

Characteristics and Subjective Evaluation of an Intelligent Empowering Agent for Health Person Empowerment

Marco ALFANO^{a,1}, John KELLETT^b, Biagio LENZITTI^c and Markus HELFERT^a

^a*Innovation Value Institute, Maynooth University, Maynooth, Ireland*

^b*Dept. of Emergency Medicine, Hospital of South West Jutland, Esbjerg, Denmark*

^c*Dipartimento di Matematica e Informatica, Università di Palermo, Palermo, Italy*

Abstract. Empowerment is a process through which people acquire the necessary knowledge and self-awareness to understand their health conditions and treatment options, self-manage them, and make informed choices. Currently, few stand-alone applications for patient empowerment exist and people/patients often go on the Web to search for health information. Such information is mainly obtained through generic search engines and it is often overwhelming, too generic, and of poor quality. Intelligent Empowering Agents (IEA) can filter such information and assist the user in the understanding of health information about specific complaints or health in general. We have designed and developed a first prototype of an IEA that dialogues with the user in simple language, collects health information from the Web, and provides tailored, easily understood, and trusted information. It empowers users to create their own comprehensive and objective opinion on health matters that concern them. The paper describes the IEA main characteristics and presents the results of subjective tests carried out to assess the effectiveness of the IEA. Twenty-eight Master students in Digital Health filled an online survey presenting questions on usability, user experience and perceived value. Most respondents found the IEA easy to use and helpful. They also felt that it would improve communication with their doctors.

Keywords. Digital Health, Patient Empowerment, Intelligent Agent, Tailored Health Information, Artificial Intelligence

Introduction

Although digital transformation in healthcare is accelerating, there is still a disconnect between current healthcare, that is focused on disease management, and a more holistic approach that looks at the health and wellbeing of the whole person [1]. The latter approach aims at empowering people by improving their comprehension of their health so that they can manage it better [2, 3, 4]. To be empowered people/patients must:

1. have the necessary knowledge and self-awareness to **understand** their conditions and treatment options;
2. be able to make informed and conscious health choices (i.e., **decide**);

¹ Corresponding Author. Marco Alfano, Innovation Value Institute, Maynooth University, Maynooth, Ireland; E-mail: marco.alfano@mu.ie.

3. actively manage, with or without advice from medical professionals, their health and well-being (i.e., **act**).

Currently few stand-alone applications for patient empowerment exist [1] and people often go on the Web to search for health information [5]. However, Web information is mainly obtained through generic search engines and it is often overwhelming, too generic, outdated, and of poor quality [3, 5, 6]. Although Artificial Intelligence (AI) could play an important role in health empowerment, it often empowers machines rather than people (e.g., self-diagnosis apps tend to be substitute doctors and keep patients as passive recipients) [7, 8].

By combining the potential of AI with the vast amount of health information available on the Web, we sought to facilitate the person/patient empowerment process by providing the user with tailored health information taken from the Web that is trustworthy and easily understood [9]. This is realized through the creation of an Intelligent Empowering Agent (IEA) that interacts with users to understand their information needs, retrieves and customizes health information from the Web (by means of an AI algorithm), and presents the user with a tailored, intelligible, and trustworthy output that facilitates his/her comprehension, thus empowering wise health decisions.

This paper describes the main characteristics of the IEA and reports a subjective assessment of an IEA prototype made by 28 students of a Master on Digital Health. This assessment has been performed to evaluate the usability, user experience and perceived value with the IEA and receive feedbacks on how to improve it.

1. Methods

1.1. IEA Description

The components of an IEA are:

a) **User query**

The user selects a complaint from a list or directly enters it as free text.

b) **User profile**

The user profile is constructed from each user's current health status (e.g., symptoms and/or conditions), background health status (e.g., sex, age, gait, BMI, comorbid illness, etc.), and lifestyle information (e.g., sleep, drugs, meal composition, etc.).

c) **Search engine**

The search engine retrieves health information from the World Wide Web and Semantic Web (e.g., health-lifesci.schema.org), other health information repositories, and internal information coming from previous searches (anonymized).

d) **AI algorithm**

The AI algorithm takes the health information collected by the search engine and chooses the most relevant one by using machine learning and decision tree mechanisms. The information is selected according to the following criteria [10], [11, 12]:

- **Language complexity**, to provide users with information that they can easily understand.
- **Information quality**, to provide users with current, accurate, trustworthy, and unambiguous information.

