities. The reference centres are therefore the specialized hubs of the CANPS network on ADHD. In the Lombardy Region there are 18 ADHD reference centres and all participated in this project.

Children and adolescents aged 5–17 years who accessed any of the 18 local centres for a diagnosis of suspected ADHD were enrolled in the Regional ADHD Registry if (a) their first access to

the service (first visit) was after 1 June 2011, regardless of the diagnosis or (b) they began their drug treatment after 1 June 2011 (if they were not already included in the national register).

Results

Access-history

The Italian Regional ADHD Register permitted an evaluation of the access to the ADHD reference centres by patients in the Lombardy Region, that is, the patients' requests and waiting times (time elapsed between the first request and the first survey).

Questions were also asked on the environment of the families and the patients (with whom they were living, if they had siblings, or if there were twins) and on the social situation of the parents, and their history, in order to better understand if there was a possible familiarity for ADHD and if there were any genetic hypotheses.

Assessment

The evaluation page contained a whole series of tests, interviews, and examinations that the patients underwent for the diagnosis of ADHD. These tests were agreed on by a specific sub-group of the regional project, formed by the operators from each participating centre, which had the task of sharing their own diagnostic methodologies (guidelines and tests) in order to allow a greater uniformity among all centres in the diagnostic phase.

Specifically, during the diagnostic evaluation the following tests/information required were as follows:

- Anamnestic data;
- Clinical interview;
- Neurological examination;
- Intelligence Quotient (IQ);
- Diagnostic Interviews: Kiddie-Schedule for Affective Disorders and Schizophrenia (K-SADS) or Development and Well-Being Assessment (DAWBA);
- Evaluation of parents: Conners' Parent Rating Scales (CPRS) and Child Behaviour Checklist (CBCL);
- Evaluation of teachers: Teachers' Parent Rating Scales (CTRS);
- Clinical Global Impressions-Severity (CIGS) or Children's Global Assessment Scale (CGAS).

Diagnosis

The diagnostic page contained questions on the patient's symptoms and behaviour. Based on the answers entered the programme then processed the data entered by the clinician and classified the diagnosis according to the diagnostic criteria of the *Diagnostic and Statistical Manual of Mental Disorders, 4th Edition, Text Revision* (DSM-IV-TR), assigning one of four possible results:

1. Patient not diagnosed with ADHD;
2. Patient diagnosed with ADHD type I (inattention);
3. Patient diagnosed with ADHD type H (hyperactivity-impulsivity);
4. Patient diagnosed with ADHD type C (combined).

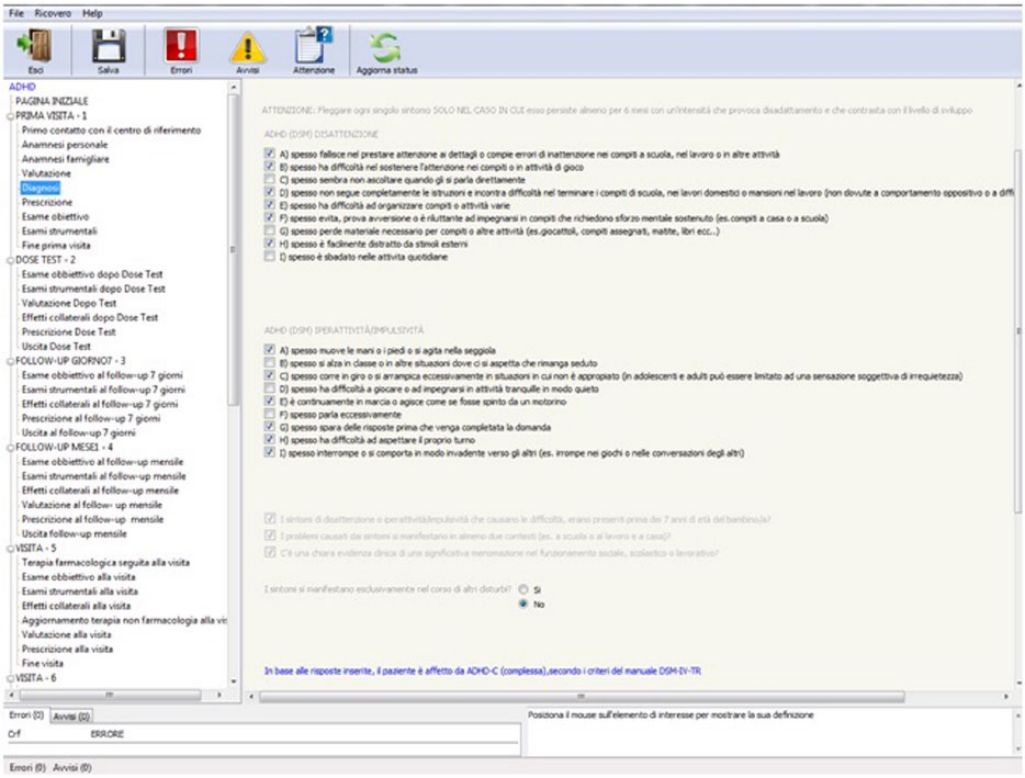

Figure 1. Data collection form in the diagnostic page.

Figure 1 shows an example of the data collection form.

In the case of an ADHD diagnosis, the centre's operator was requested to proceed with filling in the fields of the pages following the diagnosis section, according to the prescribed therapy.

In cases in which the patient was not diagnosed with ADHD the operator was sent to a page stating 'out of the registry', in which the following potential causes for the interruption of the visits were indicated: 'no ADHD', 'the patient does not show up at the visits', 'treatment interruption' or 'transfer to another ADHD centre'.

Therapy

According to the Italian Regional Registry the prescribed therapy was pharmacological, non-pharmacological, or both. The pharmacological treatment involved all the psychotropic drugs indicated for ADHD therapy: mainly methylphenidate or atomoxetine, and in a few cases other psychotropic agents.

Drug therapy was given in combination with non-pharmacological interventions, such as cognitive-behavioural therapy (CBT), child, parent, and teacher training, or counselling.

Once the therapy was prescribed the patient was seen for follow-up visits at given time periods, according to the type of prescribed therapy: in cases of methylphenidate or atomoxetine treatment, the patient was re-assessed after 7 days, while in cases of other psychotropic agents, after one month. This was different for non-pharmacological therapies, in which the type of prescribed ther-

Table 1. Drug prescription on the first visit.

Methylphenidate	Atomoxetine	Other drug	First follow-up visit
YES	YES/NO	YES/NO	Dose test
NO	YES	YES/NO	7 days
NO	NO	YES	1 month
NO	NO	NO	3 months

apy did not influence the timing of the subsequent visit if associated with a pharmacological treatment, if not, the follow-up visit was provided after 3 months of the start of therapy.

Follow-up visits

Following the diagnosis of ADHD, the register was designed to provide several, differently structured types of follow-up visits, based on the prescribed therapy, in order to optimize the compilation of the CRF and to therefore have clean and correct data. In particular, the planned follow-up visits were as follows:

First visit. The set of requests for anamnestic data of patients and families, assessment and formulation of diagnosis and prescription of therapy.

Dose test. A visit performed only in cases in which the patient was treated with methylphenidate for the first time, and it was therefore necessary to ensure that there were no adverse drug reactions.

7 days. A visit following the dose test, whose aim was to provide further checks, or a visit for those patients prescribed atomoxetine for the first time.

1 month-visit. A visit following the '7 days' (for atomoxetine or methylphenidate), or a visit performed when an another psychotropic drug was prescribed.

3 month- and/or 6 month-visit. Control visits following the 1 month-visit to monitor all patients, whether or not on drug therapy.

Extra visit. An extraordinary (unplanned) visit performed due to the occurrence of side effects and/or adverse drug reactions, changes in therapeutic plan, or additional patient monitoring.

The order of the visits in the register was decided by the software, which followed an internal logic based on the drug therapy prescribed to the patient. The drug prescription on the first visit determined the first follow-up visit according to the written criteria indicated in the following Table 1.

The calculation of the follow-up visits took into consideration the following data:

- Type of previous follow-up visit;
- Drug therapy prescribed on the previous visit;
- Presence of extra visits not provided in the therapeutic plan;
- Type of current follow-up visit;
- Prescribed therapy in the current follow-up visit;
- Patient's compliance to the prescribed therapeutic plan.

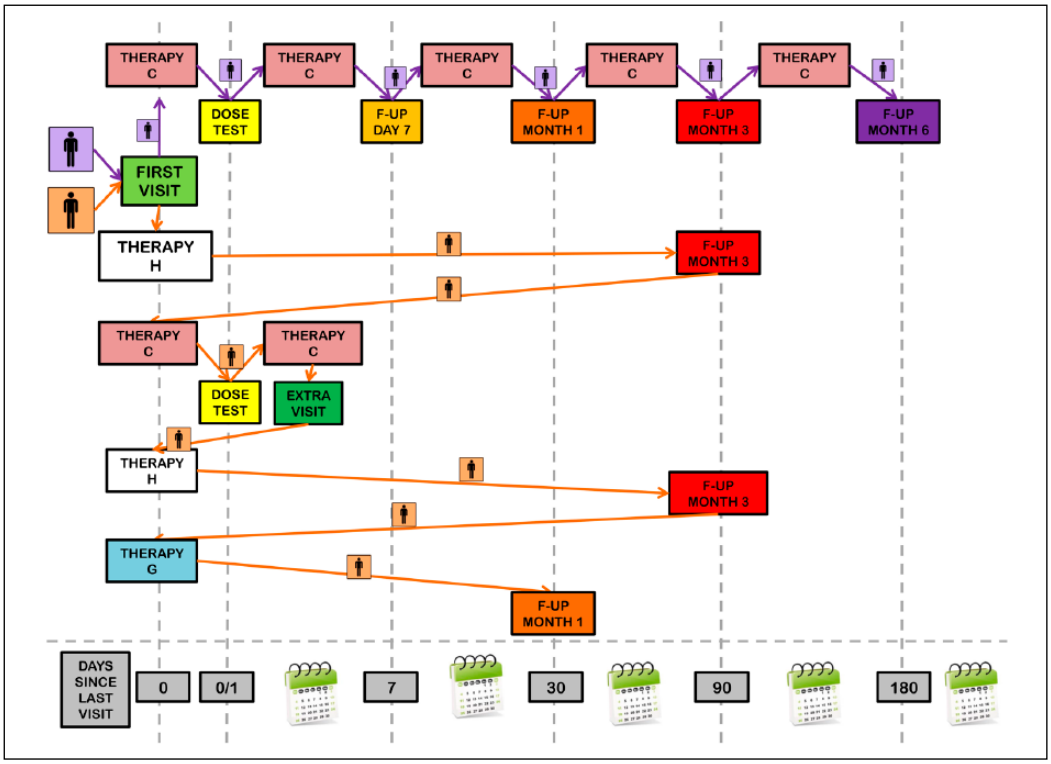

Figure 2. Follow-up visit logic.

Figure 2 shows the calculation of the follow-up visits, when the patient was in a normal situation without extra visits, and when the patient changed drug (or did not use it) and there was an extra visit.

The possible combination therapies in Figure 2 are outlined in Table 2 below.

Data collection

At the time of analysis, data from the Italian Regional ADHD Registry were collected and referred to the diagnostic and therapeutic pathways of 1338 children and adolescents. All of the 18 centres adopted the initiative and completed the patient records in the registry, with a range of 34–187 patients per centre (average 74). The number of patients per centre was related to the resident paediatric population.

Of the 1338 children and adolescents (86.7%), 1160 with suspected ADHD completed the diagnostic assessment, and 751 (64.7%) met criteria for ADHD. In all, 115 patients (15.3% of those diagnosed with ADHD) had been treated with at least one psychoactive drug: 107 with methylphenidate (5–60 mg daily), 19 with atomoxetine (10–80 mg daily) and 10 with other agents. A total of 63 adverse events were reported in 28 patients treated with drugs (rate: 24.3%), and headache, decreased appetite, asthenia and drowsiness were the leading events.

Of the children with ADHD who were treated, only 9 discontinued the drug prior to 1 year of treatment, none of whom because of adverse events. Although the medications for ADHD

Table 2. Possible combination therapy.

Therapy	
Methylphenidate + atomoxetine + other drug	**A**
Methylphenidate + atomoxetine	**B**
Methylphenidate + other drug	**C**
Only methylphenidate	**D**
Atomoxetine + other drug	**E**
Only atomoxetine	**F**
Only other drug	**G**
No drug	**H**

are generally well tolerated, the Lombardy Region ADHD registry could be a useful tool to improve the rational use of drugs in children and adolescents by disseminating and monitoring evidence-based practices and by monitoring the safety and efficacy of treatments in both the short and long terms.[5]

Data processing and monitoring

The IRCSS – Mario Negri Institute for Pharmacological Research, as coordinating centre – monitored and processed the data entered in the Italian Regional ADHD Registry from all the centres and sent a monthly summary report to each participating centre (Figure 3).

The report contained a flow-chart illustrating the paths of the all patients enrolled in the registry, with the corresponding values achieved, and consisted of 3 sections:

1. General trend of all participating centres;
2. Trend of the each single centre, referring only to the patients of the centre receiving the report;
3. Inconsistent and/or missing data detected for the patients enrolled by each single centre. The centre receiving this indication was requested to correct its data.

Discussion

The differences between the centres (different management, structure, staff, etc.) led to many problems in drafting the CRF shared by all the centres. Consequently, it was necessary to create a series of software releases subsequent to the first one in order to standardize the data collection form. This was possible thanks to the programme's flexibility, because every single change could be made without affecting the normal compilation of the registry by the participating centres.

The use of diagnostic–therapeutic pathways and the follow-up visit logic controlled by the programme based on the data entered, as well as the parallel management of other resources supporting the software such as the monthly summary data report for each centre, the periodical newsletter sent to the centres and the website (adhd.marionegri.it) content update, led to an increase in the appropriateness of the clinical management of all patients included in the registry.

Initially, the use of the software by the ADHD centres was sporadic, mainly due to the lack of staff organization and capacity in filling out a computerized CRF. Continuous support activities performed by the coordinating centre, such as providing quick replies to the centres' queries by telephone or email and holding monthly meetings with the ADHD centres, led to a large

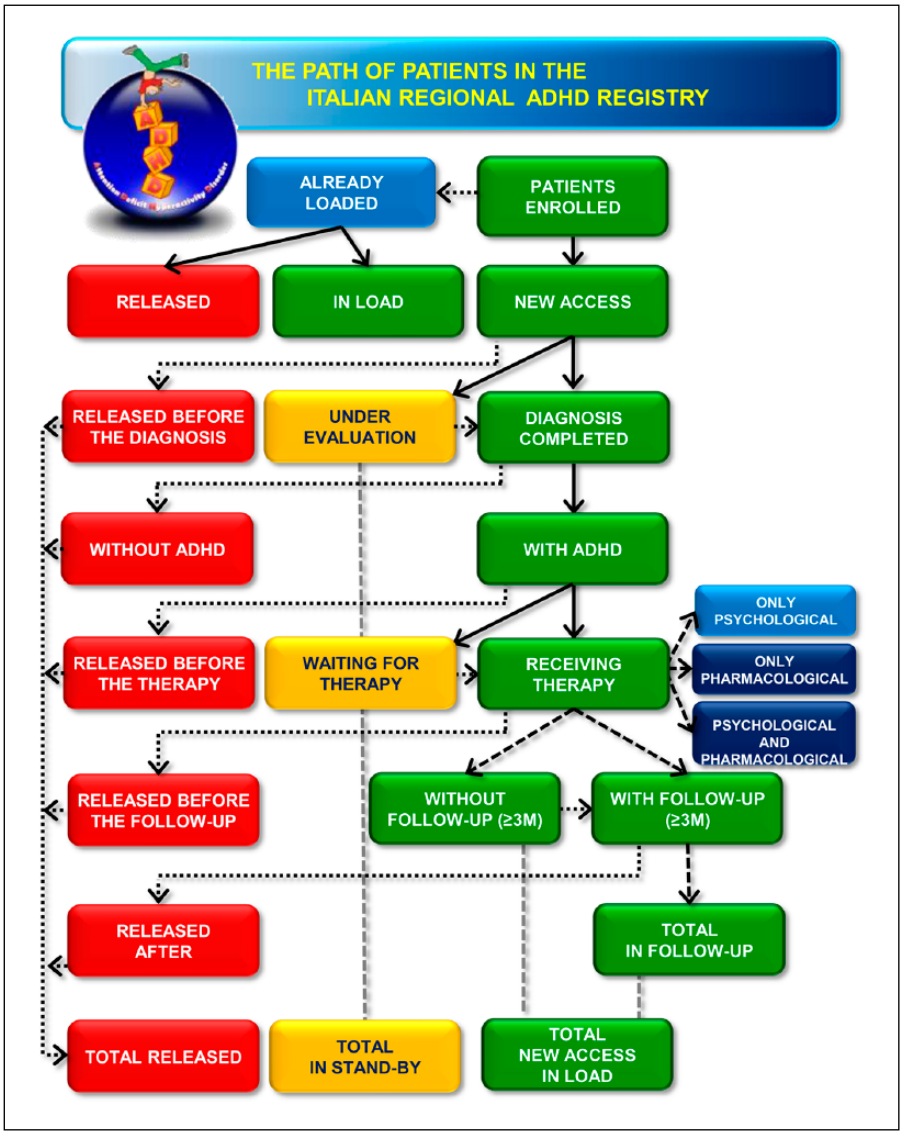

Figure 3. Report structure.

improvement, over a 1-year period, in the technical management of the programme and to a consequent improvement in the quality of data entered as well as to an increase in the frequency with which the centres connected to the programme.

The use of the software increased the centres' ability to use computer technology for clinical data collection, especially in centres that were not previously registering data systematically. Currently, most of the centres are connecting daily or weekly, with only a few centres connecting monthly. Finally, thanks to the ongoing development of the PROSAFE software, the registry can be continuously integrated and upgraded so as to bring constant improvements to the CRF and to the data collection in general, without causing any disturbance to users.

The identification of centres and the software installation were carried out through a web portal, which monitored access and authentication by the different centres involved in the project. This project has demonstrated how the software has improved the appropriateness of diagnostic and therapeutic pathways for patients enrolled in the Regional ADHD Registry. Specifically, the software described allowed a greater ability to edit, check, and manage the diagnostic and therapeutic pathways, thanks to a flexible internal frame. In particular, the calculation of the follow-up visits was automatic, based on certain data values. The programme gave the centres access to the system for later follow-ups in a manner consistent with the diagnostic–therapeutic data entered previously.

Conclusion

The Italian Regional ADHD Registry is an efficient tool to estimate the prevalence and incidence of ADHD, to evaluate the patients' psychopathological profile and comorbid psychiatric conditions, and to monitor the clinical outcome of the prescribed therapy (psychological, pharmacological treatments or both) and potential adverse events and/or side effects of pharmacotherapy in the Lombardy Region's paediatric population. The software is free of charge and is potentially available for other regions and/or LHUs.

The Italian Regional ADHD Registry therefore represents a distinctive tool to promote a collaborative experience between several ADHD centres and the coordinating centre, that is unique in the international context and that assures the appropriate care and safety of drug use in ADHD children, according to recent evidence-based practices and guidelines.

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Declaration of Conflicting Interests

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Knowledge management through two virtual communities of practice (Endobloc and Pneumobloc)

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Abstract

We developed two virtual communities of practice (Endobloc and Pneumobloc) to increase the interaction between general practitioners and nurses in primary care and hospital endocrinologists and pulmonologists. They were designed and developed using an existing web 2.0-based virtual network belonging to the local National Health System, and we quantitatively assessed the usefulness through the participation and use during the first 24 months after the launch in 2010. A total of 26,372 visits (47% Endobloc's visits) and 2351 contributions (Endobloc's contribution 38.9%) to both virtual communities of practice were registered during the first 24 months. The most popular sections were the e-Blog and the e-Consultations section in both virtual communities of practice, but some differences in the pattern of use in other sections were observed. Activity on the virtual communities of practice occurred throughout the day including weekends and holiday periods. We showed that virtual communities of practice are feasible under real-life clinical practice.

Keywords

endocrinology, integrated care, primary healthcare, pulmonology, virtual community of practice

Introduction

Most healthcare professionals in developed countries use the Internet in their daily professional activities. Physicians, nurses, and other healthcare providers are connected and share databases, medical records, and scientific information.[1,2] A transformation from analogical procedures to digital ones has taken place in the last two decades related to these new skills for publishing and information research on new findings, clinical trials or drugs.[3,4]

At the beginning of the 21st century, social networks on the Internet went through a second revolution on new technologies called web 2.0 because users became active participants creating new contents that can be shared immediately.[5] This new concept of real-time collaboration between peers has been designated networking. Within networking, the concept called "virtual community" (VC) arises. A VC is defined as "an aggregation of individuals that as business partners interact around a shared interest, where the interaction is at least partially supported and/or mediated by technology and guided by some protocols or rules."[6] VCs mainly allow participants to exchange information and provide social support to a business, a marketing project or health institution.[7] It is important to point out that a VC also allows to optimize personal resources and to spread knowledge.[8,9] With regard to online health-related knowledge transfer, strategies include the use of wikis, discussion forums, blogs, social media to data/knowledge management tools, conferencing technology, and virtual communities of practice (VCoP).[10] Most VCoPs are patient-oriented supporting groups with or without healthcare professionals as moderators or participants with the goal of promoting health, but there are also VCoPs that promote learning, exchange of information and knowledge, and also share and foster evidence-based practice between healthcare professionals.[11]

Examples of large VCoPs at the international level restricted to physicians include the community called Sermo (http://sermo.com), which has about 343,000 registered professionals mainly from the United States and the United Kingdom with 68 different medical specialties and subspecialties,[12] and Esanum (http://esanum.com), restricted to physicians mainly from Europe with members from different specialties who share data about clinical reports and collaborate in writing papers. The main conclusion after revising this initiative is that the benefit perceived by users is the satisfaction of sharing knowledge within a community of colleagues. The measurement of the impact, benefits, and effectiveness of these kinds of approaches is not easy to calculate,[10] but it seems that new possibilities of improvement are offered.[13,14]

Few data are available on the interaction between general practitioners (GPs) and hospital-specialist physicians via an online interface and their implications on daily clinical practice,[15] but online interaction has proven to improve medical care and reduce hospital referrals in several specialties.[16–19] In Catalonia, for instance, the ECOPIH project (Online Communication Tool between Primary and Hospital Care; http://ecopih.webnode.es) involves a wide selection of medical specialties and includes healthcare professionals from primary care centers (PCCs) and specialists from two important cities in the metropolitan area of Barcelona.[20,21] The qualitative evaluation of the performance of this VCoP found that communication between primary and hospital care led to improved primary care and fewer hospital referrals and that the closer the healthcare professionals were to their patients the more they used the platform, thus also indirectly contributing to improved healthcare.[21] Encouraged by the success of this regional VCoP, the aim of the current project was to implement a new tool for the management of medical knowledge focused on endocrine and metabolic disorders and respiratory diseases. This new tool is a web 2.0-based VC implemented by healthcare professionals from the primary care area of Lleida and specialized physicians from the departments of endocrinology and pulmonology of the reference hospital. In this article, we describe the development and implementation of these two VCoPs and the assessment of participation and use for the first 24 months after its launch.

Methods

Objectives and VCoP design

Based on an initiative from the Endocrinology and Pneumology departments at the Hospital Arnau de Vilanova, two VCoPs, one on endocrinology (Endobloc) and one on pneumology (Pneumobloc), were designed to allow online interaction of a population of GPs and nurses working on the clinical management of diabetic and obese patients and chronic respiratory patients attended at PCCs in the area of Lleida with the endocrinologists and pulmonologists of the Hospital Universitari Arnau de Vilanova (Lleida), all of them pertaining to the National Public Health System in Catalonia (Spain). This hospital is the one attending patients who are referred from the area, which is distributed in 22 basic healthcare districts including 220 primary care working teams (a nurse and a GP in each one), representing a total population of 440 healthcare professionals.