- **Custom information**, to provide users with tailored content (considering the user query and user profile).

e) Output presentation

Tailored relevant health information is provided on complaints (definitions of and related elements), diseases (definitions of and related elements), tests (descriptions of and related elements), and external information sources. A “traffic-light” coloring coding (i.e., red, amber, or green), that implies the need for an urgent consultation with a healthcare professional, is also provided.

1.2. IEA Implementation

A first IEA prototype, the Conversational Health Agent for Person Empowerment (CHAPE) has been developed. It can be accessed at <http://cohealth.ivi.ie/chape>. Once the user inputs age and sex, CHAPE provides a list of possible complaints that can be easily understood by a non-health literate user. Depending on the complaint selected and the user’s profile characteristics, a further sub-list of possibly related complaints is presented, to help define the primary complaint more precisely (Figure 1).

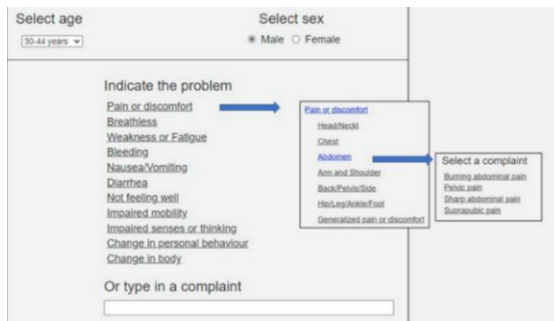


Figure 1. CHAPE interface allows users to specify their complaints in an easy and natural way.

The IEA then uses the information retrieved from the Web and organized by the AI algorithm to provide the information window shown in Figure 2.

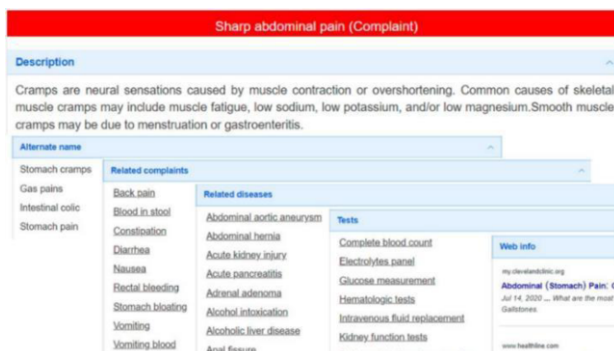


Figure 2. Output window with tailored, trustworthy, and simple information about the searched element.

1.3. IEA Subjective Tests

We have run some subjective tests to evaluate the effectiveness of CHAPE and determine features that need to be improved, ethical approval for which was obtained from Maynooth University. CHAPE was presented to a workshop of employees of the Irish Health Service Executive Agency studying for a Master on Digital Health. These students were asked to use CHAPE and fill an anonymous online survey (https://ec.europa.eu/eusurvey/runner/Chape_initial). The survey had four sections: 1. non-sensitive user-profile information, 2. questions on the usability, user experience and perceived benefit of the system, 3. desired additional features, and 4. other feedbacks. Agreement with specific questions in the survey was expressed in a 1–5 Likert-type scale as follows: 1= strongly disagree, 2= disagree, 3= undecided, 4= agree, 5= strongly agree.

2. Results

Participants

Overall, 28 responses were obtained from 20 females and 8 males, 6 with an age range 19-40 years and 22 with an age range 41-60 years. For what concerns the medical knowledge, 1 had none, 3 had basic knowledge, 4 had average, 14 had good and 6 excellent. For what concerns the computer skills, 1 had basic skills, 6 had average, 14 good, 6 excellent and 1 did not answer.

Responses:

In terms of usability, most respondents found CHAPE interface clear and helpful in identifying health information about complaints, diseases, and tests (Table 1). In terms of user experience, most respondents could better understand their complaints and related diseases and tests (Table 2). In terms of perceived value, the majority of respondents found that CHAPE would improve communication with their doctors (Table 3).