For the development of the VCoPs, we chose a web-based electronic public service meant to be flexible, safe, intuitive, cheap, and easily implemented in the context of the public institutions that were going to use it. The use of other alternatives, such as a specific program like SharePoint (Microsoft®), would have been of limited use to the participants because it would have not only required specific learning on its use, but would have been only accessible from the intranet at workplaces (i.e. hospital or PCCs) for security reasons. Conversely, the use of web-based community allows accessibility outside working hours and workplaces, thus breaking the space-time barrier to facilitate sharing knowledge between professionals. Moreover, we chose a platform belonging to the local Government, which also guarantees security in communications and ensures the privacy of the information and personal data. Both VCoPs were web 2.0-based and used the Content Management System of the platform e-Catalunya (http://ecatalunya.gencat.cat), which belongs to the Catalonian local government (Generalitat of Catalonia). This platform promotes collaborative work groups and offers a virtual space that can be easily adapted to the particular requirements of the working group or VCoP (e.g. forums, wikis, folders, mail lists, and automatic alerts) and is designed to run on desktop/laptop computers.

The process of development of both VCoPs is shown in Figure 1. Briefly, the project was developed through different consecutive stages: (1) initial design and structure of the web-site structure

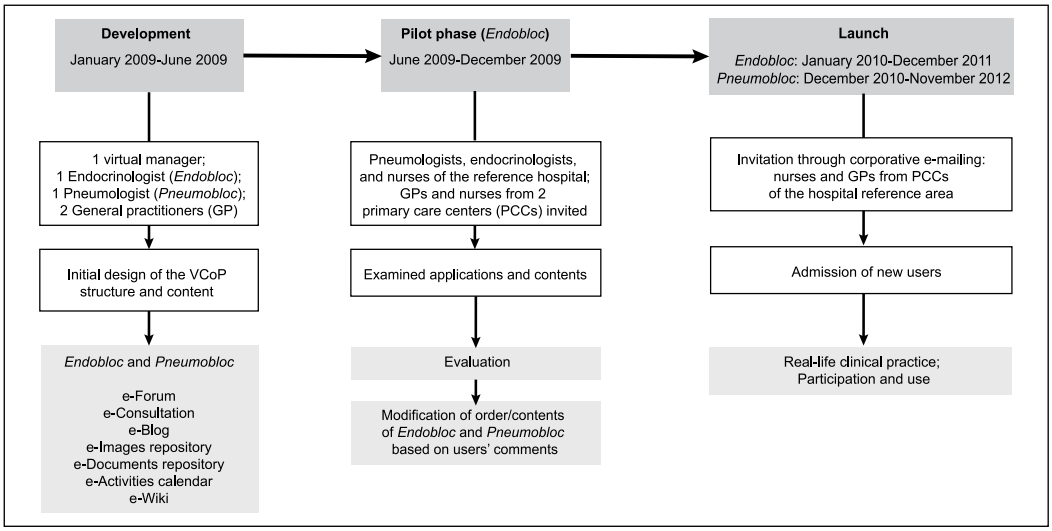

Figure 1. Development and launch of the two VCoPs.

by a community manager; (2) definition of the initial contents to be shared by the VCoP participants by a working group consisting of a virtual manager, two specialists (one endocrinologist and one pulmonologist), and two GPs; (3) dissemination meetings by the management team at the PCCs participating in the pilot phase (6 months duration) to introduce the characteristics of the project, advantages of the collaborative work in a VCoP, procedures to allow participation, and practical training on the use of the platform and its contents; (4) evaluation of the functioning and participation after the pilot phase to adapt the structure and/or contents of the VCoP based on the users' feedback and needs; (5) launch of the final VCoPs, with invitations through corporative e-mailing, dissemination meetings at all PCCs of the Hospital reference area, and training for healthcare professionals (physicians or nurses) willing to participate; and (6) follow-up and analyses on participation and use of each VCoP after 2 years of full functioning in real-life clinical practice.

Ethics and security

The research protocol was approved by the Ethics Committee and Clinical Research of the Primary Care Research Institute IDIAP Jordi Gol (Barcelona, Spain).

The e-Catalunya platform guaranteed confidentiality of personal data for the users and the content of the VCoP in accordance with the Law of Protection of Personal Data (15/1999 of 13 December). Moreover, all participants signed a letter of commitment in which they agreed to use the VCoP in accordance to the current Law, to maintain as confidential all private communications received, and to not introduce specially protected data or data that may allow identifying people (e.g. a patient's personal data).

Variables assessed

Evaluation of the functioning and participation after the 6 months pilot phase was quantitatively assessed using the data automatically recorded by the technology platform that supported Endobloc. Variables included total number of visits/connections to the network, visits per month, and day and

time of the week; total number of contributions (e.g. active participation in any section, such as making a case consultation and uploading documents or images) and their author, contributions per month, day and time of the week; and visits and contributions per section. Moreover, we qualitatively evaluated the perception, usefulness, and level of satisfaction through a specific survey consisting of 30 questions distributed among users. The participation and use of Endobloc and Pneumobloc at the end of the first 24 months after launch was quantitatively assessed through the same variables described above for the pilot phase, and we also quantified the number of lurkers, defined as subjects who initially registered as users but never visited the VCoP. Values of quantitative variables are expressed as mean and standard deviation or range, and qualitative variables are expressed as number and percentages.

Results

Development of the two VCoPs: Endobloc and Pneumobloc

The process of development of both VCoPs is shown in Figure 1. For a period of 6 months (January to June 2009), a working group designed and drafted the initial contents of each VCoP. Each team consisted of a VC manager, an endocrinologist (for Endobloc), a pulmonologist (for Pneumobloc), and two GPs. The virtual system offered three main Internet-based functions: communication and interaction with peers, access to information, and joint work. Both VCoPs (Endobloc and Pneumobloc) were identical in structure and included seven different sections, namely, an e-Forum (with common interest topics and virtual clinical sessions), an e-Consultation section (with short clinical real case reports, together with questions and comments), an e-Blog (with breaking news related to health topics and the VCoP network), an e-Images repository (for complementary data to clinical reports, e.g., X-ray images and computerized thoracic-scan images), an e-Documents repository (for common document storage), an e-Activities calendar (holding common agendas, e.g., scientific events and workshops), and an e-Wiki (with a multi-user documents creator and a sharing tool).

The site was password protected and was made available only to the participants involved and those working directly on the study. The staff working on each of the VCoPs were one community manager, aimed not only at giving methodological and technical support to participants but also at involving and committing visitors to participate, and two facilitators/moderators who reviewed content, supported participants, encouraged participants to contribute and contributed themselves, guaranteed the authenticity of contents, and ensured a respectful behavior within the group.

After the design of the structure and contents of both VCoPs, a six-month run-up feasibility period (June to December 2009) or pilot phase was performed with the Endobloc only, as both virtual communities were identical and assumed to perform in a similar way. For this pilot phase pneumologists, endocrinologists, and nurses of the reference hospital, and nurses and GPs from two PCCs were invited to participate: one PCC from an urban area of the city of Lleida where the reference hospital is located and a second one from a semi-urban and its rural reference area (between 30 and 90 min drive from the hospital).

Sixty-six healthcare professionals from the two PCCs accepted to participate. Users had access to the Endobloc and were able to examine the applications and contents, contribute in every section and, for medical consultations they could expect a reply within the following 48 h. The quantitative assessment on the participation and use showed that 59.1 percent subjects participated actively, 71.2 percent of them visited the VCoP, and 13.6 percent of them contributed with content. Nurses participated less (33% of the total participants) and were less active than GPs, with nurses accounting for 8.4 percent of total contributions, and 25 percent of total visits. Finally, a survey to assess

Table 1. Summary of activity for Endobloc and Pneumobloc VCoP 24 months after the launch.

Variable	Endobloc	Pneumobloc
Total number of visits	12,533	13,839
Total number of contributions	915	1436
Visits/month, mean (SD)	522.2 (155.3)	577 (377.9)
Contributions/month, mean (SD)	38 (14.5)	60 (117)
Contributors/month, mean (SD)	10.8 (8.5)	11.3 (8.2)
Lurkers/month, mean (SD)	54.9 (42.1)	48.8 (35.3)

SD: standard deviation.

perception and usefulness of the VCoP, answered by 63 percent of participants, showed that, on a 1–10 scale, the mean satisfaction score for all sections was above 7 and that the highest scoring services were the e-Consultation and the e-Document repository, while the e-Wiki was the least valued section. Moreover, 92 percent of participants thought that it was a good model to be used on other PCCs, and 97 percent thought that it would be useful to implement in other specialties.

The structure of Endobloc was modified based on the users' comments, which were mainly related to the ordering or labeling of the sections' contents, and Pneumobloc was adapted accordingly.

Implementation and use of Endobloc and Pneumobloc

After the acceptable levels of participation and the high degree of users' satisfaction during the pilot experience with Endobloc, this VCoP was launched and fully implemented into real-life clinical practice in January 2010, and the Pneumobloc was launched in December 2010. Primary care professionals (GPs and nurses) from the 22 districts of the reference hospital area were invited to attend scheduled meetings and were contacted through corporative e-mailing to join in both VCoPs. Their participation as professionals was a personal decision and not mandatory for clinical practice. Admission to the VCoPs was open on a continuous basis for all potential candidates from the beginning of the project, and after the initial invitation, new users were admitted as requested. To ensure that new users willing to participate were staff working at PCs or at the hospital, they were advised to send an e-mail to the community moderator who in turn resent the request to the community manager, who registered them as new users and granted permission. Finally, the e-Catalunya platform sent an e-mail to the new participant with the assigned username and password.

During the first 24 months of activity, 181 primary care healthcare professionals out of the 440 invited decided to register and join each of the VCoPs (Endobloc and Pneumobloc) and contributed to or visited its content. At the end of the first 24 months of use, we registered a total of 26,372 visits, with a similar total number of connections to each of the VCoPs and also a similar mean number of visits per month (Table 1). The total number of contributions was 2352 and was higher among users of the Pneumobloc (1436; 61%). Although the mean number of contributions per month was higher among Pneumobloc users (60 vs 38), the mean number of contributors was similar (11.3 vs 10.8), which indicates that those participating in the Endobloc were equally pro-active but contributed with less content. The activity registered in both VCoPs during the first 24 months is shown in Figure 2(a) and (b); Pneumobloc had a remarkable higher number of both visits and contributions during the first 8 months after its launch than Endobloc, but afterward activity decreased to the same level, and then both VCoPs stabilized and registered a similar rate of visits and contributions until the end of the assessment period.

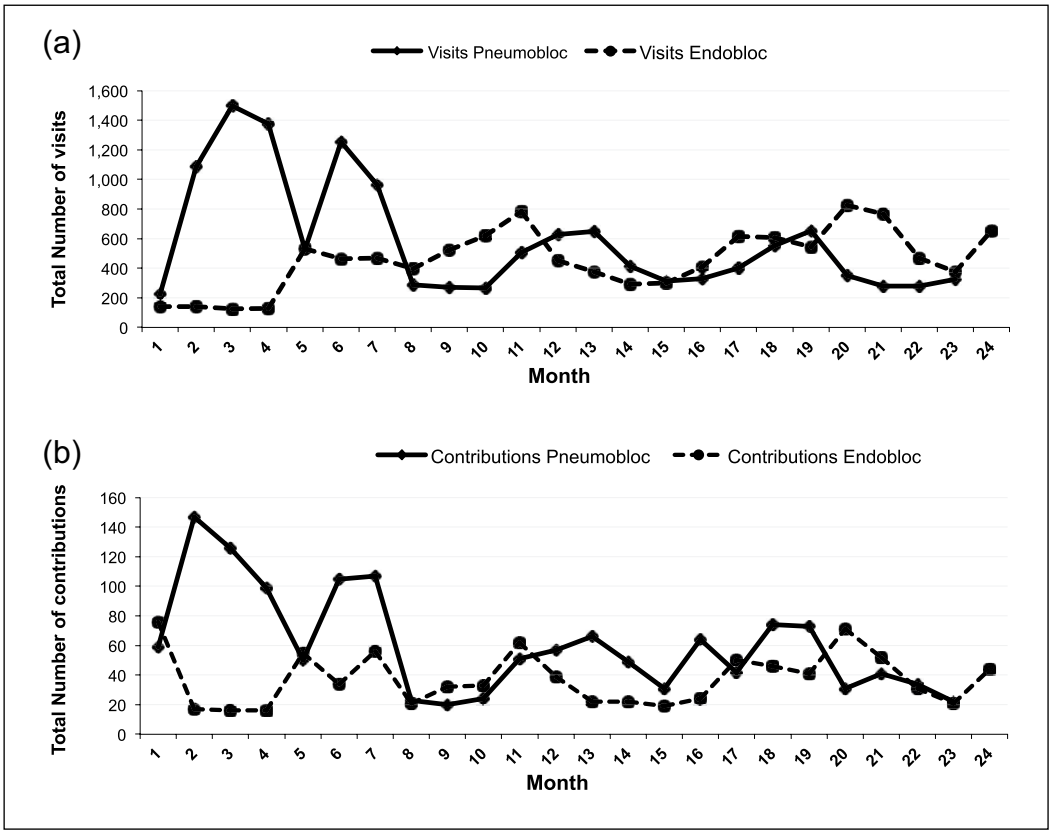

Figure 2. Pattern of activity (a, visits; b, contributions) of the two VCoPs during the first 24 months after the launch.

The pattern of connections to the different sections of the VCoPs is shown in Figure 3(a). While for both VCoPs the most visited section was the e-Consultation, with 64 percent of all visits by Endobloc users, and 38 percent for Pneumobloc users, Endobloc users rarely visited the e-blog; both the e-Images repository and e-Forum sections were much less visited than the e-Consultation section and more visited among Pneumobloc users. Finally, the least accessed content were the e-Documents repository and e-Wiki sections, with the e-Wiki accessed more frequently by Endobloc participants. The pattern of contributions to each VCoP (Figure 3(b)) also shows that Pneumobloc users contributed more than Endobloc users to all sections of the VCoP and were practically the only ones actively participating in the e-Blog section.

As for the level of activity during the days of the week and time of the day, both the mean number of visits and contributions to either VCoP occurred throughout the day including the weekend and holiday periods. However, activity was steady during working days but decreased considerably during the weekend, and there were two peaks of activity during the day: one between 7:00 and 12:00 a.m. and thereafter between 3:00 and 8:00 p.m.

Regarding the composition of participants, we observed the same trend as during the pilot phase, with nurses participating less actively than other healthcare professionals. For instance, they never contributed content to the e-Blog, while specialists contributed in 12.5 percent of cases and GPs in 8 percent of cases (the remaining contributions corresponded to the moderator, the VCoP

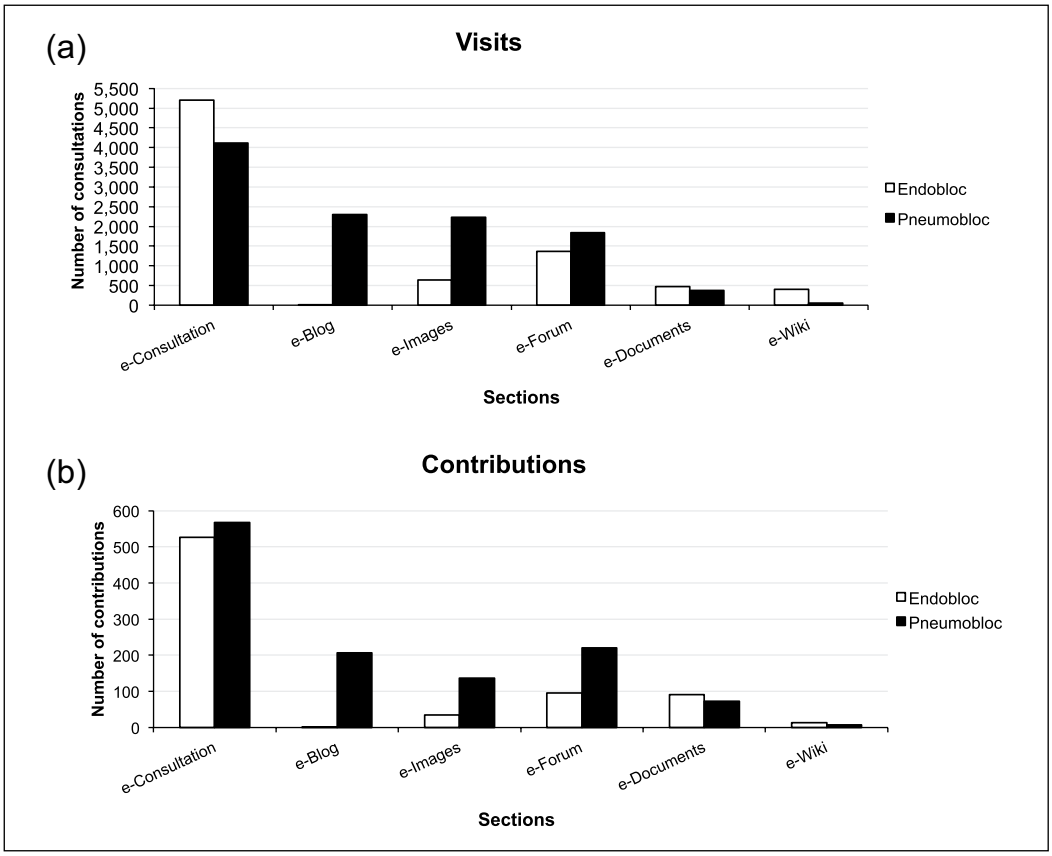

Figure 3. (a) Pattern of visits and (b) contributions to each section of the VCoPs.

manager, and the director of the project). Moreover, nurses contributed with content to the virtual clinical sessions (e-Forum sections) in 11 percent of cases, while specialists contributed in 23 percent of cases, and GPs in 17 percent of cases.

Discussion

In this article, we assessed from a pragmatic approach the development, implementation, and access to and use of two VCoPs linked to the National Health System to increase the interaction between GPs and nurses in primary care and hospital endocrinologists and pulmonologists. We demonstrated here that these VCoPs can be implemented in real-life clinical practice, which is innovative, and also that a relevant proportion of healthcare professionals became participants, which allowed sharing of content and development of new knowledge based on non conventional social networks.[22–24]

GPs play an increasingly relevant role in the management of prevalent diseases such as diabetes mellitus or chronic obstructive pulmonary disease. Although a fluent communication between GPs and specialists is a requirement for a proper management,[25] primary care professionals often experience professional isolation and need to communicate with specialists at hospitals in order to seek advice and improve their clinical practices.[11] New tools such as VCoPs have been shown to be

effective in minimizing professional isolation, and interactive collaboration has also been associated with better population health, reduced costs, and fewer health-disparities.[16,26–28] This is mainly because of the interaction among members without limitation of work-time or location, and because participants share his or her contents openly with other members so all of them benefit from it, and this flow of information generates new knowledge.[23]

Similar, although not comparable, health VCoPs include the Sermo and Esanum communities,[12] but they are restricted to physicians and do not follow the model of the experience reported here (hospital reference area with common patients for two medical specialties). Previous experiences of VCoPs to foster the collaboration between GPs and specialists in our environment include the ECOPIH community, which has a wide selection of medical specialties, although available published data do not allow a direct comparison with the VCoP described here.[20,21]

The behavior of the participants in our VCoP in terms of the use of the different sections is the same as the one observed in a similar VCoP set up for family physicians to facilitate knowledge sharing and reduce professional isolation in Australia.[29] As for the levels of participation in a VCoP, there are three defined categories: high contributors (or core group), active members, and peripheral members who rarely participate (or lurkers), which represent the 10–15, 15–20, and 65–75 percent of the participation, respectively.[30,31] In both of our VCoPs, the patterns of participation among VCoP members was higher than expected, with an average 48 percent of active members, which may be due to the simplicity, an added value that could help other similar communities that may arise following this model.[32]

We observed differences in the pattern of utilization between the two VCoPs. First, Pneumobloc users visited and/or contributed much more than Endobloc users during the first 8 months after the launch and then both VCoPs stabilized and registered similar activity rates. This is because Pneumobloc was launched 1 year after Endobloc, and users at primary healthcare centers were already familiar with the environment and positively disposed toward the use of a new VCoP. Second, despite having the same structure, the utilization of the different sections was also different between Endobloc and Pneumobloc. A higher use of the e-Image repository section on Pneumobloc and a higher use of the e-Wiki section on Endobloc were observed. Radiological tests are essential to diagnose and to manage respiratory diseases, and it is reasonable to think that this is the cause of the different pattern of use. However, the agreement during the process of decision-making between hospital and primary care staff regarding follow-up procedures is crucial for patients' management. On the other hand, the e-Wiki section was probably more visited among Endobloc users because it was used to write the unified diets for the area.

The main advantage is that Endobloc and Pneumobloc were specifically designed for their members' requirements (dispersed healthcare staff on a wide territory), an individualized approach that warrants its use but could also limit its reproducibility in other health-related environments. A first limitation of the study is its descriptive approach, focused on the feasibility of a VCoP on real-life clinical practice conditions, which may preclude the comparison with other existing initiatives. Moreover, it is a pragmatic project without a control group, and relevant patient outcomes and efficacy parameters have not been evaluated. Additionally, there is a potential bias in our study population, since participation was voluntary and there is a clear possibility that those professionals who participated were more interested in endocrinology and respiratory disease management than non-participants. Besides, participants familiar with the usage of new technologies could have been more readily predisposed to collaborate, although previous non-virtual activities in the same environment (e.g. clinical sessions, courses, or conferences) also had a non-homogeneous participation. Moreover, the fact that nurses participated less actively than other healthcare professionals (i.e. GPs and specialists) raises the question of whether the VCoPs were too focused on resolving physician's doubts and problems and whether nurses would need a specific environment and/or

sections to address their actual clinical needs. Finally, the VCoPs were designed to only run on desktop computers, but the design of a platform that also supports the use of mobile technologies could have resulted in a higher communication between the members of the communities, and it would be useful to work toward mobile support in the future to provide improved healthcare even in remote disconnected areas.

Further research is needed in this area regarding the feasibility of VCoPs in other environments with different healthcare systems, and satisfaction of users and healthcare outcomes impact compared with non-virtual procedures should also be explored.

Conclusion

Our data show that VCoPs are useful and feasible tools in a real-life clinical practice context. The benefits of participating in VCoPs include the possibility to access the platform despite the geographical location or connecting time to assist primary care professionals to solve clinical doubts with the support of specialist colleagues, which may eventually help to avoid unnecessary referrals to reference hospitals.

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Declaration of Conflicting Interests

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Identifying the readiness of patients in implementing telemedicine in northern Louisiana for an oncology practice

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Abstract

This study identified the readiness factors that may create challenges in the use of telemedicine among patients in northern Louisiana with cancer. To identify these readiness factors, the team of investigators developed 19 survey questions that were provided to the patients or to their caregivers. The team collected responses from 147 respondents from rural and urban residential backgrounds. These responses were used to identify the individuals' readiness for utilising telemedicine through factor analysis, Cronbach's alpha reliability test, analysis of variance and ordinary least squares regression. The analysis results indicated that the favourable factor (positive readiness item) had a mean value of 3.47, whereas the unfavourable factor (negative readiness item) had a mean value of 2.76. Cronbach's alpha reliability test provided an alpha value of 0.79. Overall, our study indicated a positive attitude towards the use of telemedicine in northern Louisiana.

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Keywords
feasibility study, telehealth, telemedicine

Introduction

LeRouge and Garfield[1] indicated that a critical need exists to bolster telemedicine throughout the United States. However, this need may only be fulfilled if the challenges involved in implementing telemedicine can be clearly identified. There is a lack of formal analysis of the appropriateness of the use of telemedicine during the prevailing circumstances,[2] and its adoption among clinicians is slow.[3,4] The American Telemedicine Association (ATA), whose global advocacy promotes the use of telemedicine, reports that telemedicine is a highly valued growth component of health services in the United States. According to the ATA, the telemedicine market is growing rapidly with both public and private insurers covering payments for telemedicine just as they do for in-person services, citing several prominent studies that demonstrate its cost-effectiveness over in-person services.[2]

In the coming years, technologic advancement, patient and physician technology adeptness, the shortage of providers, telemedicine successes and financial incentives are likely to make telemedicine a substantial channel for healthcare delivery.[5,6] The rural populations stand to benefit from care delivery through telemedicine with improved cost efficiency, better access and greater compliance.[7]

This study examines the acceptability of telemedicine that considers the perceptions of patients from rural and urban regions of northern Louisiana. The study also hypothesises that patient readiness is affected by such perceptions. This exploratory research aims to answer the following question: 'What is the extent of patient readiness for the use of telemedicine services and what are the perceptions (positive and negative) that must be addressed?' Specifically, we focus on patient readiness for the use of telemedicine in clinical specialty consults. A combination of parameters from the Technology Acceptance Model (TAM)[8] and the Fit between Individuals, Task and Technology framework (FITT)[9] (Figure 1) was applied in this study to the data collected using the survey instrument.

Literature review

The role of telemedicine clinical oncology practices has been evolving in many regions of the United States, thereby providing supportive care including pain assessment, nutrition and patient education.[10] Although physicians may treat patients with many diagnoses that usually require physical exams and diagnostic tests,[11] a clear indication exists regarding the need for additional technology to support these processes. Wootton[12] conducted a qualitative study to assess the value of telemedicine in the management of five common chronic diseases (chronic obstructive pulmonary disease (COPD), asthma, diabetes, heart disease and high blood pressure) and concluded that the value of telemedicine in managing chronic diseases is not substantial. In contrast, Cusack et al.[13] listed the various benefits of telemedicine with many different types of cases and suggested that the benefits outweighed the implementation costs. Recent studies have shown that a telemedicine system may aid the delivery of neuro-oncology, chemotherapy, stroke treatment and other time-sensitive treatments safely and effectively, with high levels of patient satisfaction and improved patient monitoring, adherence and knowledge.[14,15]

The consensual concerns expressed by physicians call for policy makers, academia, patient advocacy groups and private-sector organisations to create partnerships to rapidly test, evaluate,

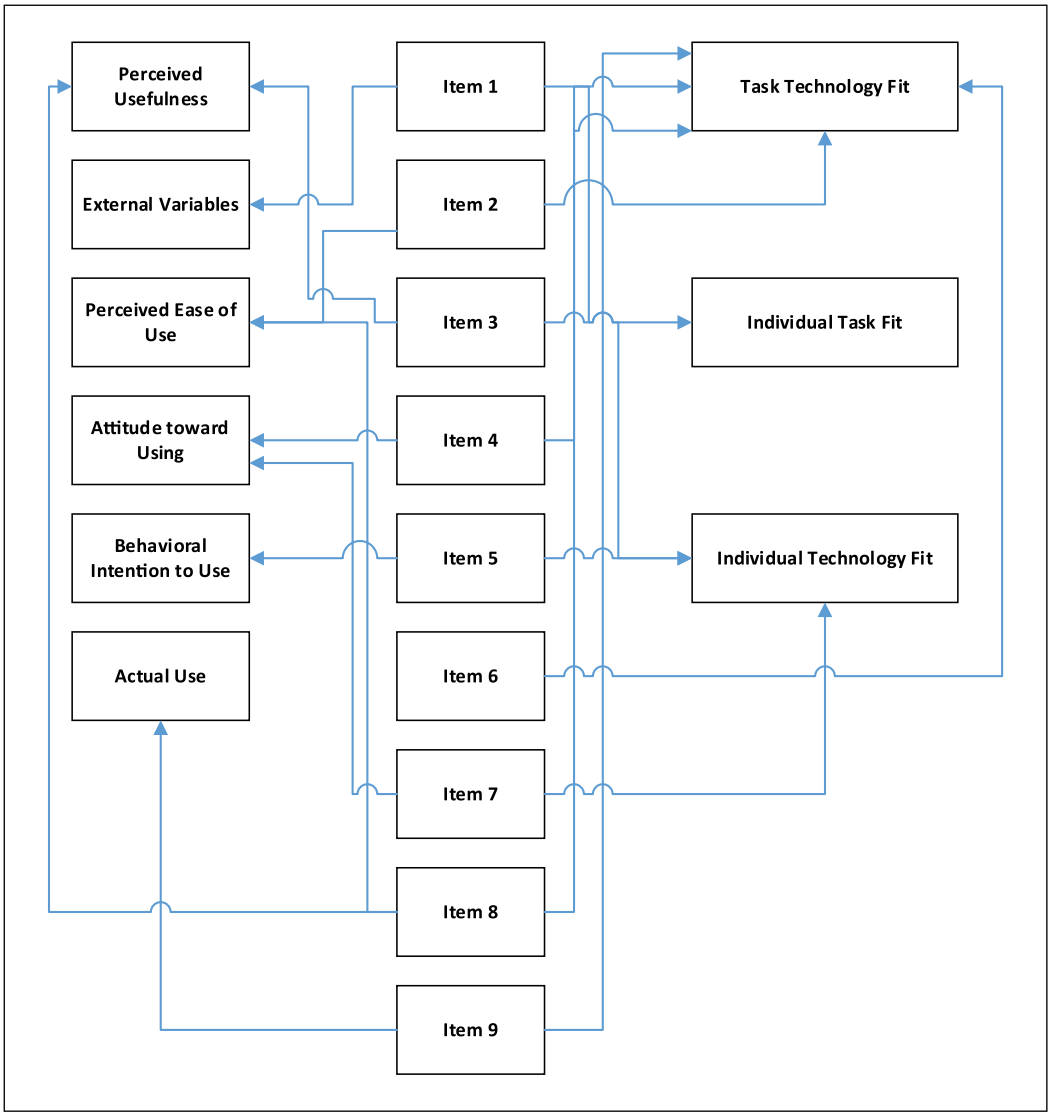

Figure 1. Integration of FITT and TAM frameworks using the survey instrument.

deploy and pay for new care models that use telemedicine.[16] State-by-state licensure and encumbrances imposed by some states impede the adoption of telemedicine. Telemedicine provides a much-needed union of integrated care through the combination of technology, business and clinical processes.[17] However, the use of telemedicine should be optimised to improve patient-centred outcomes at the population level with proper integration of telemedicine with the existing care delivery system resulting in better provider–patient and provider–provider relationships.[18,19]

In addition to the well-perceived potential benefits of telemedicine, the prior studies demonstrated that telemedicine utilisation results in better healthcare access and quality at lower costs.[10,11] For treatments such as chemotherapy that require regular case reviews, telemedicine may be a simple and efficient approach that is cost-effective, safe and associated with good outcomes.[7]

Although the observational studies conducted by Jhaveri et al.[20] found that outcomes were favourable for telemedicine compared to face-to-face care delivery, the patient satisfaction element of telemedicine requires further exploration.[21] Highly important to the creation of the collaborative partnership necessary for successful implementation of telemedicine is the establishment of strong relationships between the physician and the remote clinician (nurse/medical assistant) as well as the remote patient.[22]

In many states, simultaneous video and audio consultation only constitute the use of telemedicine. Beyond the real-time remote patient consultations, telemedicine should also comprise the remote monitoring of patients' vital signs and conditions, the storage and forwarding of diagnostics and analysis, and the provision of specialised patient care services. Additional guidelines and standards from the ATA such as clinical guidelines for telepathology may enhance the widespread adoption of telemedicine.[23] From the FITT perspective, the successful adoption of telemedicine depends on its ability to provide the right information to the right individuals at the right time.[24]

Study overview

In this study, we analysed the data by combining elements from two of the well-known theoretical models. TAM analyses the technology acceptance by the individual, the technology and the management and implementation contexts, and explains the adoption by healthcare professionals. FITT analyses the technology adoption in clinical settings based on the fit between the object attributes of the individuals, technology and clinical tasks by including individual-task, individual-technology and task-technology. The investigators examine the patient readiness for telemedicine use or the diffusion of technology by combining the attributes from the TAM and FITT frameworks. The data collection reflects the patient and physician perceptions regarding usage rather than the actual use of the technology.[25]

Based on the literature review, the investigators developed the survey instrument and conducted the survey among a representative sample of patients from the rural and urban population in and around Shreveport, Louisiana. Whereas the general goal of the survey was to identify the readiness of patients in terms of positive and negative perceptions of telemedicine use, the specific aims of this instrument with respect to the oncology practice in northern Louisiana were as follows:

1. Identify the perceptions regarding telemedicine use between individuals of different genders;
2. Identify the perceptions regarding telemedicine use between individuals of different education levels;
3. Identify the perceptions regarding telemedicine use between individuals of different ethnic groups;
4. Identify the perceptions regarding telemedicine use between individuals of different household income levels.

The investigators obtained 147 responses as detailed in Table 1. The sampling method used was convenience sampling, based on the clinics that were willing to participate in the study. The survey instrument consisted of two sections: (a) patient perspectives and (b) patient demographics. Perception questions (based on psychometric analysis) required a 5-point Likert-scale response (1 = strongly disagree through 5 = strongly agree) that would help analyse the responses by fitting them into a statistical model to assess the required readiness factors.

Table 1. Demographic characteristics of the sample.

Characteristics	Frequency	Percentage of sample (N = 147)
Gender		
Male	71	49
Female	75	51
Race		
Black/African American	37	25
Asian/Pacific Islander	3	2
White/Caucasian	90	61
Hispanic/Latino	2	1
Multiethnic	1	1
Other	0	0
Prefer not to answer	14	10
Age group (years)		
Under 40	11	7
40–49	14	10
50–59	29	20
60–69	37	25
70 and older	55	38
Household income		
Under 10,000	24	18
10,000–14,999	18	14
15,000–24,999	12	8
25,000–34,999	21	16
35,000–49,999	17	13
50,000–74,999	21	16
75,000–94,999	5	4
100,000–149,999	8	6
150,000–199,999	2	2
200,000 and above	4	3
Educational attainment		
Less than high school	9	6
Some high school	16	12
High school graduate or equivalent	47	34
Vocational/technical school	18	13
Some college or associate degree	24	17
Completed a bachelor's degree	16	12
Completed a graduate degree	8	6
Clinic location		
Urban	69	47
Rural	78	53

Not all participants elected to answer all demographic questions; therefore, some variables total less (N = 147).

Methods

The survey instrument was developed through a mix of questions with proper negation that were randomly sequenced to minimise the potential ceiling effects in data collection. After coding (and recoding with reverse scale for negatively worded questions) the survey responses, the

investigators performed both descriptive and inferential statistical analyses on the model parameters, using IBM SPSS 22. They performed statistical analyses (correlation, exploratory factor analysis and alpha analysis) to evaluate the reliability, convergent validity and discriminant validity of the responses. The responses were tested based on the models to measure the readiness of the patients to use telemedicine and to identify the barriers for telemedicine utilisation from the patient perspective.

Analysis was performed on each of the response variables to obtain the descriptive statistics, central tendency and response pattern. Considering the Likert-scale responses as ordinal, a correlation bivariate analysis was performed to determine the direction and strength of the linear relationships between the responses. Combining the concepts of the theoretical TAM and FITT frameworks, the responses were grouped into positive and negative readiness indicators. The positive readiness indicators were the perceptions regarding benefits (travel cost savings, less waiting time), motivation (better feedback, quicker response time), compatibility and relative advantage (easier accessibility and better availability of specialists) in using telemedicine. The negative readiness indicators were the perceptions concerning anxiety (suboptimal comprehension, decreased communication) and complexity (complicated technology).

The analysis was performed starting with factor analysis to reduce the components to a single dimension and to compute the corresponding weighted factor scores (weighted readiness scales). For the weighted factor scores, we used the following computation:

$$WFS = \sum FL \cdot x_i \tag{1}$$

where *WFS* represents the weighted factor scores; *FL*, the factor loadings (Component 1); and x_i, the item scores for each of the responses.

Additionally, we performed analysis of variance (ANOVA) on weighted factor scores based on different demographic categories: gender, income group, education level and ethnic group. The hypotheses are given below, with a significance level of 0.05:

Hypothesis I. Survey responses will differ by gender;

Hypothesis II. Individuals with higher income levels will have more favourable attitudes towards the use of telemedicine;

Hypothesis III. Individuals with higher education levels will have more favourable attitudes towards the use of telemedicine;

Hypothesis IV. Survey responses will differ among ethnic groups.

Finally, we performed ordinary least squares (OLS) regression analyses to estimate the influence of the demographic factors such as ethnicity, age and income on weighted factor scores (readiness scales).

Survey development integrating FITT and TAM models

The survey instrument developed by the investigators integrates both FITT and TAM models. Here, Item 1 targets external variables from the TAM model by including gasoline cost and distance from the clinic and the Task-Technology fit from the FITT model. Item 2 identifies the ability of the patient to understand the physician through telemedicine, thereby covering 'perceived ease of use' from the TAM model and the Task-Technology fit of the FITT model. Item 3 inquires about

the physician ability to understand the patient, thereby indicating the 'perceived usefulness' criteria from TAM and the Individual-Task fit from FITT. Item 4 tests the patient attitude towards using telemedicine from TAM and the Task-Technology fit from FITT. Item 5 focusses on 'behavioural intention to use' from TAM and the Individual-Technology fit from FITT because it inquires about the possibility of improving feedback through telemedicine. A focus on the reduction in response time is indicated in Item 6 using telemedicine, thereby covering 'perceived usefulness' from TAM and the Task-Technology fit from FITT. The investigators determined whether telemedicine was too complicated through Item 7, which covers 'perceived ease of use' from TAM and the Individual-Technology fit from FITT. Item 8 targets the 'perceived usefulness' from TAM and the Task-Technology fit from FITT because it probes whether the individual would be interested in using telemedicine rather than driving to a bigger city. Finally, Item 9 focusses on the 'actual use' criteria of TAM and the Task-Technology fit from FITT.

Results

The results gathered indicated that the patients were reasonably ready to use telemedicine and needed more exposure, education and opportunity to utilise the telemedicine services effectively. Nevertheless, telemedicine services are not commonly offered by physicians in many areas in the United States due to barriers such as licensure, reimbursements, liability and privacy rules.[4,5]

Factor analysis and ANOVA on weighted factor scores

The factor analysis results from SPSS are shown in Table 2. Principal component analysis was used for the extraction method, and components with eigenvalues greater or equal to 1 were selected as the principal components. Furthermore, the orthogonal rotation method Varimax was used as the rotation method, which helps identify the best dimension to explain total variance.

Component 1 had an eigenvalue of 3.717 and Component 2 had an eigenvalue of 1.443. Together they explained 57.33 per cent of the total variance (Table 2). Loadings for each component showed the correlation relationship between the item and its corresponding component. Because the investigators re-coded using a reverse scale for negatively worded questions with the first component explaining the majority of the variance, the items should be reduced to a single-dimension scale. High scores represented positive readiness towards telemedicine, whereas low scores represented negative readiness towards telemedicine. Weighted factor scores were calculated by multiplying loadings with item scores.

High-loading values (Tables 3 and 4) for Item 1 (Cost Savings), Item 4 (Less Waiting), Item 5 (Better Feedback), Item 6 (Quicker Response Time), Item 8 (Easier Accessibility) and Item 9 (Better Specialist) indicated a positive correlation between the benefits, motivation, compatibility and relative advantage in using telemedicine and the total factor scores. Favourable factors contributed positively and highly towards higher weighted factor scores (readiness scores).

In contrast, Item 2 (Comprehension Concerns) and Item 7 (Technology Complexity) loaded slightly on Component 1, indicating anxiety and complexity, which are interpreted as unfavourable factors that affect negatively towards telemedicine readiness.

Item 5 had the highest loading among all the favourable factors and was therefore considered the salient item. The context of Item 5 is 'I feel telemedicine can improve patient feedback regarding the side effects of therapy'. Alternatively, Items 2 and 7 contributed nearly equally to the unfavourable factor.

Table 2. Factor analysis – principal component results and total variance explained.

Total variance explained						
Component	Initial eigenvalues			Rotation sums of squared loadings		
	Total	Percentage of variance	Cumulative percentage	Total	Percentage of variance	Cumulative percentage
1	3.717	41.296	41.296	3.630	40.338	40.338
2	1.443	16.033	57.329	1.529	16.991	57.329
3	.893	9.923	67.252			
4	.791	8.787	76.039			
5	.568	6.310	82.349			
6	.546	6.065	88.414			
7	.408	4.532	92.947			
8	.345	3.836	96.782			
9	.290	3.218	100.000			

Table 3. Readiness in terms of benefits, motivation and relative advantage.

Favourable factor (readiness+): mean score 3.46				
Conducts	Mean	Median	Mode	Factor loading[a,b] (Component 1)
Cost Savings	3.56	4.00	4.00	0.683
Less Waiting	3.26	4.00	4.00	0.779
Better Feedback	3.53	4.00	4.00	0.802
Quicker Response Time	3.53	4.00	4.00	0.603
Easier Accessibility	3.53	4.00	4.00	0.763
Better Specialist Available	3.35	4.00	4.00	0.796

[a]Extraction method: principal component analysis.
[b]Rotation method: varimax with Kaiser normalisation.

Table 4. Readiness in terms of communication factor based on comprehension, communication and technology.

Unfavourable factor (readiness−): mean score 2.77				
Conducts	Mean	Median	Mode	Factor loading (Component 1)
Comprehension Concerns	3.05	3.00	4.00	−0.083
Communication Concerns	2.42	2.00	2.00	0.548
Technology Complexity	2.83	3.00	2.00	0.162

The instrument was validated using ANOVA. Performing ANOVA on weighted factor scores allowed the investigators to identify the significance of the individual demographic variables to the response items listed in the survey. The purpose of performing regression is to identify the standardised coefficients that determine the relative importance between the different demographic variables from the survey. Factor analysis is used to reduce the data dimension to uni-dimension. Reducing the data into uni-dimension aided in calculating the

Table 5. ANOVA hypothesis tests on gender, income, education and ethnic groups.

	F statistics	p value
Gender	0.045	0.832*
Income	0.328	0.964
Education	1.182	0.321
Ethnic Groups	0.702	0.623

ANOVA: analysis of variance.
*Significant level alpha = 0.05.

weighted factor scores. Additionally, Cronbach's alpha coefficient was calculated to test the reliability of the instrument.

ANOVA on weighted factor scores instead of raw data would be more effective. We performed ANOVA to test the hypotheses targeting gender, income, education and ethnic groups independently. Table 5 shows the ANOVA results.

All the p values of testing on favourable factor scores were greater than 0.05, which indicates that the investigators should not reject any of the null hypotheses and should conclude that no significant difference existed between gender, income levels, education levels and ethnic groups towards the weighted favourable factors. People of different genders, income levels, education levels and ethnic groups showed similar attitudes towards telemedicine readiness.

Descriptive statistics and OLS regression analysis

Favourable factors (readiness+) (mean = 3.47, value >3 is towards agreement with positive perceptions) indicate that the patients agreed with the perceived benefits, motivation and relative advantage. Unfavourable factors (readiness−) (mean = 2.76, value <3 is towards disagreement with negative perceptions) indicate that patients did not tend to agree with the negative perceptions such as communication problems, comprehension concerns and technologic complexity. The details of the individual components are illustrated in Tables 3 and 4. According to these tables, we measured the readiness factor as 0.69 (favourable minus unfavourable factor mean values, that is, 3.46 − 2.77).

A bivariate analysis of Pearson's correlation (two-tailed) showed significant correlations at the 0.05 level among the items in the scales. Both readiness scales had reasonably acceptable results for the measure of scale reliability. Cronbach's alpha coefficient of 0.840 (alpha > 0.70) for the six items in the favourable factors suggests that the items had relatively high internal consistency. However, the alpha coefficient for the three items in the unfavourable factor scale was only 0.476 (alpha < 0.70). This finding suggests that the items did not have high internal consistency, which could have been due to the phrasing of one of the questions indicating negative perceptions in the reverse direction.

We were able to draw some inferences from the OLS regression analysis on weighted factor scores based on age, household income, ethnicity and education, which could only explain approximately 6 per cent of the variance in readiness ($R^2 = 0.0532$, $F = 0.59$, sig = 0.8193 at 0.05). A standard beta coefficient was calculated to compare the relative importance between parameters. Table 6 shows that none of the parameters were significant to the model, which signifies that this model may only be used in descriptive analysis rather than prediction analysis.

A negative linear relationship trend (standard coefficient: −0.11439) tended to exist between age and agreement. That is, as age increased, item agreement declined. For example, for Item 3, 'I think that the doctor will be able to understand me through telemedicine video', a steady decline

Table 6. Ordinary least square regression result and standardised parameters.

Parameter estimates					
Variable	Parameter estimate	Standard error	t-value	Prob. > |t|	Standardised estimate
Intercept	2.13101	0.27802	7.67	<.0001	0
Age	−0.00348	0.00317	−1.10	0.2736	−0.11439
Income	0.00855	0.02175	0.39	0.6951	0.04632
Education	0.00443	0.03007	0.15	0.8833	0.01584
Rurality	−0.06044	0.09144	−0.66	0.5101	−0.06876
Male	0.05442	0.08661	0.63	0.5312	0.06202
Asian	−0.18775	0.26505	−0.71	0.4803	−0.06797
Hispanic/Latino	0.31042	0.33559	0.92	0.3571	0.09216
African American	−0.03959	0.11094	−0.36	0.7219	−0.03765
Multiethnic	0.13164	0.45988	0.29	0.7753	0.02776
Ethnic/other	−0.27192	0.20967	−1.30	0.1975	−0.12595

was observed in agreement from the under-40 age group (73%) to the 70 and over age group (50%). Similarly, in responding to Item 4, 'I would prefer to see a physician sooner though telemedicine than wait to see a physician in-person', 82 per cent of participants under age 40 agreed with the statement, whereas only 46 per cent of the 70 and over age group agreed.

The results of the household income variable displayed a sporadic pattern of responses. Moreover, it showed a positive correlation with factor scores (standard coefficient 0.04632), which signified that the greater the household income, the greater the readiness towards telemedicine. No significant differences were found.

Overall, the education variable suggested that those who completed a graduate degree were more polarised, tending to agree with the use of telemedicine at a higher percentage than individuals with lower education levels (standard coefficient 0.01584). For example, in responding to Item 3, of those who completed a graduate degree, 63 per cent agreed with the statement, 'I think that the doctor will be able to understand me through telemedicine video', whereas 13 per cent disagreed. For the same item, only 44 per cent of those who completed less than high school agreed with the statement, whereas 44 per cent disagreed. A similar pattern was seen for Item 6, 'I feel telemedicine can reduce physician response time', for which 88 per cent of those who completed a graduate degree agreed with the statement and 0 per cent disagreed compared to those who completed less than high school for which 50 per cent agreed and 25 per cent disagreed.

The results for males and females were consistent across the items. Males indicated a higher inclination towards the use of telemedicine than females (standard coefficient 0.06202). The only deviations in agreement (greater than 10 percentage points) occurred with Items 7 and 8. Females (36%) were more likely than males (22%) to agree that the idea of telemedicine sounded too complicated (Item 7). Additionally, males (68%) were more likely than women (58%) to agree that they would prefer to see a specialist via telemedicine rather than go to a big city (Item 8). No significant differences were found (Tables 7 and 8).