Table 1. Responses to “How easy to use do you find CHAPE?” question.

Statements	No of respondents (and %) who agree or strongly agree
I find the CHAPE interface clear and easy to understand	23 (82.1%)
CHAPE helps me to identify my problem/complaint	18 (64.2%)
CHAPE helps me to identify diseases related to my complaint	21 (75%)
CHAPE helps me to identify tests related to my complaint	22 (78.5%)
CHAPE helps me to identify web information related to my complaint	23 (82.1%)
I think that CHAPE is simple and can be used without prior knowledge	17 (60.7%)
I find that CHAPE is fast in responding to my input	24 (85.7%)

Table 2. Responses to “How helpful do you find CHAPE?” question.

Statements	No of respondents (and %) who agree or strongly agree
After using CHAPE I understand my complaints and diseases better	17 (60.7%)
CHAPE helps me to understand tests related to my complaint	21 (75%)
CHAPE helps me to improve my overall comprehension of complaints and diseases	20 (71.4%)
The websites that CHAPE provides me to explore further health information are useful for me	23 (82.1%)
I consider the information provided by CHAPE trustworthy	15 (53.5%)
I consider the information provided by CHAPE relevant to me	18 (64.2%)

Table 3. Responses to “Which of the following statements apply to you?” question.

Statements	No of respondents (and %)
CHAPE encourages me to take a more active interest in my health and wellbeing	14 (50.0%)
CHAPE helps me to improve communication with my doctor	17 (60.7%)
CHAPE helps me to improve my health	12 (42.86%)

In terms of additional features and other feedbacks, six respondents recommended to expand the user profile with others health parameters and improve interaction with the system by adding a graphical or tactile interface, photo recognition, and a choice history. Three respondents suggested to add clinical terminology like SNOMED and extracting insights from the gathered information such as population health. Some concerns were expressed on the lack of complaints details (1 respondent), an overly simplified problem section (1 respondent), and the used language not suitable for users with a low level of medical knowledge (1 respondent).

3. Discussion

CHAPE has been designed and implemented to provide relevant, trustworthy, and easy-to-understand health information about complaints and diseases to facilitate people/patients’ empowerment.

The literature presents few studies that link person/patient empowerment to intelligent agents and these are quite different from CHAPE: Issom et al. [13] present a chatbot that focuses on the self-care of Sickle-Cell Disease without addressing the comprehension step; Macedo et al. [14] present a chatbot that provides information, created by healthcare professionals, to people with Parkinson’s Disease; Iatraki et al. [15] present a health information recommender (with manually created information) for cancer patients; Yadav et al. [16] present an AI-driven mobile application that predicts cases of anemia and thalassemia, designed for use by healthcare professionals and not by patients. All these above applications focused on specific diseases and provided manually edited health information. In contrast, CHAPE allows the user to choose from different complaints and diseases, and automatically collects information, appropriate to the user’s needs, from the entire Web. Furthermore, the subjective test have shown CHAPE’s effectiveness in terms of usability, user experience and perceived value.

4. Conclusions and Future Work

This paper has presented the characteristics and subjective evaluation of an Intelligent Empowering Agent (IEA) that provides relevant, trustworthy, and easy-to-understand health information to facilitate people/patients’ empowerment. Subjective testing showed that the IEA is easy to use and helpful, and the majority of respondents considered it would improve their communication with healthcare professionals.

To test it on a wider demographic, the user interface is being redesigned to be more conversational (chatbot like) and include more user profile information, such as gait, body type, nutritional status, comorbidities etc. Complaints and diseases are being associated with Concept Unique Identifiers (CUI) of the Unified Medical Language System™ to map them to standard terms taken from medical-term classifications such

as ICD-9, ICD-10, or SNOMED. How information is gathered and filtered out will be explicitly explained to improve trustworthiness. Although user input is anonymous, users will be provided with an option to grant or withdraw informed consent to use their data.

5. Acknowledgment

This work was supported, in part, by Science Foundation Ireland grant 13/RC/2094_P2.