Across ethnicity, African Americans and Caucasians displayed a consistent pattern of responses with few exceptions. For example, 49 per cent of African Americans compared to 38 per cent of Caucasian participants agreed with Item 2: 'I am concerned about being able to understand what the doctor says through telemedicine video'. Conversely, Caucasian participants (66%) were more likely to agree with Item 8, 'If a specialist were not available in my local area, I would prefer to see a specialist via telemedicine rather than go to a big city', than African-American participants

Table 7. Likert-scale analysis of questions related to proximity.

	1. The money saved in time away from work and gasoline cost would affect my decision to use telemedicine through my local provider's clinic rather than travelling to a distant location for a face-to-face visit with a specialist		2. I am concerned about being able to understand what the doctor says through telemedicine video		3. I think that the doctor will be able to understand me through telemedicine video		4. I would prefer to see a physician sooner though telemedicine than wait to see a physician in-person	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
All	3.6	1.1	3.0	1.2	3.6	1.0	3.3	1.2
Gender								
Male	3.5	1.1	3.0	1.1	3.5	1.0	3.4	1.1
Female	3.6	1.1	3.1	1.2	3.6	.9	3.1	1.3
Race								
Black/African American	3.5	1.3	3.1	1.3	3.6	1.2	3.1	1.4
White/Caucasian	3.6	1.1	3.0	1.1	3.6	.8	3.3	1.2
Other	3.3	1.0	2.8	1.3	4.0	.8	3.2	1.3
Age group (years)								
Under 40	3.9	.8	2.5	1.1	3.7	.8	3.8	1.0
40–49	3.1	1.1	2.6	1.2	3.6	.6	2.8	1.2
50–59	4.0	1.2	3.1	1.2	3.5	1.3	3.6	1.3
60–69	3.6	1.1	3.0	1.1	3.7	.8	3.3	1.2
70 and older	3.3	1.1	3.3	1.2	3.4	1.0	3.0	1.2
Household income								
Under 10,000	3.6	1.3	3.2	1.3	3.7	1.2	3.5	1.2
10,000–14,999	3.2	1.3	3.1	1.2	3.6	.9	2.5	1.4
15,000–24,999	3.7	.9	3.3	.9	3.5	.8	2.9	1.0
25,000–34,999	3.6	1.2	3.1	1.2	3.6	.9	3.3	1.3
35,000–49,999	3.6	1.0	2.9	1.3	3.8	.8	3.6	.9
50,000–74,999	3.9	1.0	3.0	1.2	3.8	.8	3.4	1.2
75,000 and above	3.5	1.3	2.5	.9	3.5	1.0	3.4	1.2
Educational attainment								
Less than high school	3.1	1.4	3.0	1.4	3.3	1.2	2.9	1.5
Some high school	3.8	1.1	3.7	.8	3.9	.7	3.4	1.1
High school graduate or equivalent	3.7	.9	3.3	1.0	3.5	.7	3.2	1.1
Vocational/technical school	3.4	1.3	3.0	1.3	3.6	1.0	3.3	1.3
Some college or associate degree	3.6	1.1	2.5	1.1	3.7	1.0	3.4	1.3
Completed a bachelor's degree	3.1	1.4	2.2	.9	3.6	1.1	3.1	1.4
Completed a graduate degree	4.4	.7	3.1	1.4	4.1	1.0	3.6	1.3
Clinic location								
Urban	3.6	1.1	3.0	1.2	3.7	1.0	3.3	1.2
Rural	3.5	1.1	3.1	1.2	3.5	.9	3.2	1.2

SD: standard deviation.

(54%). African-American participants also disagreed with Items 1, 3, 4, 5, 7 and 8 at least 10 per cent more frequently than did Caucasian respondents. No significant differences were found.

The response patterns of the rural and urban participants were very similar with most items agreed and disagreed upon at a similar rate. Rurality showed a negative correlation with the weighted factor scores (standard coefficient: −0.06876), which indicates that individuals from rural areas had a higher tendency to reject telemedicine. The only exceptions were the responses to Item 3, 'I think that the doctor will be able to understand me through telemedicine video', and Item 8, 'If a specialist were not available in my local area, I would prefer to see a specialist via telemedicine rather than go to a big city'. For Item 3, 69 per cent of the urban sample agreed with the statement compared to 58 per cent of the rural sample. Similarly, 70 per

Table 8. Likert-scale analysis of questions related to likeability of telemedicine.

	5. I feel telemedicine can improve patient feedback regarding the side effects of therapy		6. I feel telemedicine can reduce physician response time		7. The idea of telemedicine sounds too complicated		8. If a specialist were not available in my local area, I would prefer to see a specialist via telemedicine rather than go to a big city		9. The use of telemedicine would provide me specialised care that I would not otherwise have access	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
All	3.5	1.0	3.5	.9	2.8	1.1	3.5	1.1	3.3	1.1
Gender										
Male	3.5	1.0	3.4	1.0	2.7	1.0	3.6	1.1	3.4	1.0
Female	3.6	1.0	3.6	.9	3.0	1.3	3.4	1.1	3.3	1.1
Race										
Black/African American	3.5	1.2	3.6	1.1	2.7	1.3	3.3	1.3	3.4	1.2
White/Caucasian	3.6	.9	3.5	.9	2.8	1.0	3.6	1.0	3.3	1.0
Other	3.2	1.3	3.4	1.1	3.0	1.4	3.5	1.1	3.1	1.1
Age group (years)										
Under 40	3.7	1.0	3.5	1.1	2.5	.8	3.6	.8	3.2	.8
40–49	2.9	1.1	3.1	1.0	2.9	1.0	3.2	1.2	3.1	.9
50–59	4.0	1.0	3.6	1.0	2.4	1.1	3.6	1.2	3.4	1.2
60–69	3.6	1.0	3.8	.8	2.7	1.2	3.6	1.2	3.5	1.1
70 and older	3.4	.9	3.4	1.0	3.2	1.1	3.5	1.0	3.3	1.0
Household income										
Under 10,000	3.7	1.2	3.6	1.1	3.2	1.4	3.4	1.3	3.4	1.4
10,000–14,999	3.5	.9	3.6	1.0	2.9	1.3	3.1	1.3	3.1	1.2
15,000–24,999	3.3	.9	3.5	.9	2.8	1.1	3.5	.8	3.6	.8
25,000–34,999	3.1	1.2	3.4	1.0	3.0	1.0	3.4	1.1	3.5	1.0
35,000–49,999	3.7	.8	3.3	.9	2.7	1.1	3.5	.9	3.5	.8
50,000–74,999	3.7	.8	3.6	.7	2.7	1.0	3.8	1.0	3.0	.9
75,000 and above	3.6	1.1	3.7	.9	2.3	1.0	3.7	1.2	3.2	1.1
Educational attainment										
Less than high school	3.3	1.4	3.3	1.3	4.0	1.4	3.2	1.5	3.4	1.3
Some high school	3.9	.9	3.5	.8	3.4	1.1	3.6	1.0	3.6	1.0
High school graduate or equivalent	3.4	.8	3.4	.8	3.1	1.0	3.5	.9	3.3	.9
Vocational/technical school	3.4	1.1	3.4	.8	2.4	.9	3.3	1.1	3.3	1.1
Some college or associate degree	3.7	1.1	4.0	.9	2.3	1.0	3.8	1.2	3.5	1.0
Completed a bachelor's degree	3.5	1.3	3.0	1.3	2.6	1.2	3.3	1.1	3.1	1.3
Completed a graduate degree	3.6	1.2	4.1	.6	1.9	1.0	3.6	1.5	3.0	1.3
Clinic location										
Urban	3.5	1.1	3.7	.8	2.8	1.1	3.7	1.0	3.5	1.0
Rural	3.5	1.0	3.4	1.0	2.9	1.1	3.3	1.1	3.2	1.0

SD: standard deviation.

cent of the urban sample agreed with Item 8 compared to 57 per cent of the rural sample. No significant differences were found.

Participants tended to agree with the survey items, indicating a positive association with telemedicine. For example, 61 per cent of the sample agreed with Item 1, 'The money saved in time away from work and gasoline cost would affect my decision to use telemedicine through my local provider's clinic rather than travelling to a distant location for a face-to-face visit with a specialist', whereas only 18 per cent of the sample disagreed with the item. Similarly, over 60 per cent of the sample agreed with Item 3, 'I think that the doctor will be able to understand me through

telemedicine video', and Item 8, 'If a specialist were not available in my local area, I would prefer to see a specialist via telemedicine rather than go to a big city'.

Discussion

The readiness factor of 0.69 (values may vary from −4 to +4) indicates that the patients had positive perceptions towards the use of telemedicine in northern Louisiana. However, the relatively moderate scores (preferred score is closer to +4 with readiness+ closer to 5, herein 3.46 and with readiness− closer to 1, herein approximately 2.76) suggest that prospective patients need some motivation to elevate their readiness levels. This requires all the stakeholders in the healthcare community such as policy makers, providers, payers and patients to identify the determinants[6] of successful telemedicine utilisation.

Demonstration of a positive perception is vital to the applicability of telemedicine that is both cost-effective and less resource intensive, while increasing access to healthcare for remote patients.[26] This study examined the patient readiness for the use of telemedicine based on the attributes of objects and dimensions of TAM and FITT frameworks. According to the postulates of the model, the perceived benefits and motivational factors significantly influence the intention to use telemedicine among patients across the demographic characteristics. Therefore, telemedicine access encompassing uniformity and a simplified patient approach will result in user-friendly utilisation that is cost-effective for patients.[7]

Perceived benefits appear to represent the most significant factor influencing the patients to use telemedicine. Reduced anxiety and complexity concerns enhance the utilisation of telemedicine. Patients show only moderate concerns about inadequate communication, anxiety and technologic complexity. Telemedicine may reduce the need for in-person referrals and allow patients to access care without a face-to-face visit with a specialist. The lack of trial-ability of teleconsultations limits the confidence that patients need to subscribe to telemedicine services. However, before implementing telemedicine services, a need exists to conduct a formal analysis to identify the patients, conditions, economic concerns and clinician preferences that will benefit the utilisation and render services efficiently and effectively.[3,13] Telemedicine usage is also affected by protected health information (PHI) security concerns. Compliance of telemedicine use with the Health Insurance Portability and Accountability Act (HIPAA) has unique, significant security challenges that call for apposite implantation of the technology.[27] Given the present circumstances, some literature indicates that the Affordable Care Act is likely to increase the use of telemedicine in many areas such as for remote consultations, gap service coverage, emergency services, mandated services and multisite group chart rounds.[28] Many patients are also likely to use telemedicine services using video calls from personal devices such as tablets, phones or computers that meet the technologic requirements.[29]

This study suggests that the patients were ready, but not very well informed and trained. Moreover, they required greater motivation through education, observations and trial-ability with better human–computer interaction (HCI) through the Clinical User-Experience Evaluation (CUE).[30] The well-planned implementation of a telemedicine system enhances the geographical access of the care providers and the efficient use of their time while reducing the barriers to effective patient interaction. To stimulate the rapid adoption of telemedicine, efforts are needed to remove the barriers identified in this study by adopting an optimum strategy for efficient and effective utilisation of telemedicine services. Our observations indicate that a healthcare delivery system should demonstrate to the amenable patients the compatibility and equivalence of telemedicine with in-person visits through better trainability and observability.[18,31]

Limitations of the study

The investigators identified three main limitations of this study: (a) the survey respondents were mainly from an oncology practice, (b) the survey items did not include some technical components such as the type of devices the respondents would be more comfortable using and (c) a nation-wide or international survey may be required to further ascertain the results gathered from the investigation. Further research conducted within this project will attempt to overcome some of these limitations.

In addition to this, one of the contributions of the study is the development of a survey instrument that covers the aspects included in the TAM and FITT frameworks. This feature is illustrated in Figure 1. Because the survey was employed using respondents who happened to be predominantly patients, it did not cover the actual use factor of the TAM framework to the extent we would have preferred. The actual use criteria will be thoroughly tested in the next phase of the study in which we intend to survey the physicians regarding their perceptions of telemedicine uses. Additionally, this study is limited only to the perceptions of patient motivation and readiness among non-users of telemedicine, which calls for further exploration into patient satisfaction, outcomes, safety, efficacy and other quality measures that help the triple aim of enhanced care, better health and lower cost of the health system.[32]

Planned future study

The investigators plan on advancing this study to explore the contextual utilisation of telemedicine to determine how the effectiveness and efficiency of telemedicine usage vary with time, place and specific services in a diverse population. This endeavour aids in the more effective implementation of telemedicine following pertinent healthcare regulations with a flexible and integrated care delivery system that is patient-centric and fosters innovation.[18] Additionally, the investigators also plan to survey the physicians regarding their perceptions of telemedicine usage and the application of the Innovation Diffusion Model (IDM).[33] The investigators involved in the study also wish to use this instrument in a non-oncology practice and in a different part of the United States to identify trends in the perception of telemedicine use. Incorporating telemedicine as part of the standard of care depends on human factors, technology and economics. This study suggests that a need exists for improvements in the human factors to positively influence health economics through telemedicine use. The needs, gaps and challenges of the current landscape must be addressed through proper patient engagement.[34,35] Future studies should select diverse samples from multiple communities so that variations in the readiness to use telemedicine may be better portrayed. Additionally, personal characteristics such as the need for care, motivation and knowledge about telemedicine should be simultaneously considered in the investigation.

Conclusion

To conclude, the investigators succeeded in fulfilling the aforementioned specific aims of the study. The analysed results indicated a positive trend towards the perception of telemedicine use among the respondents involved in the study. According to our study, Cronbach's alpha reliability test provided an alpha value of 0.79, which approximates 0.8 and could be considered as good. The factor analysis indicated a uni-dimensional scaling because the first component explained the majority of the total variance. The first component explained 40 per cent of the total variance from which we could compute the weighted factor scores. The ANOVA tests based on the weighted factor scores showed that no significant difference was detected among the groups of gender,

household income, education, ethnicity and rurality. The ordinary least squares regression showed no significant predictors towards weighted factor scores with an R^2 value of 0.06. However, this study requires further probing due to the aforementioned limitations.

Overall, the study indicates that the positive inclination towards the use of telemedicine for the study sample was based on perceived benefits, motivation and relative advantage, whereas the negative inclination of the subjects was due to communication problems, comprehension concerns and technologic complexity.

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Article

ChronicOnline: Implementing a mHealth solution for monitoring and early alerting in chronic obstructive pulmonary disease

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Abstract

Lack of time or economic difficulties prevent chronic obstructive pulmonary disease patients from communicating regularly with their physicians, thus inducing exacerbation of their chronic condition and possible hospitalization. Enhancing Chronic patients' Health Online proposes a new, sustainable and innovative business model that provides at low cost and at significant savings to the national health system, a preventive health service for chronic obstructive pulmonary disease patients, by combining human medical expertise with state-of-the-art online service delivery based on cloud computing, service-oriented architecture, data analytics, and mobile applications. In this article, we implement the frontend applications of the Enhancing Chronic patients' Health Online system and describe their functionality and the interfaces available to the users.

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Keywords
chronic obstructive pulmonary disease, cloud computing, health services, mobile applications, monitoring

Introduction

Chronic obstructive pulmonary disease (COPD) is a preventable and treatable respiratory disease that causes limitations in lung airflow. The most common symptoms of patients suffering from COPD are frequent respiratory infections, a chronic cough, excessive sputum production, shortness of breath, and progressively worsening dyspnea.[1]

According to the World Health Organization, 450 million people suffer from COPD on the planet. It is estimated that COPD accounts for >3 million deaths per year, while globally is responsible for >29 million years of life in conditions of disability. COPD will be the fourth leading cause of death worldwide by the end of 2030.[2]

Epidemiological studies conducted in the United States, Denmark, Norway, Italy, Spain, Japan, and Greece reported an overall COPD prevalence of 4–10 percent in the population.[3–9] In Greece, COPD's prevalence is also high. Adult smokers from 9 to 100 suffer from the disease (8.4%), that is, 600,000 Greeks, while 56 percent of them, that is, 300,000, are not aware that they suffer from the disease. Even half of the patients continue to smoke ignoring the risks of the disease. Men suffer 2.5 times more than women (11.6% vs 4.8%).[9]

Usually, COPD is recognized late, either during an acute exacerbation of the disease or because the symptoms have increased too much obliging the patient to go to the doctor. The disease lasts several decades, while progressively impairs the quality of life of patients and immobilize them at home in continuous supply of oxygen due to respiratory failure. In the final stages, the patient often needs hospitalization, even in the intensive care unit greatly increasing the health costs. Although COPD is a disease of the lungs, this can cause significant systemic effects in a percentage of patients (affects other vital organs such as the heart and muscles). It is also associated with many comorbidities (such as heart failure, metabolic disorders, sleep apnea syndrome, and depression) posing patients' management particularly difficult.

COPD treatments include smoking cessation, vaccinations, rehabilitation, bronchodilators, steroids, and long-term oxygen therapy.[10] The total cost of the medicines, emergency visits, or hospitalizations is enormous. Various studies have estimated the cost associated with the treatment of COPD patients: £0.8 billion in the United Kingdom in 2003,[11] US$18 billion in the United States in 2005,[12] and US$2.1 trillion worldwide in 2010.[13] In a prospective 1-year follow-up study conducted in 268 general practices in Spain,[14] the hospitalization costs for the treatment of acute COPD exacerbations represented about 45 percent of the direct costs, the medication costs represented about 40 percent of the direct costs, and the costs for the in-clinic visits and the diagnostic procedures represented about 15 percent of the direct costs.

Lack of time or economic difficulties prevent patients from communicating regularly with their physicians, thus inducing exacerbation of their chronic condition and possible hospitalization. Therefore, the prevention of exacerbations of COPD patients in order to improve quality of life for chronic patients and reduce costs is the primary concern of the medical community.

In this article, we implement the frontend applications of the *Enhancing Chronic patients' Health Online* (ECHO) system.[15] The ECHO system uses a combination of cloud and service-oriented computing, online services, data analysis, and eHealth applications to connect COPD patients to their physicians. The ECHO system is expected to monitor patients, verify the diagnosis with online alerts in order to avoid medical emergencies and unnecessary hospitalizations at low cost and at significant savings to the national health system. Part of this work was carried out in project ECHO.[16]

State of the art

Several studies investigate the use of eHealth services in order to improve patients' quality of life and reduce COPD exacerbations. A literature review was conducted to examine various eHealth practices such as telemetry or telephone calls or home visits by nurse specialists and their impact on the management of chronic diseases.[17] Most studies in the review have been relatively short term (<6 months); thus, no evidence for the value of telehealthcare is verified. A meta-analysis published by Cochrane Library in 2011 included 10 randomized controlled trials, which investigated the hospitalizations, the exacerbations, the quality of life measures, the hospital visits, and the mortality in COPD patients using telehealthcare.[18] According to the review, telehealthcare increased significantly the quality of life in two trials with wide confidence interval (CI; mean difference: −6.57, 95% CI: −13.62 to 0.48) and reduced the number of the patients who visited a hospital (odds ratio: 0.27, 95% CI: 0.11–0.66) and the number of admissions per year in six trials (odds ratio: 0.46, 95% CI: 0.33–0.65). The difference in mortality rates was not clinically significant.

A systematic literature review demonstrated that hospital at home schemes resulted in substantial cost savings with equal effectiveness and patient safety compared with inpatient care for acute exacerbations of COPD.[19]

A currently published systematic review and meta-analysis found a significant effect of telehealthcare (telephone calls, web, or mobile services) on physical activity level and no effect on physical capacity and dyspnea.[20]

Studies have used mobile application technologies to monitor patients and facilitate health in a cost-effective way for both patients and physicians. But no study has used the technologies and the architecture similar to our approach. The study by Sanchez-Morillo et al.[21] evaluated an electronic questionnaire for the detection of COPD exacerbations with a 6-month follow-up of 16 patients, using a k-means clustering algorithm. The authors found the questionnaire and the above-mentioned methodology helpful for the detection of COPD exacerbations.

A mobile-assisted home care model uses a mobile application that enables patients report their COPD symptoms.[22] A Web portal is developed for clinicians to manage and analyze patients' data and send feedback when necessary. A method for computer-aided assistance including event detection, alerting, monitoring, and treatment advice at a distance from the hospital is developed. COPD symptoms are collected and interpreted by a probabilistic model to access automatically the risk of worsening of symptoms due to an exacerbation.[23]

A basic difference in the architecture of the ECHO system and the above-mentioned studies is that our system enables the communication of patients and physicians through predefined messages based on mobile applications for both the patients and the physicians. Thus, physicians can use a push notification service for immediate alerting of emergent situations. Another capability of the ECHO system is that the patients' mobile application gathers data automatically from mobile devices (e.g. global positioning system (GPS) location) which are used in data analysis. The backend of the ECHO system supports data processing by means of cloud computing technologies that allow fast analysis of complex or large sets of patient data in order to help physicians dynamically adjust treatment plans in a cost-effective way.

Medical problem

It is very common for chronic disease patients to not have regular and frequent communication with their physicians, as they should. Some of the reasons that lead to it are lack of time, economic difficulties, or negligence. Unfortunately, this situation may lead to exacerbation of their chronic

condition and to medical emergencies. The ECHO system enables closer connectivity of humans and systems, through the use of the latest technologies of smartphones, cloud computing, and intelligent data mining, in order to ensure uninterrupted care and chronic ailment crisis avoidance. Specifically, the goals achieved by the ECHO system are the following:

- Collect and manage data about the health status, medical history, current treatment, and action plan in case of worsening of symptoms, thus improving the monitoring of patients.
- Reduce or eliminate symptoms and improve health status, enabling the management and treatment of COPD exacerbations.

The methodology applied for COPD is described as follows: The patient provides (on a daily basis) the following mobile data to the database supported by the backend of the ECHO system:

- Measurements of predefined vital signs (biomarkers)
  - Oxygen saturation
  - Heart rate
  - Temperature
  - Peak expiratory flow rate (PEFR)
  - Walking distance

- Answers the following questions:
  - Did your shortness of breath increased?
  - Did your cough increased?
  - Did your sputum changed?
  - Did you have chest pain or discomfort?
  - Did you change your medications?

These data are transmitted to the system and are made available to the physician who creates and regularly (e.g. at regular follow-ups or during unexpected events such as exacerbations and emergency visits to the doctor or hospital) updates a medical record of the patient. The condition of the patient is evaluated, and recommendations or treatments are sent by the physician. The detailed actions performed by the users of the system are described below.

From a health-care provider's point of view:

1. The health-care provider creates and then regularly updates a detailed medical record of the patient as part of the diagnosis in compliance with appropriate health-care regulations and standards (e.g. HL7).[24] This would include the demographics, symptom and sign comorbidities, exacerbations or relapses and the appropriate tests (pulmonary function test, O2 Sat, blood gases, etc.), and quality-of-life questionnaires such as Clinical COPD Questionnaire (CCQ)[25] or others.
2. Based on the above, the system will verify the diagnosis using predetermined criteria (as described above).
3. In addition, based on the medical record and with the appropriate severity scales, the system will evaluate severity of the patients.
4. Furthermore, the system would evaluate whether the patient is treated with the appropriate medications in accordance with the international guidelines[26] and advice the health-care provider social interaction feedback loop.

5. The above data of the medical record and in particular those of the severity will be reviewed frequently at regular follow-ups or during unexpected events such as exacerbations and emergency visits to the doctor or hospital. For the regular scheduled visits, reminders will be developed to increase compliance to the follow-up. These data are also fed into the model building feedback loop which, at longer time intervals, reevaluates diagnosis and severity algorithms and risk models.

Alarms and warning flags are part of the early warning feedback loop. From a patient's point of view:

- Every day, the patients have to answer five simple questions concerning their disease, and five biomarkers (as given above) will be collected by the smartphone all predetermined and part by the patient–client interface.
- These data are transmitted to the system and automatically and continuously compared with the severity indexes of the file of the patient.
- The early warning and severity feedback loop evaluates daily the condition of the patient and can identify mild-moderate or severe exacerbations of the disease.
- Following this analysis, early warning flags are with simple instruction to the patients such as "Increase your medication," "Call your Doctor," and "Go to the Hospital." The levels of warning and the advices (flags) will be developed for each disease severity level and in accordance with the current guidelines.

Overall architecture

The ECHO system[15] consists of a frontend and a backend as shown in Figure 1.

The frontend is either delivered as application on iOS and Android smartphones or as a web application made available via browsers. The implementation of the backend was developed by University of Stuttgart, and the implementation of the frontend in web browsers and mobile applications was developed by OpenIT. The backend was integrated through JSON APIs to the frontends, which consisted of Android mobile application, iOS mobile application, and PHP-based web user interface (UI).

There are two types of user roles either on mobile devices or in browsers: the frontend for patients and the frontend for doctors. The application for patients allows patients to provide information about their actual health status and to be advised about actions to be taken based on their health record, all stored in the cloud infrastructure. The application for doctors allows physicians to pass recommendations to patients based on their actual health status and their health records stored in the cloud infrastructure. The application will receive notifications about urgent health situations of a patient that require immediate reactions.

The backend consists of the "Health Server" and is delivered as a cloud service, packaged in a portable manner based on the Topology and Orchestration Specification for Cloud Applications (TOSCA) standard.[27] "Health Data" stores and manages two different sources of data: patients' health data entered from smartphones on a daily basis and physicians' consultations (patient data, examination results, and prescriptions). Both health risks and situations requiring immediate reactions are determined by corresponding analytics functions maintained by the component "Analytics" in the backend. "Health Services" manage patients' data and are composed into higher level services with advanced functionality by means of "Orchestrations" offered by the Health Server. The Health Server functionality with all its services is made available via a unified "Health API"

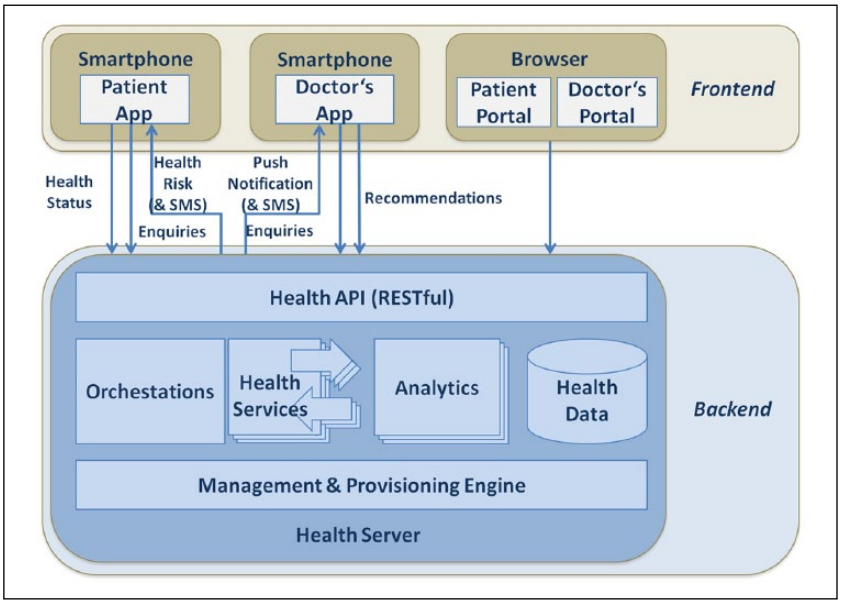

Figure 1. ECHO overall architecture.

following the representational state transfer (REST) architectural style,[28] ensuring the seamless integration between the backend and the frontend. All the components of the Health Server are managed by the "Management and Provisioning Engine."

The frontend user application is described in detail in the next section. The data management and the health server implementation are described by Steimle et al.[29]

Frontend implementation

We implement the application "ChronicOnline" that serves as the entry point of information by the patients, the frontend for the health data database of the backend, and a notification center serving the doctors. The application is available on the Google play store.[30] The functionality of the application for both roles, the patient and the doctor, is described in detail below.

User requirements

The ChronicOnline application reached by the role "patient" provides the following functionality:

- Patient's authentication using existing standard secure and authentication protocols of identification management (e.g. OAuth 2.0).
- Linkage of the patient's smartphone application to the health record keeping, cloud-based database.
- A stream of data about the patient's chronic disease condition (e.g. COPD), their location, and data entered manually by humans.
- Push notification for the patients depending on their chronic disease situation.

The ChronicOnline application reached by the role "doctor" provides the following functionality:

Table 1. Actions that a user can perform in the mobile application.

Role	Actions	Descriptions	Data
Doctor or patient	Login	Login procedure	
Patient	GET/notifications/mine	Return the notifications delivered to the patient account	
Doctor	GET/notifications/mine	Return the notifications delivered to the doctor account	
Doctor	GET/patients/{accountId}/ notifications	Return the notifications delivered to the provided patient account	
Patient	GET/patients/report	Return a list of the daily reports of the patient account	
Patient	POST/patients/report	Create a daily report of the patient account	Date, time, questions 1–5, biomarkers
Patient	GET/patients/report/ {recordId}	Return a daily report of the patient account	
Patient	PUT/patients/report/ {recordId}	Edit a daily report of the patient account	
Doctor	GET/patients/{accountId}/ report	Return a list of the daily reports of all the patients accounts	
Doctor	POST/patients/ {accountId}/report	Create a daily report of a patient account	Date, time, questions 1–5, biomarkers
Doctor	GET/patients/{accountId}/ report/{recordId}	Return a daily report of a patient account	
Patient	GET/notifications/mine	Return the notifications delivered to the patient account	
Doctor	GET/notifications/mine	Return the notifications delivered to the doctor account	
Doctor	GET/patients/{accountId} notifications	Return the notifications delivered to the provided patient account	

- Physician's authentication using existing standard secure and authentication protocols of identification management (e.g. OAuth 2.0).
- Push notifications about health status updates of their patients.
- Access to all health data related to their patients.

In Table 1, we present the actions that a user of the mobile application is able to perform according to his role (doctor or patient). More specific, Table 1 consists of four columns. The first column displays the role of the user (doctor or patient). The second column displays the action that the user can perform based on his role: login and get or post request methods supported by the http protocol. In the third column, there is a short description of each action. In the last column, the parameters for each action are presented.

Design of graphical user interface

This section describes the graphical user interface (GUI) for the application that is provided by the ECHO system. The GUI for this application satisfies certain requirements so as to maximize the possibility to be attractive both to doctors and to patients. These requirements are the following:

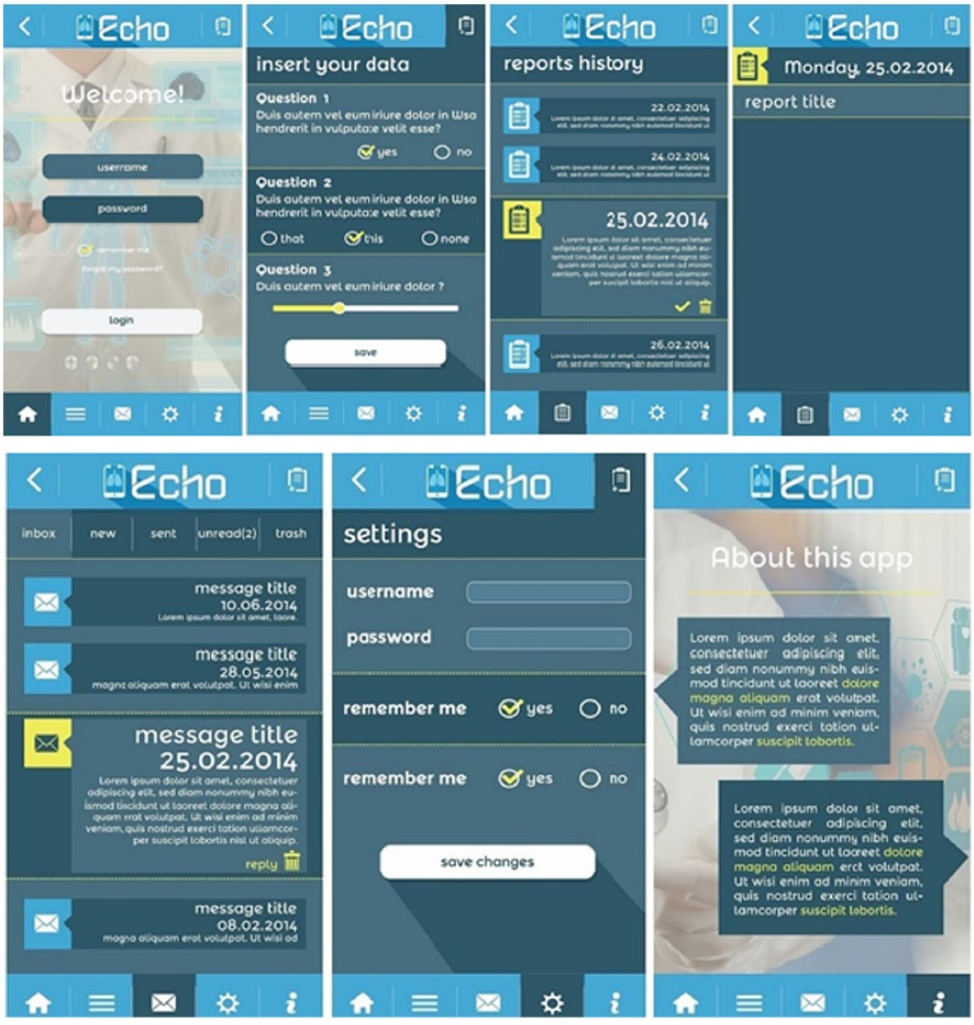

Figure 2. Different screens of the mobile application for the patients.

- Easy to use;
- Well organized;
- Complete (so that it provides all the necessary features);
- Responsive (for the browser application);
- Attractive.

The proposed application aligns to these requirements. Below we present thoroughly the different screens that are produced when using the GUI for the application.

ChronicOnline for patient. In case of a patient (Figure 2), the application has five different screens, apart from the login screen, which is common for all users. The first screen is the "daily report" screen. In this screen, the patient answers daily the questions that are stored in the application (see The Medical Problem section), in order to specify his health condition.

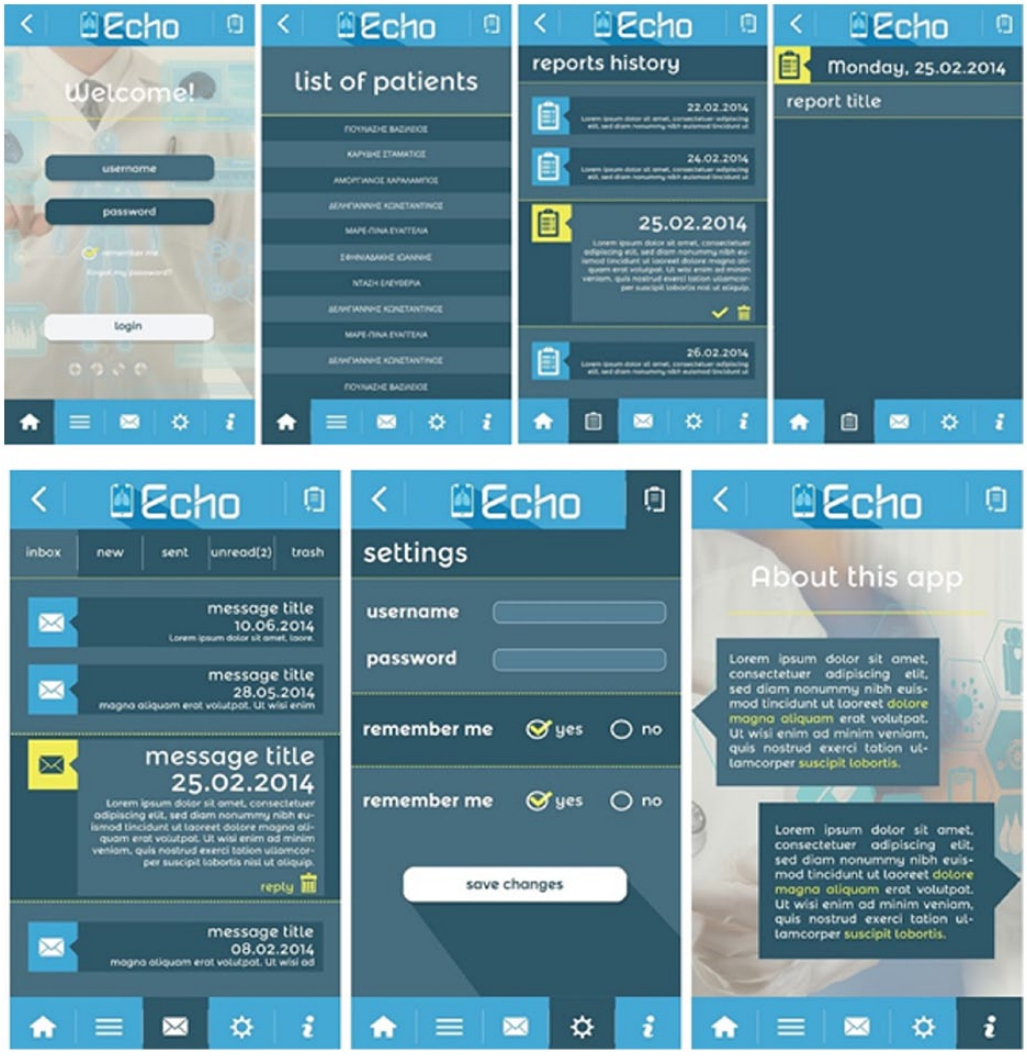

Figure 3. Different screens of the mobile application for the doctors.

The second screen is the "reports history," where a patient can find all his previous reports based on the date. From this screen, the patient can choose a specific date and view his report in that date. The third screen is the "message" screen. In this screen, there is a submenu with tabs for the main categories of messages that is new, sent, unread, and trash. In every screen of these categories, the user has the option to view the details of any message through the "message body" screen. The fourth screen is the "settings" screen, where the user can change his credentials. Finally, the last screen is the "about this app" screen, which gives information about the application and the ECHO project.

ChronicOnline for the doctor. In case of a doctor (Figure 3), the application has five different screens, apart from the login screen, which is common for all users. The first screen is the "list of patients," where the doctor can choose a specific patient's reports to view. The second screen is the "reports

history" screen, which displays all the daily reports of the specific patient sorted by date. The "message," "settings," and "about this app" screens have the same functionality, as in the application for the patient.

Conclusion

The ECHO system suggests an integrated solution that connects chronic patients to their physicians through cloud infrastructure and online services, served by mobile and web applications, thereby enabling regular monitoring of patients and avoidance of medical emergencies. In this article, we implement the frontend applications of the ECHO system and describe their functionality and the interfaces available to the users. As a future work, we aim to test and validate the proposed system using a group of patients provided by the Respiratory Ailments Clinic of University of Crete.

Declaration of Conflicting Interests

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SAGE

Through the eyes of the Informationist: Identifying information needs of the Breast Imaging Service at a tertiary medical center specializing in cancer

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Abstract

The information services offered by Embedded Librarians over the years have led to the more modern—and domain knowledge-specific—role of the Informationist. A 10-point questionnaire was developed and used to interview 12 attending physicians and three fellows chosen at random. The participants are either on the research track (n = 3) or the clinical track (n = 9). A two-part schematic was also created to capture more detailed feedback about the information needs and information-seeking behavior of clinicians regarding patient care (clinical) and research activities. Bibliographic management tool use and time-related factors were also captured in the interviews and written schematics. The role of the Informationist is an emerging, yet valuable one to assigned clinical groups. Clinician's knowledge-base, current awareness, productivity, and evidence-based care can be improved by use of Informationist services.

Keywords

bibliographic management, clinical medical librarian, embedded librarian, health information databases, Informationist

Introduction

An interview-based study provided an enlightening approach in understanding the information needs of the attendings and fellows at Memorial Sloan Kettering (MSK) Cancer Center's Breast Imaging Service. This is a niche group within the larger Department of Radiology with unique needs and they often require that the information requested be delivered in easily digestible formats in their fast-paced work environment in support of patient care and other research endeavors. Designed in partnership between the groups' Informationist and senior leadership, this study's objectives included evaluating information needs, establishing a resource knowledge baseline of the participants,

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determining the existing ways through which the clinician's access evidence, and examining any gaps in the current services being offered. The goal was to diagnose what could be improved in order to enhance the information experience and deliver user-driven services.

The role of the Informationist, generally, consists of embedding an information professional into the clinical and/or research workflows of a specified group of individuals to enhance their information/knowledge management, evidence-based practice (EBP), and patient care practices.[1] Although the title of Informationist may be relatively new, the idea behind placing a librarian with a clinical group goes back to the 1970s when Gertrude Lamb decided to move medical reference librarians out of the stacks and onto clinical services, creating what is known as clinical librarianship.[2] Ms Lamb's legacy continues as the clinical librarian role exists in many academic and research library settings worldwide.[3] The information services offered by these individuals over the years have led to the more modern—and domain knowledge-specific—role of the Informationist. The MSK Library offers a clinical medical librarian (CML) program which consists of the reference librarians acting in an Informationist capacity to a number of departments throughout the organization.

Materials and methods

A 10-point questionnaire (Appendix 1) was developed and used to interview 12 attending physicians and three fellows. Attending physicians are fellowship-trained breast imagers who are either on the research track (n = 3) or the clinical track (n = 9). Research track attendings are expected to perform independent research and publish articles. Both research and clinical track attendings are expected to perform clinical work, teach residents and fellows, and have administrative responsibilities. Breast imaging fellows have completed a residency in radiology and are obtaining a year of additional training that includes 9 months dedicated to clinical breast imaging. Breast fellows are responsible for the work in the clinic, several interdisciplinary conferences as well as a single independent research project during the training period. A two-part schematic (Appendix 2) was also created to capture more detailed feedback about the information needs and information-seeking behavior of clinicians regarding patient care (clinical) and research activities. This group of study participants was chosen at random and represents half of the Breast Imaging Service in the Department of Radiology at MSK.

Interviews took place in person and via phone or WebEx (virtual) for those participating from satellite locations. Interview questions were developed in collaboration with the Breast Imaging Service chief attending in an effort to keep the questionnaire relevant to this specialized group of clinicians. The study survey schematic was designed for the purpose of capturing more detailed feedback on the types of information sought and the participants' resources/knowledge-base (and behavior) used to locate the information. The schematic was either completed at the time of the interview (12 participants) for each individual or at a later time that was convenient for the clinician (3 participants).

Results

Clinical information needs vary among attendings and fellows in the Breast Imaging Service (Figure 1). Most attendings seek images of findings and procedural/technical imaging modality issues when it comes to their clinical practice. Fellows are seeking out challenging cases, most likely for weekly case conferences or journal clubs.

Taking a look at the ways in which attendings and fellows find the clinical information they seek (Figure 2), it is apparent that most attendings gravitate toward Google, PubMed, Radiology-specific journals, and the library. Fellows tend to use Google and PubMed, but they also utilize a

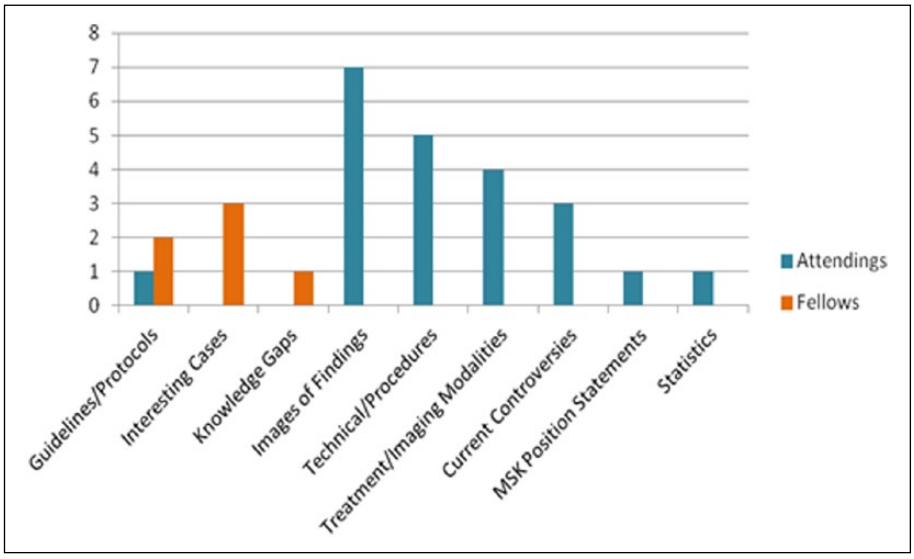

Figure 1. Attendings versus fellows—clinical information needs (attending responses = 12 and fellow responses = 3).

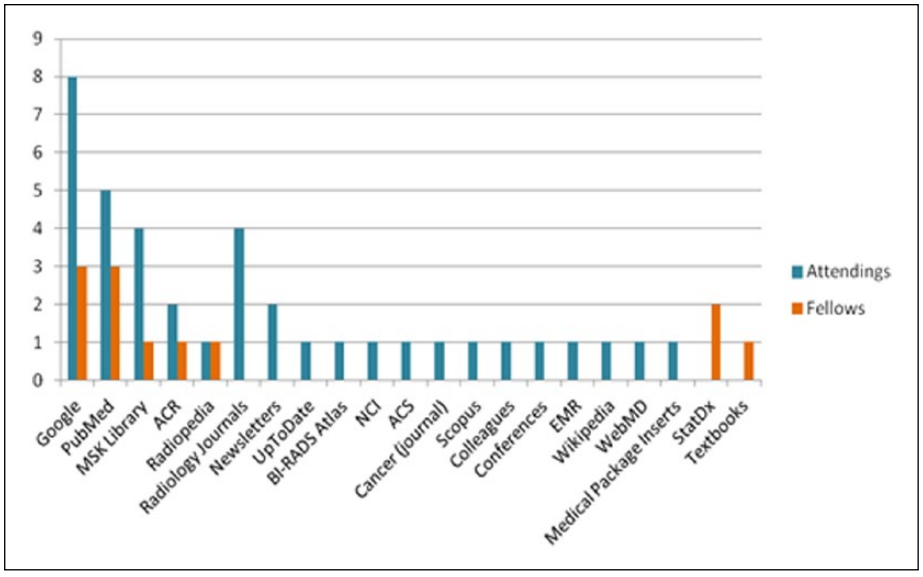

Figure 2. Attendings versus fellows—clinical resource knowledge base (attending responses = 12 and fellow responses = 3).

diagnostic imaging tool called StatDX while most attendings may not. None of the attendings interviewed mentioned this resource. StatDx is a diagnostic decision support system which provides access to peer-reviewed and non-peer-reviewed information on imaging cases in a variety of radiology sub-specialties.[4]

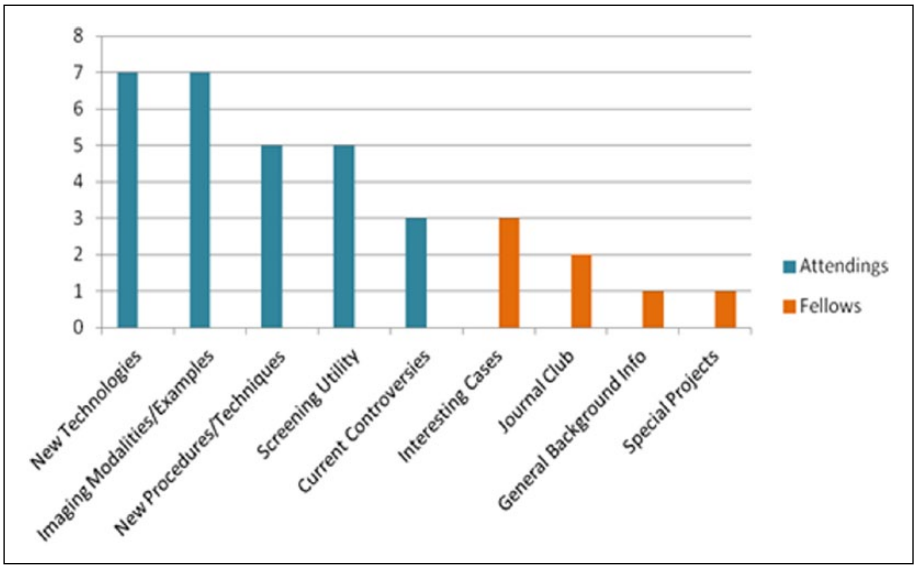

Figure 3. Attendings versus fellows—research information needs (attending responses = 12 and fellow responses = 3).