References

- [1] Snowdon A. Digital health: A Framework for Healthcare Transformation. HIMSS. 2020 Retrieved from <https://www.himss.org/resources/digital-health-framework-healthcare-transformation-white-paper>.
- [2] European Health Parliament. Patient empowerment and centredness. 2017 Retrieved from <https://www.healthparliament.eu/patient-empowerment-centredness/#:~:text=There%20is%20a%20widespread%20consensus,expanding%20burden%20of%20chronic%20diseases>.
- [3] Alfano M, Lenzitti B, Taibi D, Helfert M. Provision of tailored health information for patient empowerment: An initial study. In: Vassilev T, Smrikarov A editors. Proceedings of the 20th International Conference on Computer Systems and Technologies CompSysTech '19; 2019 June 21-22; Ruse, Bulgaria: ACM; p. 213-220.
- [4] Bodolica V, Spraggon M. Toward patient-centered care and inclusive health-care governance: a review of patient empowerment in the UAE. *Public Health*. 2019; 169(971):114-124.
- [5] Finney Rutten LJ, Blake KD, Greenberg-Worisek AJ, Allen SV, Moser RP, Hesse BW. Online Health Information Seeking Among US Adults: Measuring Progress Toward a Healthy People 2020 Objective. *Public Health Reports*. 2019;134(6):617-625.
- [6] Daraz, L., Morrow, A.S., Ponce, O.J. et al. Can Patients Trust Online Health Information? A Meta-narrative Systematic Review Addressing the Quality of Health Information on the Internet. *J GEN INTERN MED*. 2019, 34, 1884–1891.
- [7] Davenport T, Kalakota R. The potential for artificial intelligence in healthcare. *Future Healthc J*. 2019; 6(2): 94-98.
- [8] Fast E, E. Horvitz E. Long-term trends in the public perception of artificial intelligence. In Proceedings of 31st AAAI Conference on Artificial Intelligence AAAI 2017; 2017. pp. 963–969.
- [9] Alfano M., Kellett J., Lenzitti B. Helfert M. Proposed Use of a Conversational Agent for Patient Empowerment. In Proceedings of the 14th International Joint Conference on Biomedical Engineering Systems and Technologies - Volume 4: Scale-IT-up: 817-824.
- [10] Bol N., Smit ES, Lustria MLA. Tailored health communication: Opportunities and challenges in the digital era. *Digital Health*. 2020; 6: 1–3.
- [11] Cheung KL, Durusu D, Sui X, de Vries H. How recommender systems could support and enhance computer-tailored digital health programs: A scoping review. *Digital Health*. 2019; 5: 1–19.
- [12] Alfano M, Lenzitti B, Taibi D, Helfert M. On-Line Retrieval of Health Information Based on Language Complexity, Information Customization and Information Quality. In: Ziefle M, Guldemond N, Maciaszek LA editors. Information and Communication Technologies for Ageing Well and e-Health. ICT4AWE 2020. Communications in Computer and Information Science, vol 1387. Springer, Cham; 2021: p. 1–20.
- [13] Issom, D. Z., Rochat, J., Hartvigsen, G., & Lovis, C. (2020). Preliminary evaluation of a mHealth coaching conversational artificial intelligence for the self-care management of people with sickle-cell disease. *Studies in Health Technology and Informatics*, 270, 1361–1362.
- [14] Macedo, P., Pereira, C., Mota, P., Silva, D., Frade, A., & Madeira, R. N. (2019). Conversational agent in mhealth to empower people managing Parkinson's disease. *Procedia Computer Science*, 160, 402–408.
- [15] Iatraki G, Kondylakis H, Koumakis L, Chatzimina M, Kazantzaki E, Marias K, Tsiknakis M. Personal Health Information Recommender: implementing a tool for the empowerment of cancer patients. *Ecancelmedscience*. 2018; 12:1–11.
- [16] Yadav S., Ganesh S., Das D., et al. Suśruta: Artificial Intelligence and Bayesian Knowledge Network in Health Care – Smartphone Apps for Diagnosis and Differentiation of Anemias with Higher Accuracy at Resource Constrained Point-of-Care Settings. In: Madria S., Fournier-Viger P., Chaudhary S., Reddy P. (eds) *Big Data Analytics. BDA 2019. Lecture Notes in Computer Science*, vol 11932. Springer, Cham.