Regarding the research aspect of the Breast Imaging Service, the majority of attendings responded that they primarily conduct research to locate imaging modalities and new technologies in the field (Figure 3). Fellows, on the other hand, reported that their top research priority is to find interesting cases. Fellows responded similarly when asked what they search for during their clinical activities. Unlike the clinical information needs of both groups, the research needs offered no overlap in participant answers. That is, attendings and fellows as user groups had unique responses to the research information needs question.

When asked about their resource knowledge base involving a research project—or when generally conducting research—most attendings responded that the library or PubMed were their go-to sources for information discovery (Figure 4). Similarly, fellows also responded that the library and PubMed ranked at the top of their information resources list. Research in this context is used loosely. It includes all presentations (both internal and external), publications, conference articles, conference abstracts, and so on. Both groups conduct research for a variety of reasons, whether it is for personal awareness or for a professional endeavor.

Bibliographic management tool use

Another important aspect of both clinical practice and research practice is whether or not members of the Breast Imaging Service use a bibliographic management tool to curate and organize their publications/references with relative ease. EndNote was identified as the premier tool among the Breast Imaging Service with five attendings and two fellows using the program for citation management. Interestingly, only one individual (an attending) responded with Mendeley as a preferred tool of choice. Another noteworthy finding is that the National Center for Biotechnology Information (MyNCBI) was also mentioned by one attending, and a total of four individuals (one fellow and three attendings) responded that they don't use a bibliographic management tool at all.

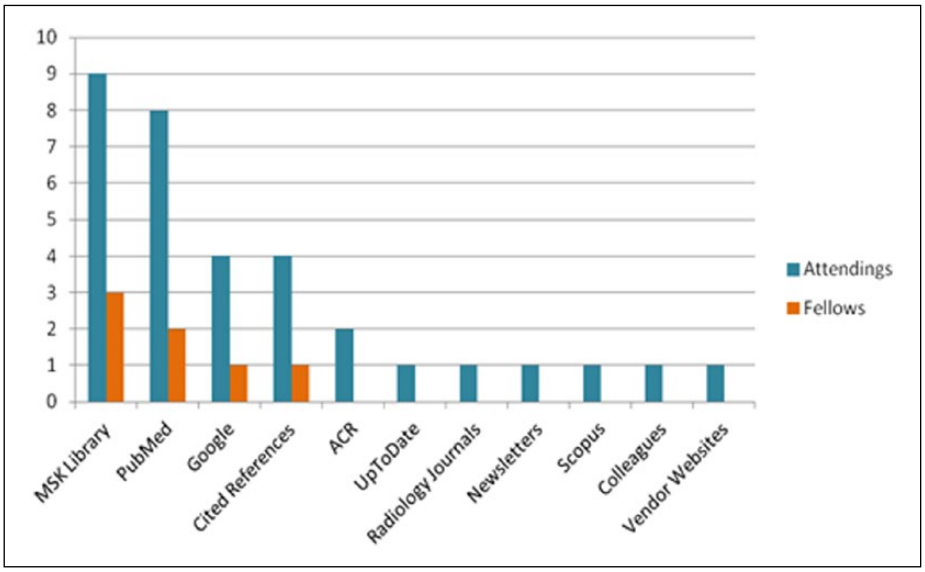

Figure 4. Attendings versus fellows—research resource knowledge base (attending responses = 12 and fellow responses = 3).

Desired time versus actual time

Time-related questions were incorporated into the interview process as a means of understanding just how long attendings and fellows spend searching for the information they need in both their clinical and research settings. Tables 1 and 2 show the desired time versus the actual time spent on finding clinical and research information, separated by role (attending and fellow).

The time ranges (averages) presented in these charts reveal a few things. Fellows tend to spend less time than desired searching for information on a typical patient case, while attendings actually spend more time than desired on a patient case. When it comes to researching a topic for a presentation, publication, conference, and so on, fellows seem to put in the amount of time they desired in a given week. Attendings, on the other hand, offered answers at opposite ends of the spectrum. On average, attendings would like up to ~15 h a week for research purposes. The low range of attendings responded that the actual time put in on a weekly basis is up to ~4 h and the high range of respondents cited spending up to ~72 h a week conducting research. The two disparate ranges in actual research time put in by attendings is due to the fact that some of those clinicians interviewed have little focus on research projects—as they do not pertain to their job function. These are mostly attendings who work in a more clinically focused environment at a satellite location of MSK—not all radiologists are required to publish or present at national meetings.

Table 1. Clinical questions—desired time versus actual time.

Fellows		Attendings	
Desired	Actual	Desired	Actual
~15 min	~2–3 min	~0–15 min	~0–30 min

Table 2. Research activities—desired time versus actual time.

Fellows		Attendings	
Desired	Actual	Desired	Actual
~1–4 h[a]	~1–4 h[b]	~1–15 h[a]	Low range: ~1–4 h[b] High range: ~15–72 h[b]

[a]Desired time is during working hours.
[b]After-hours or weekend time.

Overall, both fellows and attendings would like to have more time during the work week devoted, specifically, to conducting research for publication or presentation.

Discussion

While the desire to spend more time on information-related activities is present, often the reality of work priorities and the focus on patient care limits the time that can be allocated in conducting topic searches. An Informationist can help to ease the research burden by working closely with his or her assigned team to deliver and organize the published information located in a way that permits the attending or fellow to continue to enhance their knowledge and expertise.[5] Over time, the Informationist will develop a sixth sense in the topics that matter and can also proactively distribute published studies and other sources of information that will help support an ongoing learning environment and quality patient care.

Interpreting the responses from the questionnaire as well as the complete schematics from survey participants, an Informationist can contribute as a team member and collaborator by offering the much-needed support for clinical and research activities. One apparent way in which an Informationist may help a clinical group is by offering general consultation and training services, both on an individual and group level. Knowing the information needs of the attendings and the fellows will help to drive training opportunities.

Survey participants, regardless of status or experience, have their unique ways of locating information as well as their arsenal of go-to resources. Informationists can not only assist with the resource knowledge base that already exists within a group, but they can help to expand where these individuals seek information and offer an alternative perspective to research and EBP. Offering just-in-time resource training can enhance the research experience of the clinician as well as save them time and effort. New resources/databases can be introduced and various advanced and existing techniques for discovering information may prove useful to busy clinicians.[6] Educating clinicians on targeted research methods and resources is a key role of the Informationist and one that has proven value.[7] According to the survey results, both attendings and fellows tend to leverage the same resources in their research endeavors and so there is an opportunity for the Informationist to showcase other information resources that would support the workflow and research activities of these groups as well as keep them abreast of new features and enhancements in the tools that they use daily.

For example, based on the questionnaire results, 4 out of 15 individuals (26.6%) responded that they do not use a bibliographic management tool to organize and curate their references when working on a research project. An Informationist can offer customized training sessions on specific tools or the importance of organizing references in general. Steps can also be taken to increase awareness about bibliographic management tools during individual consultation or other potential teaching moments by way of various on-campus meetings and conferences.

When it comes to general research practices, current awareness alerts and notifications can be tailored for the individual and set-up by an Informationist for the ongoing learning of the clinician. This is especially true when it comes to the fellows as there is more of a research focus than clinical among this group—they are not usually as clinically oriented as the attendings in the service as they act in more of a learner capacity throughout their fellowships. Presenting search results from a number of different resources may bring varying perspectives to light as well as help to keep clinicians informed on topics important to them.[8] Current awareness alerts can serve a number of different purposes. For instance, an alert created for the Breast Imaging Service helps to keep members in the know about current imaging controversies and new guidelines/policies from both the published literature (MEDLINE) and lay press (major newspapers, Auntminnie.com, *New England Journal of Medicine* (NEJM), *Journal Watch, Medscape Radiology*, etc.). The benefit of this level of service can span both the clinical and research spectrums. Clinicians may find pertinent information for use in a presentation, or they might simply utilize the current awareness alert as a discovery tool for understanding the current policies, procedures, and protocols in their field.

Informationists may also have the opportunity to insert themselves into the various clinical and research workflows of the group in which they are embedded. Time is always a factor when it comes to busy clinicians and so trusted information services can assist with guidance on overall productivity practices related to scoping the literature for evidence, as well as productivity practices related to technical workflows.[9] For instance, iPad (and other tablet) personalization can be made to enhance the experience and productivity of both fellows and attendings. Introducing document annotation, bibliographic management, and note-taking apps on personal and professional devices may help to save time and effort when researching a topic, composing an article, or developing a presentation. The Informationist can be more than simply the gatekeeper and disseminator of information.[10] A true partnership can take place between information professionals and clinical practitioners as a move away from the traditional transaction-based relationship between the librarian and clinician takes place. It is becoming increasingly important for clinicians to receive targeted and succinct information on-the-go and at the point of care and the Informationist is in an excellent position to support these needs.[11]

EBP is not only a buzz word among the medical community when it comes to patient care; it is now an imperative way of diagnosing and treating patients given the exponential volume of articles published each week. Most attendings and fellows feel confident in their ability to address difficult or unique patient care issues; staying updated with the literature is a critical way in which they maintain their level of expertise. It might be an added incentive for clinicians to participate in EBP training if it was offered in a self-paced capacity (e.g. video tutorials, short training documents, and LibGuides/research guides).[12] The Informationist can support the clinician in point of care decision-making by retrieving the highest level of evidence possible. EBP training sessions can be implemented to offer clinicians the tools needed to perform complex searches and feel more confident with their results, ultimately to support their decision-making process.[13] One-to-one consultation services and educational sessions on various EBP resources can help the clinician to save time, be more efficient, and offer high-quality decision-making regarding patient care.

Given where each group is in their career ladder, the differing responses to the questionnaire and schematic make sense. Throughout the fellowship, fellows tend to focus their efforts on learning the imaging techniques and established practice.[14] Therefore, their research activities mainly consist of reading case studies on varying modalities or interesting cases on difficult-to-diagnose images. The attendings in the service have more experience and are more knowledgeable on the standard practices of care as well as interpreting images. Overall, the professional level, position, and role of the clinician influence their research- and information-based needs.

Conclusion

The limited sample size of this study limits the generalizability of the survey and schematic results. However, the following take-home points can be drawn from the findings of this study:

- The role of the Informationist is an emerging, yet valuable one to assigned clinical groups;
- Clinician's knowledge-base, domain current awareness, productivity enhancement, and evidence-based care can be improved using Informationist services;
- An Informationist embedded in a clinical group's workflow can help clinicians to save time and spend their time more efficiently when it comes to research endeavors and patient care.

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Declaration of Conflicting Interests

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Appendix 1

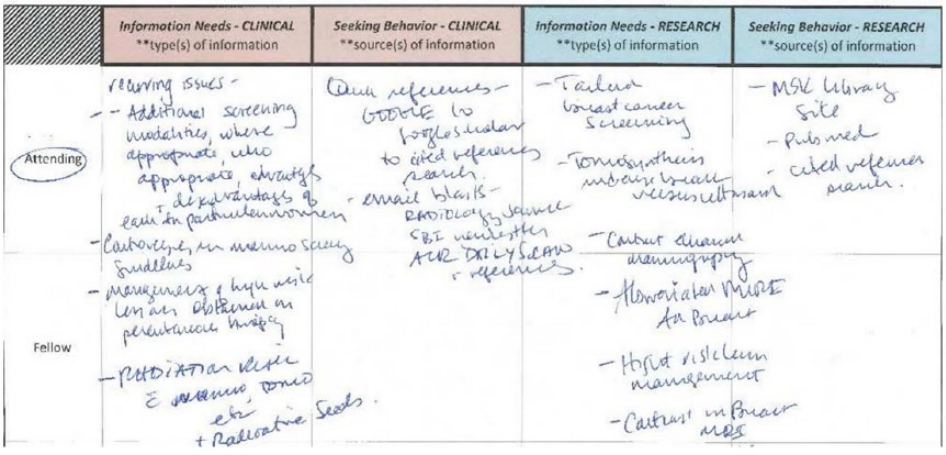
Survey questionnaire

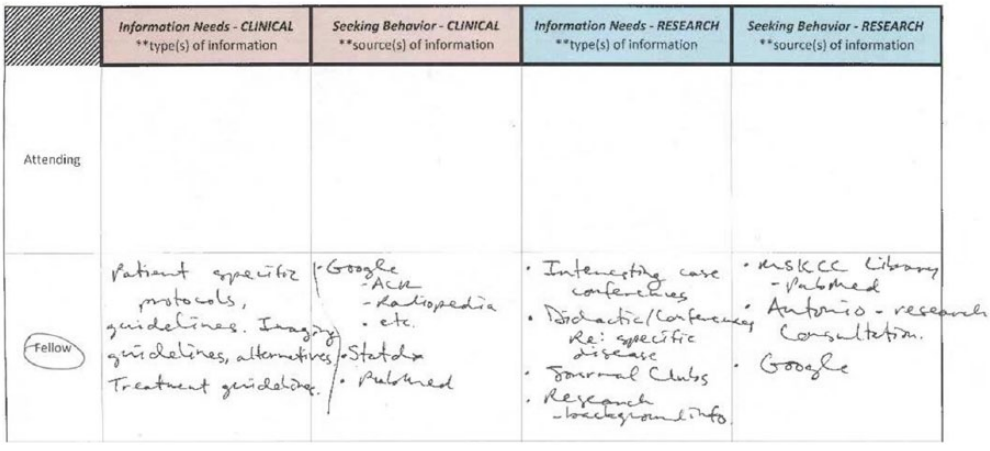
Information needs and behavior study—questionnaire
Interviewee:_____
Date:_____
Interviewer: _____

1. When researching a topic, condition, procedure, and so on for publication/presentation, where do you begin your search?
2. Why do you begin with this particular route?
3. When researching a topic, condition, procedure, and so on for patient care/decision-making, where do you begin your search?
4. Why do you begin with this particular route?
5. How do you keep yourself updated on the literature in your field? Please list sources/means of receiving current information.
6. Do you use a bibliographic management tool to organize and store your references while working on a research project?
7. If so, which tool do you use and do you feel as though you're taking full advantage of its capabilities?
8. Using your go-to resource/database for clinical management, please demonstrate how you would find information to help inform your decision-making on a patient's condition on *stereotactic core needle biopsy and non-palpable breast lesions*.
9. Are you satisfied with the results you retrieved?
10. How much time would you like to spend on clinical/patient care inquiries?
11. How much time, in reality, do you spend on searching for clinical/patient care information?
12. Using your go-to resource/database for research purposes, please demonstrate how you would find information on *tomosynthesis screening in dense breasts*.
13. Are you satisfied with the results you retrieved?
14. How much time would you like to spend on research inquiries?
15. How much time, in reality, do you spend on searching for information in your research field or area of interest?

Appendix 2

Completed survey schematic examples (attending and fellow)





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Article

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Abstract

Tailored messages are those that specifically target individuals following an assessment of their unique characteristics. This systematic review assesses the evidence regarding the effectiveness of tailoring within eHealth interventions aimed at chronic disease management. OVID Medline/Embase databases were searched for randomised control trials, controlled clinical, trials, before -after studies, and time series analyses from inception - May 2014. Objectively measured clinical processes/outcomes were considered. Twenty-two papers were eligible for inclusion: 6/22 used fully tailored messaging and 16/22 used partially tailored messages. Two studies isolated tailoring as the active component. The remainder compared intervention with standard care. In all, 12/16 studies measuring clinical processes and 2/6 studies reporting clinical outcomes showed improvements, regardless of target group. Study quality was low and design did not allow for identification of interventions' active component. Heterogeneity precluded meta-analysis. This review has demonstrated that there is a lack of evidence to suggest that tailoring within an eHealth context confers benefit over non-tailored eHealth interventions.

Keywords

clinical decision-making, decision-support systems, eHealth, evidence-based practice, information and knowledge management

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Background

Long-term conditions affect one in five people, yet account for 80 per cent of general practice consultations.[1] More than half of all clinical decisions fail to take account of the best-available evidence.[2] In addition, evidence-based guidelines often do not accommodate co-morbidities and multiple medications.[3–5] There is a recognised need to find innovative ways of integrating knowledge into clinical workflow, to contextualise and personalise care, and to manage the complex care needs and human factors which contribute to unwanted variation in practice.[6]

Clinical decision support systems (CDSSs) utilise algorithms of varying complexity that are applied to existing eHealth systems. Typically, a CDSS within an electronic health record (EHR) will present the user of the EHR with a series of messages designed to improve clinical care, for example, identification of possible drug interactions or prompts to consider clinical investigations. The use of such automated reminders via CDSS has been shown to be one of the most consistently successful approaches to encourage clinicians to adopt evidence-based practice.[7] In terms of efficacy, a 2005 systematic review concluded that while a number of studies showed an improvement in clinical processes (e.g. adherence to guidelines), there was a lack of evidence demonstrating improved clinical outcomes.[8] In the same year, a separate systematic review found that CDSSs, which incorporated contemporaneous recommendations (as opposed to simple summaries of data) and were available within the normal work stream, were more likely to result in improved clinical outcomes − 90 per cent (30/32) of interventions which included these features demonstrated improved outcomes.[9]

Communicating with messages that are specifically tailored to an individual has been found to be more effective than generic messages at changing behaviour.[10] The theory underpinning the use of such methods draws heavily on a number of behaviour change theories, including the Health Belief Model,[11] Prochaska and DiClemente's[12] Stages of Change, and Bandura's[13] Social Cognitive Theory. The tailoring of messages to specific individuals is viewed as the most sophisticated form of automated communication that can be used to deliver health education and material aimed at health promotion.[14] Tailoring has been defined as 'any combination of strategies and information intended to reach one specific person, based on characteristics that are unique to that person, related to the outcome of interest, and derived from an individual assessment'.[15] This assessment is dependent on the type of intervention and the target audience, but could be based on routinely collected data (e.g. professional role, socioeconomic status, health records or clinical parameters) or data collected from the individual with the specific intention of formulating a tailored message (e.g. health literacy, self-efficacy or pre-existing attitudes and knowledge). Interventions that utilise tailored messages tend to involve the distribution of printed material aimed at primary health promotion, for example, dietary advice,[16–18] smoking cessation,[19,20] or uptake of screening.[21]

There is a lack of literature concerning the use of tailored messages aimed at changing healthcare practitioner (HCP) behaviour. There is also a lack of evidence to inform the design and modality of tailored messaging, and whether the effectiveness of existing eHealth technologies (e.g. CDSS) can be improved were they to incorporate tailored messaging.

Objective

This systematic review aimed to assess the published evidence regarding the effectiveness of eHealth interventions designed to improve the management of chronic diseases by providing information or advice that has been tailored to the recipients, that is, HCPs or patients.

The research question was as follows: Does the cumulative published research evidence support the hypothesis that a system that incorporates messages specifically tailored to an individual

(HCP or patient) results in improved clinical processes or outcomes in the management of long-term conditions?

Method

Types of studies

Randomised controlled trials (RCTs), controlled clinical trials (CCTs), controlled before and after studies, and interrupted time series (ITS) analyses were considered for inclusion in the review. Studies published in any language were considered.

Types of recipients

Studies that involved patients with a specified long-term condition receiving healthcare (any setting), and/or HCPs responsible for the care of those with long-term conditions (any setting), were considered.

Types of interventions

We considered interventions that used eHealth technologies to deliver tailored information to patients or HCPs within the care setting. The search strategy, therefore, included a combination of terms relating to eHealth, health records, and communication strategies (including tailoring of information).

Types of outcomes

Any outcome was considered where a comparison was drawn between the intervention and no intervention and/or existing practice with regards to objectively measured professional performance, clinical outcome, or patient behaviour. The study's stated primary outcome was our main outcome of interest, with consideration also given to any stated secondary outcomes or post hoc analyses. Patient and professional satisfaction was also recorded, but studies were not included if this was the sole outcome.

Search strategy

A search strategy was devised to include keywords and text words relating to the following terms: chronic disease, methodology, eHealth, health records, communication, and user groups (available on request). Text words were appropriately truncated to maximise returns. Terms were combined using Boolean logic. There was no keyword identified for tailored messaging, and so we adopted a broad search strategy. As well as including variations of tailored messaging as text words, we included an exploded search of other communication-related keywords in an effort to capture studies that utilised tailored messages but did not refer to it as such. The search was run against both Ovid Medline (1946–present) and Embase (1974–present), with no restrictions placed on language.

Eligibility criteria for inclusion

Studies that were RCTs or CCTs were deemed eligible if the other criteria mentioned above were met. Additional methodologies (controlled before–after studies and interrupted time series

analyses) were considered if they met quality criteria specified by the Cochrane Effective Practice and Organisation of Care Group (EPOC) data collection checklist.[22] In accordance with the EPOC criteria, the quality criteria for inclusion of both types of studies were as follows:

- Controlled before–after studies were only eligible if the control site was deemed suitable; there was evidence of contemporaneous data collection, and there were ⩾2 intervention and ⩾2 control sites.
- Interrupted time series analyses were included if there was a clearly recorded point in time when the intervention began and where there were ⩾3 data points recorded both before and after the intervention commenced. Given the potential heterogeneity of the studies relevant to the review, study inclusion was not based on a minimum cut-off for methodological quality.

Data collection and analysis

Titles and abstracts were initially reviewed by a single reviewer (N.T.C.) and discarded if deemed not to be relevant to the research question. A shortlist was then compiled for which full-text articles were sought. These were independently reviewed by two reviewers (N.T.C. and C.W.). Any discrepancies were resolved by consensus. An online data abstraction form (modified from the EPOC data collection checklist[22]) was used for data collection.[23] An overall quality rating was assigned to RCTs based on the following criteria: allocation concealment, blinded or objective assessment of primary outcome(s), completeness of follow-up, reliable primary outcome, and protection against bias. In accordance with previously published EPOC systematic reviews,[24,25] studies were rated as being of high quality if the first three criteria were met with no additional concerns. Studies were of moderate quality if ⩽2 criteria were 'not done' or 'not clear' and of low quality if this applied to >2 criteria.

Assessing tailoring

Kreuter et al.[15] judged that an intervention incorporated tailored messaging if the intervention included both the following:

1. An assessment of individual patient characteristics;
2. Communication that was specifically targeted at that individual.

Owing to the limited number of published studies that the search strategy returned, we accepted interventions that included either of these criteria, as agreed by the two reviewers.

Protocol

A review protocol has not been published but is available from the corresponding author on enquiry.

Results

Search results

The search strategy was run twice – September 2013 and again in May 2014. The final yield from both searches was 1074 returns, of which 89 were duplicates. Of the remaining 985 studies, 818 were initially rejected based on title alone, with a further 112 discarded after review of the abstract

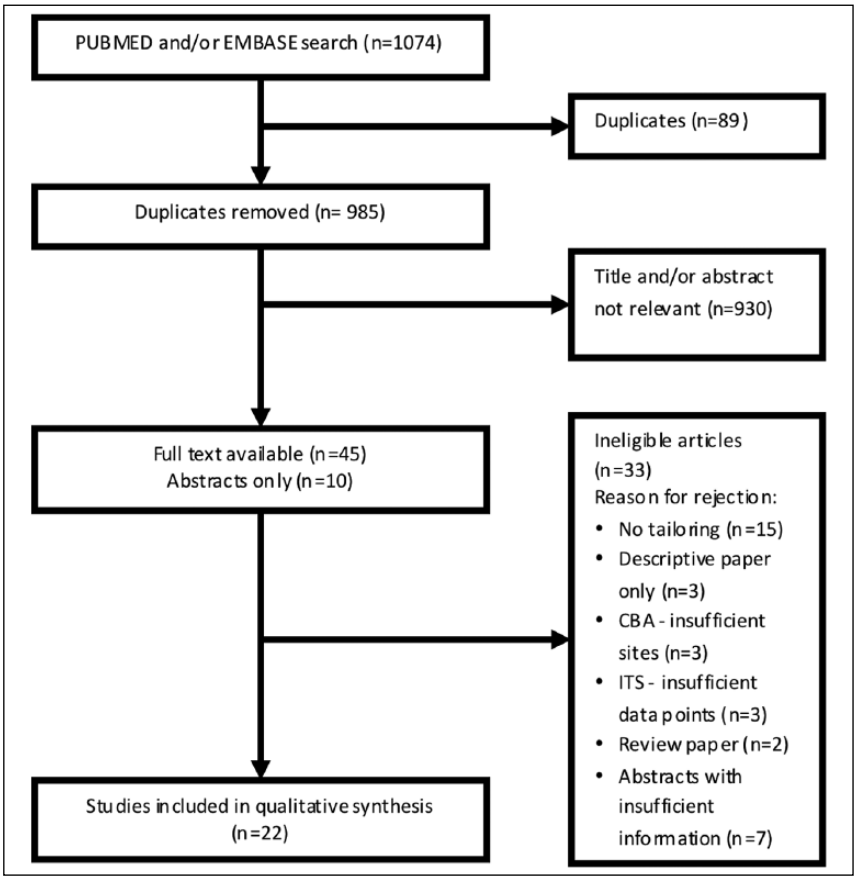

Figure 1. PRISMA diagram of literature search.

(see Figure 1). Full-text papers were sought for the provisional shortlist of 55 studies and were available for 45 of these. The abstracts of the remaining 10 studies were assessed and included if there was sufficient information to meet the inclusion criteria. Owing to the absence of any tailoring component in the intervention, 15 papers were rejected. The remaining 40 papers were then reviewed by the two reviewers. Furthermore, 18 papers were then rejected as they failed to meet (or had insufficient detail to satisfy) the eligibility criteria, leaving 22 papers to be considered in the review.

These 22 studies are shown in Table 1 (sorted by first author). All of the studies were published since 2002 and most were conducted in North America.[26–41] The majority were RCTs.[26,28,30–34,36,37,39–45] The clinical problem addressed by the various interventions varied, but the most common applications were diabetes,[26,27,35,36,39,44] cardiovascular disease,[32,35,39,43] and the prescribing of medication.[30,31,37,46]

Setting and characteristics of the studies

Most studies were undertaken in either an outpatient or community-based setting and involved physicians (see Table 2). Other professional groups included nurses and pharmacists. The studies

Table 1. Studies eligible for inclusion in the review.

First author (ref)	Year	Design	Country	Clinical speciality	Clinical problem
Avery[46]	2012	RCT	UK	General/family practice	Medication prescribing
Boukhors[26]	2003	RCT	Canada	General/family practice	Diabetes
Cafazzo[27]	2012	ITS	Canada	Paediatrics	Diabetes
Carroll[28]	2012	RCT	USA	Psychiatry	Maternal depression
Cruz-Correia[42]	2007	RCT	Portugal	Other	Asthma
Epstein[29]	2011	RCT	USA	Paediatrics	ADHD
Field[30]	2009	RCT	Canada	General/family practice	Medication prescribing
Fossum[47]	2011	CCT	Norway	Other	Pressure ulcers
Gurwitz[31]	2008	RCT	USA/Canada	Other	Medication prescribing
Jones[48]	2011	ITS	UK	General medicine	Acute medicine
Kinn[32]	2002	RCT	USA	Other	Hypertension
Mcdonald[33]	2005	RCT	USA	Paediatrics	Preventative service
Nagykaldi[34]	2012	RCT	USA	General/family practice	Preventative care
Persell[35]	2010	ITS	USA	General medicine	CVD, diabetes, and cancer
Persell[43]	2013	RCT	USA	General/family practice	CVD
Pinnock[45]	2013	RCT	UK	General medicine	COPD
Quinn[36]	2008	RCT	USA	Other	Diabetes
Raebel[37]	2007	RCT	USA	Obstetrics and gynaecology	Medication prescribing
Ross[44]	2006	RCT	USA	General medicine	Diabetes
Sequist[39]	2005	RCT	USA	General medicine	CVD and diabetes
Tierney[40]	2005	RCT	USA	General medicine	Asthma
Vollmer[41]	2011	RCT	USA	Not clear	Asthma

RCT: randomised controlled trial; ITS: interrupted time series; ADHD: attention-deficit hyperactivity disorder; CCT: controlled clinical trial; CVD: cardiovascular disease; COPD: chronic obstructive pulmonary disease.

were undertaken in both academic and non-academic settings. There was a general lack of information describing the experience or qualifications of the various professional user groups. Thirteen of the studies directed the intervention at HCPs.[28–32,35,37,39,40,45–48] The remainder directed the intervention at patients,[27,33,34,41–44] or at both HCPs and patients.[36] Study quality is noted in Table 4. Further details on individual study characteristics are available on request.

Influence of tailoring component on intervention design

All of the studies included in the review incorporated some degree of individual patient assessment. This assessment was made via automated data queries of routinely collected clinical datasets or via additional data entry completed by patient and/or HCP (see Table 3).

The use of individually tailored communication was only evident in a minority of studies.[27,33,34,41,43,44] All of these studies delivered messages to individual patients based on data specific to that patient, for example, risk of illness/injury and how this might be modified for the individual;[33,34,43] individualised educational content;[41,44] or individualised clinical results.[27] For the remainder of studies, the content of communication was dictated by automated algorithms based on the individual assessment rather than the specific circumstances of the end-user. For example, it was common that automated CDSS aimed at HCPs would provide prompts based on

Table 2. Clinical setting and characteristics of providers.

First Author (ref)	Location of care	Academic status	Profession involved	Level of training	Mean age (year)	Years in practice
Avery[46]	Community-based care	–	Physicians, pharmacists	–	–	–
Boukhors[26]	Outpatient care	–	Physicians	–	–	–
Cafazzo[27]	Outpatient care	–	Physicians	–	–	–
Carroll[28]	Outpatient care	University/teaching setting	Physicians	–	–	–
Cruz-Correia[42]	Outpatient care	–	Physicians	–	–	–
Epstein[29]	Community-based care	–	Physicians	Accredited and/or licensed	47	–
Field[30]	Community-based care	Non-teaching setting	Physicians	–	–	–
Fossum[47]	Nursing home	Non-teaching setting	Nurses	Accredited and/or licensed	–	–
Gurwitz[31]	Inpatient care	University/teaching setting	Physicians, nurses	–	–	–
Jones[48]	Inpatient care	University/teaching setting	Physicians, nurses	–	–	–
Kinn[32]	Outpatient care	–	Physicians	Accredited and/or licensed	–	–
Mcdonald[33]	Outpatient care	University/teaching setting	Physicians	Accredited and/or licensed	–	Post-graduate level 1–3
Nagykaldi[34]	Community-based care	Non-teaching setting	Physicians, Nurses	–	–	–
Persell[35]	Community-based care	University/teaching setting	Physicians	–	–	–
Persell[43]	Inpatient care	University/teaching setting	Physicians	In training	–	–
Pinnock[45]	Outpatient care	–	Physicians	–	–	–
Quinn[36]	Outpatient care	–	Physicians	–	–	–
Raebel[37]	Pharmacy	Non-teaching setting	Pharmacists	–	–	–
Ross[44]	Outpatient care	–	–	–	–	–
Sequist[39]	Outpatient care	University/teaching setting	Physicians	Mixed	40	–
Tierney[40]	Outpatient care	Non-teaching setting	Physicians, pharmacists	Mixed	–	–
Vollmer[41]	Community-based care	–	–	–	–	–

Table 3. Role of tailoring in the interventions. 'Tailored assessment' relates to the assessment of individual patient characteristics and how that data was collated. 'Tailored communication' describes whether or not communication was specifically targeted to an individual.

First Author (ref)	Tailored assessment	Tailored communication	Recipient of communication	Tailored communication detail
Avery[46]	Automated data query	None	Healthcare practitioner (HCP)	Message contents dependent on data
Boukhors[26]	Data from patient	None	Patient	Message contents dependent on data
Cafazzo[27]	Data from patient	Tailored to user	Patient	Message contents dependent on data and tailored to user requirements (trend wizard)
Carroll[28]	Data from parent and HCP	None	HCP	Message contents dependent on data
Cruz-Correia[42]	Data from patient and HCP	None	Patient	Message contents dependent on data
Epstein[29]	Data from patient and HCP	None	HCP	Message contents dependent on data
Field[30]	Automated data query	None	HCP	Message contents dependent on data
Fossum[47]	Automated data query	None	HCP	Message contents dependent on data
Gurwitz[31]	Automated data query	None	HCP	Message contents dependent on data
Jones[48]	Automated data query	None	HCP	Message contents dependent on data
Kinn[32]	Automated data query	None	HCP	Message contents dependent on data
Mcdonald[33]	Data from patient	Tailored to user	Patient	Message contents dependent on individual data taking into account the individual circumstances
Nagykaldi[34]	Data from patient and HCP	Tailored to user	Patient	Message contents dependent on individual data taking into account the individual circumstances
Persell[35]	Automated data query	None	HCP	Message contents dependent on data
Persell[43]	Automated data query	Tailored to user	Patient	Message contents dependent on individual data taking into account the individual circumstances
Pinnock[45]	Data from patient	None	HCP	Message contents dependent on data
Quinn[36]	Data from patient and HCP	None	Patient and HCP	Message contents dependent on data
Raebel[37]	Automated data query	None	HCP	Message contents dependent on data
Ross[44]	Automated data query	Tailored to user	Patient	Message contents dependent on individual data taking into account the individual circumstances
Sequist[39]	Automated data query	None	HCP	Message contents dependent on data
Tierney[40]	Automated data query	None	HCP	Message contents dependent on data
Vollmer[41]	Automated data query	Tailored to user	Patient	Message contents dependent on individual data taking into account the individual circumstances

Table 4. Reported outcomes and main results from studies included in the review. Study quality score compiled for RCTs only (see 'Methods').

Study	Study quality	Outcome(s)	Main results of the outcome(s)
Avery[46]	Moderate	Number of potential drug AE*	Intervention group significantly less likely to have been prescribed contraindicated medication (all three measures)
Boukhors[26]	Low	Number of hypoglycaemic events*	No significant difference in incidence of hypoglycaemia
Cafazzo[27]	ITS	Number of blood glucose tests and glycaemic control (HbA1c)*	Number of blood glucose tests increased with intervention. No difference in secondary outcomes – incidence of hyperglycaemia and glycaemic control
Carroll[28]	Low	Number of mothers identified as having depressive symptoms and number of mothers referred for psychiatric assessment	Intervention groups more likely to have depression detected and more likely to be referred to specialist
Cruz-Correia[42]	Low	Patient satisfaction and patient adherence to recommended monitoring	Patients were satisfied with system Patients adherence was not altered with electronic system – if anything adherence improved with paper system
Epstein[29]	Low	Proportion using recommended diagnostic tools at follow-up*	Significant increase in use of diagnostic questionnaires
Field[30]	Moderate	Alert rate*, Type of alert* – incorrect dose, incorrect frequency, drug should be avoided, incomplete clinical information (creatinine)	Overall, no difference in rate of alerts between groups.
Fossum[47]	Low	Proportion with malnourishment, proportion at risk of malnourishment and pressure ulcer	No change in risk of PU No change in prevalence of PU No change in prevalence of malnourishment
Gurwitz[31]	Low	Number of drug-related AE*	No significant difference in AE's between intervention and control
Jones[48]	ITS	Length of stay (LoS)*, accuracy of early warning score (EWS), adherence to protocol, clinical response to EWS alert, rate of cardiac arrests, number of critical care bed days, and mortality rate	Significant decrease in LoS during intervention period
Kinn[32]	Low	Likelihood of being diagnosed with hypertension, likelihood of receiving ≥1 antihypertensives, number of antihypertensives per patient, and use of combination therapy, BP	Significantly more patients receiving appropriate diagnosis in intervention group Intervention group significantly more likely to be on antihypertensive. Intervention group had significantly less antihypertensive agents prescribed.

(Continued)

Table 4. (Continued)

Study	Study quality	Outcome(s)	Main results of the outcome(s)
Mcdonald[33]	Low	Parent safety knowledge, prevention beliefs, and safety behaviours	Improved safety knowledge at follow-up.
Nagykaldi[34]	Low	Provision of preventative services, number of log ins to portal, and patient centredness	Minimal use of portal Patient centredness score improved in intervention group
Persell[35]	Low	LDL cholesterol*, change in BP, smoking cessation, prescription of a statin, and number of office visits	No significant difference in rate of lowered LDL No significant difference in attendance at clinic Significantly more statins prescribed in intervention group
Persell[43]	ITS	16 quality performance indicators (QPIs) – prescribing for chronic disease and screening procedures*	Performance measures improved
Pinnock[45]	High	Time to admission to hospital with exacerbation of COPD*, time to admission, number and duration of admissions, deaths, QoL, and number of patient contacts	No significant difference in admission rate or QoL in those receiving intervention.
Quinn[36]	Low	Physician satisfaction, diabetes self-care, and glycaemic control	Physicians satisfied Glycaemic control improved Patients self-care improved
Raebel[37]	Low	Proportion of pregnant women dispensed a contraindicated medication*	Intervention group were significantly less likely to be prescribed a contraindicated medication
Ross[44]	Low	System usage	Intervention group had greater usage of system
Sequist[39]	Low	Receipt of recommended care* and HCP perceptions surrounding guideline adherence	Patients in intervention group significantly more likely than control patients to receive recommended diabetes care and CAD care
Tierney[40]	Low	Percentage adherence to management recommendations*	No significant differences in adherence to guideline between groups
Vollmer[41]	Low	Patient adherence to medication*, patient QoL, reliever medication use, asthma control, and healthcare utilisation	Small but significant increase in adherence

AE: adverse event; HbA1c: glycated haemoglobin; LoS: length of stay; EWS: early warning score; LDL: low-density lipoprotein; QPI: quality performance indicators; COPD: chronic obstructive pulmonary disease; QoL: quality of life; BP: blood pressure; IQR: interquartile range; SD: standard deviation; ITS: interrupted time series; CAD: coronary artery disease; PU: peptic ulcer; HCP: healthcare practitioner.
*Denotes primary outcome(s) where stated

an assessment of a patient's data, but the prompt provided by the system was generic to the system and not tailored to the HCP's job-description or clinical context.

Of the six studies that fulfilled both criteria for having used tailored communication (as dictated by Kreuter et al.[15]), the primary outcomes (where stated) were patient self-care (improved),[27] serum lipids (no difference),[43] and medication adherence (better than control but reduced overall).[41] The remainder of studies did not state the primary outcome, but reported on service uptake (improved in intervention group),[44] patient knowledge (improved in intervention group, but multiple comparisons made),[33] and patient centredness (improved in intervention group).[34]

Comparison – tailored intervention versus non-tailored intervention

Two studies compared an intervention which utilised tailoring with an intervention that included untargeted activity.[33,44] Neither study specified the primary outcome of interest in the methods. Both studies provided tailored educational material to patients and compared outcomes with patients who had received non-tailored material. For example in one study,[33] parents completed a questionnaire designed to assess previous injuries sustained by their child as well as parental perceptions of their child's current risk of injury. The educational material then incorporated the events previously described as well as addressing any misconceptions in injury risk identified from parental responses. Tailoring resulted in an increase in patient service uptake in one study,[44] with multiple comparisons being made in the other, introducing the possibility of a type 1 error.[33]

Comparison – intervention versus no intervention

The primary outcome was not overtly stated in eight of the studies. Of the 22 studies included in the review, the main outcome of interest was related to clinical processes and performance in 14, with the remainder concerned with clinical outcomes (see Table 4).

Studies where the stated primary outcome related to clinical processes included HCP adherence to existing guidelines,[29,35,39,40] avoidance of adverse drug events,[30,31,37,46] patient adherence to medication,[41] and patients' frequency of clinical testing.[27] Of the six studies which failed to stipulate the primary outcome, one measured HCP adherence to an existing guideline aimed at improving diagnosis rates.[36]

A total of 12 among the 16 studies concerned with clinical processes reported a favourable outcome. For those studies aiming to assess HCP adherence to guidelines, most reported an improvement;[28,29,32,35,39] however, one of these studies also noted a pre-intervention improvement in the ITS analysis, introducing the possibility that secular change was responsible for the observed improvement.[35] The rate of potential adverse drug events was significantly reduced in half of the relevant studies.[37,46] When compared with controls, patient medication adherence was said to be higher; however, the actual difference was small and both groups' overall adherence fell during the study period.[41] The other measures of patient-driven clinical processes also improved (blood sugar testing[27] and service uptake[44]).

Two of the six studies concerned with clinical outcomes reported positive findings. Four studies measured clinical parameters as the primary outcome which included glycaemic control (unchanged),[26] length of hospital stay (improved),[48] change in serum lipids (unchanged),[43] and time to admission to hospital (unchanged).[45] Clinical parameters were also measured in two further studies and included glycaemic control (improved)[36] and presence of malnourishment and/or pressure ulcers (unchanged).[47]

Comparing patient-orientated interventions with HCP-orientated interventions

Eight of the studies targeted patients with the intervention,[26,27,33,34,41–44] one study involved an intervention aimed at both HCPs and patients,[36] and the remainder focussed solely on HCPs (see Table 3).

For the eight studies where the intervention targeted patients, five (63%) reported that the intervention produced a positive effect. This included increased patient satisfaction,[42] monitoring of blood glucose,[27] adherence to medication,[41] system usage,[44] and knowledge[33] (see Table 4).

For the 14 studies where the intervention was targeted at HCPs, a similar proportion reported positive findings (8/14, 57%). These included improved adherence to guidelines,[29,35,39] detection of morbidity,[28,32] decreased adverse drug events,[37,46] and length of hospital stay[48] (see Table 4).

Risk of bias in included studies

There was a high risk of bias for all studies included in the review, with the exception of one high-quality study[45] (see Table 4). Three studies were assessed as having concealed allocation adequately.[37,40,45] The remaining studies either failed to do so or did not provide sufficient information. Four studies reported that the assessors were sufficiently blinded to allocation group.[30,31,40,45] Of the remainder, 10 studies derived outcome data from automated data queries, making assessment bias unlikely.[28,29,32,37,39–41,43,44,47] Seven studies were assessed as having adequate follow-up of professionals and/or patients.[30,32,33,41,45–47]

Three of the studies were ITS analyses.[27,35,48] All three used a reliable outcome measure. It was unclear how either of these studies protected against detection bias (in terms of either data collection or blinded assessment) or secular changes in the population being studied. One study reported on the completeness of the dataset, which was assessed as being satisfactory.[35]

Discussion

In order to assess the effectiveness of tailored messages within eHealth interventions, a comparison needs to be made between outcomes of tailored interventions and non-tailored interventions. However, based on the results of this review, the research question remains incompletely answered for a number of reasons.

First, any direct comparison between tailored and non-tailored interventions was limited to a minority of the included studies. Nearly all studies compared the intervention to a no change/standard practice control group as opposed to a non-tailored intervention. This makes it impossible to ascertain whether any improvements were secondary to the tailoring component of the intervention per se.

Second, the outcome of either of these comparisons presented a mixed picture. A number of studies concluded that there was improvement in clinical processes, for example, adherence to guidelines, avoidance of prescription errors, and increased service uptake when compared to no intervention. However, most of these studies presented methodological weaknesses meaning that these conclusions should be met with caution.

Third, only a minority of studies included in the review included an intervention that fulfilled both criteria for what is considered to be tailoring of information. All of the other studies included in the review incorporated only one of the two components that define true tailoring. The adoption of studies meeting this less strict definition increased the number of studies eligible for inclusion but made it difficult to address the research question specifically.

Last, the quality of most of the included studies was assessed as low. However, the introduction of methodological quality as an eligibility criterion for inclusion would have excluded almost all

of the studies identified. Meta-analysis was not possible owing to the heterogeneous nature of the interventions and outcomes of the studies reviewed.

It should be noted that this review is limited to describing the *effectiveness* of tailored messages within eHealth systems and has done so by adopting a quantitative approach. For those studies that demonstrate improved outcomes, no attempt has been made to assess which components of the intervention were responsible. This will no doubt vary by setting (e.g. patient-orientated versus HCP-orientated interventions) and would require alternative methodologies.

Significance

Despite these limitations, some limited conclusions can be drawn. Irrespective of the degree to which the intervention incorporated tailoring, or the degree to which tailoring was responsible for the observed outcomes, it is notable that 14 of the 22 studies included reported positive findings. These improvements were largely limited to clinical processes as opposed to clinical outcomes and were observed in interventions aimed at both patients and HCPs. It is also notable that none of the included studies reported any harm. This would suggest that personalised eHealth interventions (aimed at either patients or HCPs) can safely effect behaviour change which may in turn reduce unwanted variation in practice. To what extent tailoring of messages is responsible for this effect is unknown.

The lack of studies that combine eHealth technologies with interventions that utilise tailoring of information is surprising, given the evidence that tailoring is effective when used in conjunction with traditional media, and the ease with which tailoring algorithms can be incorporated into new technologies. This may reflect the fact that both are relatively recent innovations. Given the existing evidence that tailored messages via traditional media can effect behaviour change, it would seem a logical extension to incorporate them into eHealth interventions. Clearly, there is a need for additional work in this area. Future research should delineate the role of tailoring in eHealth (e.g. by comparing it with non-tailored interventions as opposed to no intervention or standard care) as well as identifying which are the active components of such interventions (e.g. via future qualitative studies).

Conclusion

Tailoring of information to recipients has previously been shown to be an effective way of changing behaviour when used with traditional media. This review suggests that eHealth-tailored information delivery may improve clinical care, but there is currently a lack of evidence to conclude that the use of tailoring within an eHealth context confers any benefits over non-tailored eHealth interventions. This lack of evidence reflects the low number of good quality studies in this area. It is only by designing studies where the role of tailoring is isolated as the active component in the intervention, that the effectiveness of tailoring can be adequately assessed.

Declaration of Conflicting Interests

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

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Usability evaluation of the digital anger thermometer app

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Abstract

The digital anger thermometer is a prototype for a mobile application (app) for use with adults in anger management treatment. The digital anger thermometer incorporates standards of software development in addition to anger management resources from the Substance Abuse and Mental Health Services Administration. The digital anger thermometer underwent a usability study conducted by five expert reviewers. The results indicate that it is easy to learn, efficient, and ergonomically sound. However, it does not offer support features or user-error tolerance. The digital anger thermometer prototype requires additional usability studies and comparative research in order for it to become an actual mental health app.

Keywords

databases and data mining, e-health, evidence-based practice, health information on the web, mobile health

The digital anger thermometer (DAT) is a prototype for an anger management application (app). The purpose of this article is to review the features and usability of the DAT. Despite the availability of numerous mental health apps, few appear to consider usability evaluations in their development.[1,2] Such an evaluation is an important precondition for the usefulness and efficiency of apps.[3] It saves time and money in the developmental phases of a project and reduces overall system errors.[1,4] Consequently, the DAT mobile app prototype underwent an expert review to inform design revisions so that it may eventually become a useful tool in anger management.

With advances in mobile device technology, clients now have access to a wide range of therapy apps to supplement their treatment.[5] Mobile apps typically include tools for tracking moods, managing daily stressors, and improving overall mental health.[6] Apps are also capable of monitoring physical symptoms, providing biofeedback, guiding the user through therapeutic scripts, and offering additional self-help resources. There are an increasing number of individuals using mobile technology, and mental health apps allow them to participate actively in their own care.[7] At the same time, there is growing demand for expansive and cost-effective mental

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health services.[8] The portable and cost-effective nature of therapy apps could extend treatment to individuals with limited access to mental health resources.[9,10]

Therapy apps address a wide range of issues such as mood disorders, anxiety, post-traumatic stress disorder, schizophrenia, and anger. In a mixed-methods field study using a mood-tracking app, participants reported lower mean scores on a series of single-dimension instruments for anger, anxiety, and sadness scales ($p \leqslant .01$ for all three) following its use.[11] Apps assist in modulating emotions through self-regulation. Self-regulation reduces the severity of mental health symptoms, improves interpersonal relationship, and helps individuals live and work effectively.[12] Anger problems affect relationships and physical health,[13] and anger management requires self-regulation and awareness.[14,15]

Studies show that mood-tracking mobile devices reduced anger and stress levels. Of 78 trait-anxious participants, researchers noted lower scores in both stress reactivity and anxiety following the use of an app addressing cognitive biases.[11,16] Similarly, other researchers[17] reported an overall decrease in state anxiety while using the Mobile Stress Management app ($F(1, 28) = 71.365$, $p \leqslant .001$). Although the DAT requires future trials to assess its potential, it models some of the features of currently studied apps by tracking anger levels, cues, and patterns. The interactive nature of the DAT tools could increase client participation in treatment.[18] Apps similar to the DAT include the Mobile Stress and Anger Management Tool[19] (M-SAT) and Mobile Therapy app.[11] The M-SAT is a support suite used conjointly by therapist and client. The M-SAT provides real-time support and cognitive behavioral therapy tools and tracks stress and anger levels through physiological sensors and an electronic anger meter (EAM). The interval scale on the M-SAT meter is the same as the meter within the DAT. However, unlike the M-SAT, the DAT directly links the user to online anger management resources and activities based on selected anger meter levels.

The mood-mapping app, known as Mobile Therapy, shares several qualities with the DAT. For one, it is an adjunctive treatment tool requiring weekly interviews between therapists and clients in order to work through anger levels and cues. The Mobile Therapy app's real-time anger management resources resemble those found in the DAT. The Mobile Therapy app employs a selectable mood scale similar to the one featured in the DAT. The original version of the DAT was a hand-held device known as the EAM.[19] The EAM featured an analog scale of illuminated light-emitting diodes (LEDs), each representing a level of anger. Results of testing the EAM with participants revealed that subsequent designs would benefit from digitization to fit the growing trend of portable device usage.[20] While the DAT is largely a digital version of the EAM, it improves upon it by incorporating software development protocol and additional resources on anger management.[21–25]

The eventual purpose of the DAT is anger assessment. Individuals experience anger through physical symptoms, cognitions, and behaviors.[26,27] Anger is traditionally assessed through self-report inventories. State (anger episodes in real-time) and trait (pervasive patterns) anger are often included in anger inventories.[28] When attempting to measure anger objectively, it is important to consider spectrums of anger that take into account the intensity, frequency, and manner of the episodes.[28–30] An anger spectrum might also include affective experiences from mild irritability to actual assault.[31] In order to measure anger with mobile devices, developers are beginning to incorporate spectrums of affect into their app designs.[11,30] The development of the DAT aligns itself with this practice by including an anger meter informed by sources while undergoing app development guidelines.

While the contribution of this article is to show the initial development of the DAT, completion of the app requires several stages beyond the usability evaluation. These include issuing additional evaluations to target users, field testing, deployment, and maintenance.[32] It is important to use participants that the app intends to serve during early phases of development. Testing for a majority of commercial apps occurs with participants for which the app is intended.[33] Field testing

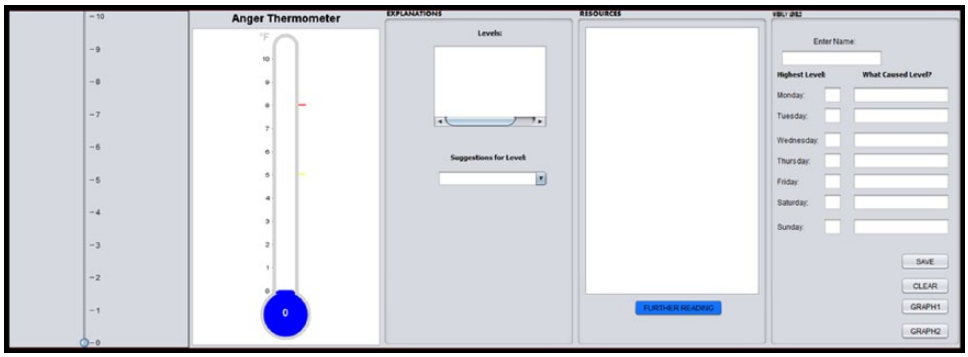

Figure 1. Overview of the DAT app.

commences when testers control for as many variables as possible in the user's environment.[34] After testing, deployment and maintenance involve configuring networks and adjusting security for true mobile use.[35] Prior to any of these steps, basic design and usability must occur.[36]

The section "Features of the DAT" outlines the features of the DAT and the body of literature that informs its design. The section "Materials and methods" outlines the usability evaluation. The section "Results" discusses the implications and further work required for developing the DAT.

Features of the DAT

Every app consists of a series of displays and functions known as a graphical user interface (GUI).[37] A GUI is an interfacing program containing a series of controls and displays that allow a user to interact with a computer.[37] The DAT interface was designed for Microsoft Surface Pro tablets and emerging Windows-based mobile systems. An overview of the main DAT form is shown in Figure 1. The following section outlines the tools involved in constructing the prototype, followed by the layout. The layout includes a login frame, a database, main GUI, dialog boxes, and graphing tools.

Development tools

Developing the DAT required an integrated development environment (IDE), which is a set of programming tools used to develop software.[38] Programming occurred on an ASUS X75A powered by an Intel Core i3 processor with a 4-GB RAM. SQLlite open-source software provided the framework for constructing the DAT database.

Login screen and security

The issue of security in mental health apps is ongoing.[39] Security standards for the ubiquitous use of mobile mental health applications are lacking.[40] Even now, the Health Insurance Portability and Accountability Act of 1996 (HIPAA) does not adequately address the security issues surrounding telehealth.

Security breaches of programs and pages are a major concern and increasingly make news headlines, such as the case of the Heartbleed bug, which affected mobile applications last year.[41] The SQLite database that holds user login information includes the SQLCipher encryption extension, a security component that actively defends against hacker intrusions. This extension works concurrently with the database to encrypt information further and is a standard choice for mobile

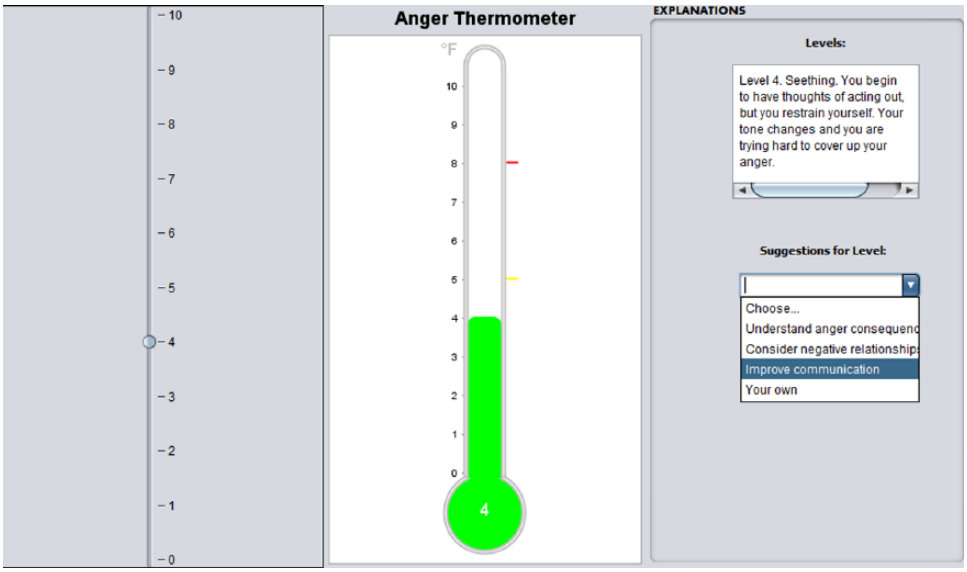

Figure 2. The user selects an anger level, which populates the explanation and suggestions text fields.

applications. Additionally, the DAT login page allows a user to select a password up to 14 characters in length, offering adequate unpredictability.[42] The DAT also requires that the user enter both characters and numbers in the password.

Database

A database is a collection of digitally retrievable information.[43] Mobile app design standards recommend that mobile applications with multiple storage requirements use a shared database.[44] The DAT employs the open-source database known as SQLite.[45] The SQLite software library uses an SQL database engine capable of lightweight data storage, making it ideal for most mobile apps.

Main form

DAT thermometer. The main form consists of several panels, and the main panel contains a thermometer graphic controlled by user input on a slider button (see Figure 2). Inspiration for the thermometer design came from the 10-scale anger meter featured in the Substance Abuse and Mental Health Services Administration (SAMHSA) anger management manual.[20,24] The thermometer currently provides a means for self-report with the hope that someday it can be used for more direct measurement of anger.

The DAT uses an interactive 0–10 scale on all items and the default meter level is zero, signifying no anger, represented by a blue graphic color of the "mercury" at the bulbous base of the thermometer graphic. This incremental measure of arousal is an important component of assessing anger.[30,46] Starting at one, the information on anger levels begins to appear and the mercury color changes to green. As it progresses, the colors change to warmer yellow and red tones. This color scheme primarily follows temperature thermometers that monitor heat levels, popularly found in graphic anger meters.[47] The thermometer connects two other panels, one for explaining the levels and the other for recording anger incidents.

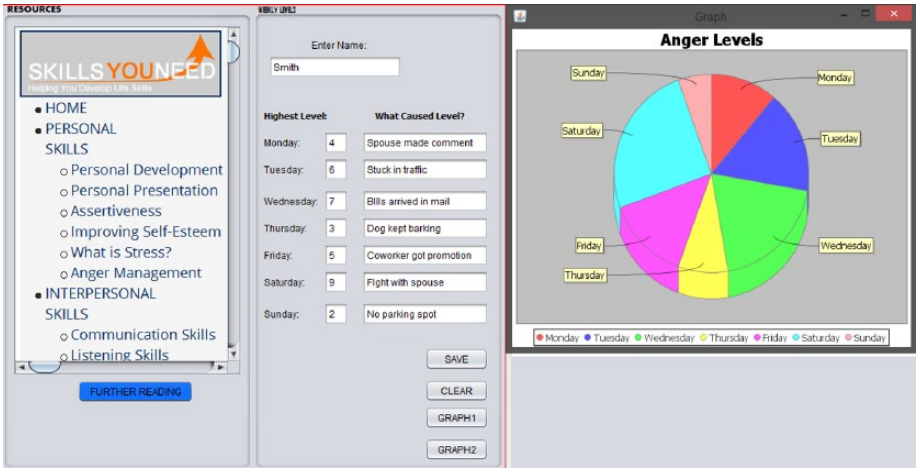

Figure 3. The user selects a hyperlink for improving communication skills. With weekly levels filled out, clicking the graph button produces a pie chart of the data.

Explanations panel. The explanations panel contains the results of each selected level. It explains the symptoms of anger on various levels of a spectrum.[23,31] The top end of the panel features a combination box containing suggestions for possible interventions tailored to each level of anger. Typical interventions include cognitive behavioral therapy, relaxation scripts, and progressive muscle relaxation. Previous anger management app research revealed the necessity for users to add their own interventions;[11,48] consequently, this panel offers an editable text field prompt for entering a personalized intervention.

After choosing an intervention, clickable hyperlinks (shortcuts between web pages) to online anger management resources appear (see Figure 3). Effective anger management requires a psychoeducational component.[49] The sites offer information on cognitive behavioral therapy,[50] mindfulness,[51] deep breathing,[52] and general relaxation.[53] Because additional self-help resources reinforce anger intervention effectiveness,[54,55] a button on the bottom of the panel links the user to further reading on anger management.

Weekly levels panel. The weekly levels panel contains tools for monitoring and recording the highest level of anger throughout the week, an important component of anger management.[23,56] The weekly levels panel can record behavioral information across a designated time span for informing treatment,[57] and the panel includes spaces known as text fields for recording the highest daily level of anger, along with fields for adding user notes regarding the level. With the ability to review anger levels over time, a user can record possible antecedents to the anger or further describe the anger incident for use in clinical sessions.[25] The weekly levels panel also offers a means for the user to illustrate the data through a pie chart or bar chart, which provides users with quick visual representation of the anger data, although no evidence currently supports the use of such a graphic. The panel also features a *save* function for the charts so that users can review information over time.

Materials and methods

Usability evaluations help identify strengths and weaknesses of applications while offering feedback for improving their usability.[1] They also offer a glimpse into actual user experiences prior to

further development of software models so that developers can streamline the applications and reduce system errors.[58] The DAT underwent a usability evaluation conducted by subject matter experts. The evaluation consisted of a questionnaire issued to the experts in a controlled setting. The scored instruments revealed information pertaining to the design and functions of the DAT.

Questionnaire

This study employed the IsoMetrics questionnaire[59] (for the evaluation of DAT GUI). The IsoMetrics inventory is a user-oriented instrument based on part 10 of the ISO 9241. It presents with an appreciable amount of literature backing its use in the evaluation of health-based applications.[1,60–63] Validity studies of the instrument resulted from comparing the scale means of five major software systems.[59] The questionnaire consists of 75 items, each ratable on a 5-point Likert-style scale within seven test dimensions: *Suitability for the task, Self-descriptiveness, Controllability, Conformity with user expectations, Error tolerance, Suitability for individualization*, and *Suitability for learning*.

Participants and procedure

The expert evaluation occurred between July and August 2014. Probabilistic models show that five raters are sufficient for usability testing.[64] The minimum requirements for participation included an advanced degree in a computer field and at least 2 years of software development. Candidates included three app developers, a website designer, and a computer scientist. Mean age of these participants was 32.2 years (standard deviation (*SD*) = 2.32, range: 29–36).

The IsoMetrics manual[65] guided the testing procedure. Each expert received an interview regarding their general experience and familiarity with systems similar to the DAT prior to receiving the test. Any questions that arose were addressed prior to handing out the questionnaire. The experts then received a brief review of the app and a paper version of the IsoMetrics questionnaire, followed by a reading of the text on the instructions statement.

There was a high selection rate on the IsoMetrics test. Scoring involved use of the mean to calculate the response averages. Negatively formulated items underwent a transformation prior to calculation. An analysis of the *Suitability for the task* subscale further illustrated positive and negative points of the DAT.

Results

The results of the questionnaire are in Table 1. The means and corresponding SD scores were calculated from the responses of the five raters. The standard cutoff score for the IsoMetrics usability evaluation is 3, which denotes a moderate score.[1] Any rating higher than 3 is therefore considerable, but should be assessed depending on the context of use.[65] The highest scores are in the *Conformity with user expectations* ($M = 3.68$, $SD = 0.47$) and *Suitability for learning* ($M = 3.80$, $SD = 0.57$) dimensions. The lowest scores are in the *Error tolerance* ($M = 2.75$, $SD = 0.26$) dimension, of which there is high agreement among the raters.

Individual evaluation of the items yielded additional information. The items with the highest scores included S.5, *ease of retrieving about a certain entry field* (4.00), and E.1, *anticipating which screen will appear in next processing sequence* (4.20). The lowest scored items pertained to S.3, *understanding immediately what is meant by the messages displayed by the software* (2.40), and F.6, *entries are checked for correctness before further processing is initiated* (1.80).

Table 1. Usability evaluation scores of the DAT.

Dimension	*M*	*SD*
Suitability for the task	3.41	0.46
Self-descriptiveness	3.38	0.41
Controllability	3.28	0.26
Conformity with user expectations	3.68	0.47
Error tolerance	2.75	0.26
Suitability for individualization	3.40	0.75
Suitability for learning	3.80	0.57

All scores from $n = 5$ raters.

The *Suitability for the task* dimension covers the overall effectiveness and efficiency of software features. Delineation of this area reveals detailed information about the usability of the DAT. The results are given in Figure 4. Item descriptions with the corresponding means and SDs are as follows.

Positively rated items include the following:

- A.1. The software forces me to perform tasks that are not related to my actual work ($M = 4.60$, $SD = 0.89$) (reverse-scored for statistical analysis).
- A.8. Too many different steps need to be performed to deal with a given task ($M = 4.20$, $SD = 1.30$) (reverse-scored for statistical analysis).

Negatively rated items include the following:

- A.3. The software lets me completely perform entire work routines ($M = 2.20$, $SD = 0.54$).
- A.4. The functions implemented in the software support me in performing my work ($M = 2.40$, $SD = 0.89$).

The positively rated items show a measure of efficiency in performing the tasks (above a rating of 3), although there appears to be an outlier in at least one of the responses of A.8 where the rating deviated significantly from the other respondents. The negatively rated items indicate incompleteness of the program and lack of support features. Considering these results, the DAT app could be improved as discussed below.

Discussion

A usability evaluation and anger management resources informed the development of the DAT. The results indicate that the overall ergonomic quality of the DAT is appreciable, and it presents with some measure of efficiency, but the expert sample size was low and the program is far from complete. The highest dimension score is in the *Suitability for learning* subscale. This indicates that it does not require much time to learn the DAT program and that some features of the software assist the user in becoming familiar with the layout. The lowest score is in *Error tolerance*. This essentially means that the program is not accommodating mistakes made by the user, and small user errors are yielding larger issues within the program. During testing of the DAT, several crashes occurred in the programming when users attempted to correct their information. Analysis of the

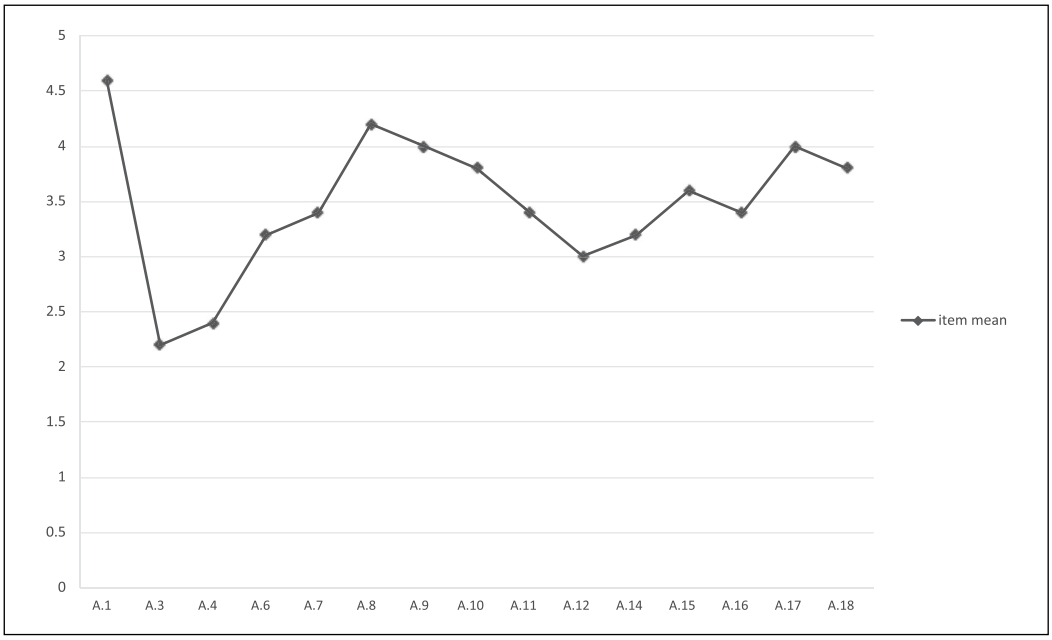

Figure 4. Mean values for individual items in the *Suitability for the task* dimension.

individual items in the *Suitability for the task* dimension indicated a lack of support features when these events occurred. This affirms that the DAT requires debugging in this area and that the DAT can benefit from a user support component currently absent in its design. In addition to reworking the software aspect of the DAT, its ability to work as a mental health app requires further exploration.

Despite the growing popularity of mental health apps, there are numerous drawbacks to their use, including effectiveness, device limitations, security, and reimbursement.[66] There is a lack of studies in app effectiveness, and newly formed committees are only now beginning to determine standards to ensure measures of reliability and validity.[67] Although some practitioners are beginning to use apps as therapeutic tools, no long-term studies on their effectiveness in treatment have been done.[5] In a comprehensive 5-year literature search of 5464 abstracts, researchers found little evidence for the effectiveness of mental health apps.[9] Although there is some evidence for their effectiveness in use with engaging younger individuals in therapy, gaps in research remain to address app feasibility, cross-cultural considerations, technical literacy, and ethical issues.[68]

Concerning device limitations, limited memories of many portable devices are unable to hold large amounts of data.[69] Small features can deter disabled and elderly individuals from using apps.[70] Small device size forces mobile apps to run with reduced graphics and formats and it makes these devices easy to lose. Smaller devices are vulnerable to prying eyes and hackers, which pose a threat to the security of sensitive information contained in the devices.[71]

Cost is a significant barrier to the widespread adoption of mental health apps. The use of mobile technology in treatment sometimes requires dialing costs incurred by clinician and client.[72] A large gap exists in reimbursement for healthcare technology: there is no billing code for the use of mobile apps in therapy.[46] In time, with growing initiatives for technology and participatory care, this could change and mobile apps could be used for billable expenses. Until then, clients, clinicians, and researchers must cover the costs of app technology.

The DAT, like other mental health apps, requires controlled studies to determine true effectiveness.[11] Subsequent versions of the DAT should incorporate the results of this study during further development. The next stage of usability engineering involves iterative development.[73,74] This includes a process of continuously evaluating and changing features of the DAT in order to identify major bugs in the software. In addition, a second usability study using non-expert users will help to identify additional issues with software ergonomics by offering a population resembling intended users of the DAT.[4,75]

After refining the user interface of the DAT, its ability to measure anger requires examination. To assess effectiveness, a follow-up study might include a negative affect measure such as the State-Trait Anger Expression Inventory[27] used in conjunction with trials of the DAT in a pre- and post-study of participant scores. If the DAT app undergoes such refinements, it could become an additional tool for use in anger management treatment.

Conclusion

Development of the DAT app included sources on anger management and a usability evaluation. A digital variation of the SAMHSA anger meter scale is at the core of its user interface. The main body of the DAT contains tools derived from established anger management interventions. Although the DAT includes some standards and sources in its design, the usability evaluation pointed to incomplete areas of the DAT that require further study before becoming a shareable app. Additionally, the DAT requires experimental studies with target users in order to assess its effectiveness.

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