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Analyzing recommender systems for health promotion using a multidisciplinary taxonomy: A scoping review

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ABSTRACT

Background: Recommender systems are information retrieval systems that provide users with relevant items (e.g., through messages). Despite their extensive use in the e-commerce and leisure domains, their application in healthcare is still in its infancy. These systems may be used to create tailored health interventions, thus reducing the cost of healthcare and fostering a healthier lifestyle in the population.

Objective: This paper identifies, categorizes, and analyzes the existing knowledge in terms of the literature published over the past 10 years on the use of health recommender systems for patient interventions. The aim of this study is to understand the scientific evidence generated about health recommender systems, to identify any gaps in this field to achieve the United Nations Sustainable Development Goal 3 (SDG3) (namely, “Ensure healthy lives and promote well-being for all at all ages”), and to suggest possible reasons for these gaps as well as to propose some solutions.

Methods: We conducted a scoping review, which consisted of a keyword search of the literature related to health recommender systems for patients in the following databases: ScienceDirect, PsycInfo, Association for Computing Machinery, IEEEExplore, and Pubmed. Further, we limited our search to consider only English-language journal articles published in the last 10 years. The reviewing process comprised three researchers who filtered the results simultaneously. The quantitative synthesis was conducted in parallel by two researchers, who classified each paper in terms of four aspects—the domain, the methodological and procedural aspects, the health promotion theoretical factors and behavior change theories, and the technical aspects—using a new multidisciplinary taxonomy.

Results: Nineteen papers met the inclusion criteria and were included in the data analysis, for which thirty-three features were assessed. The nine features associated with the health promotion theoretical factors and behavior change theories were not observed in any of the selected studies, did not use principles of tailoring, and did not assess (cost)-effectiveness.

Discussion: Health recommender systems may be further improved by using relevant behavior change strategies and by implementing essential characteristics of tailored interventions. In addition, many of the features required to assess each of the domain aspects, the methodological and procedural aspects, and technical aspects were not reported in the studies.

Conclusions: The studies analyzed presented few evidence in support of the positive effects of using health recommender systems in terms of cost-effectiveness and patient health outcomes. This is why future studies should ensure that all the proposed features are covered in our multidisciplinary taxonomy, including integration with electronic health records and the incorporation of health promotion theoretical factors and behavior change theories. This will render those studies more useful for policymakers since they will cover all aspects needed to determine their impact toward meeting SDG3.

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1. Introduction

In order to achieve the United Nations Sustainable Development Goals, particularly goal 3, “Ensure healthy lives and promote well-being for all at all ages” (SDG3), it is imperative to invest in health-promotion activities. Over the years, numerous health-promotion interventions have been developed that help people adopt a healthy lifestyle and independently manage their health behaviors. Even though these interventions have been proven to be effective [1], they are not suitable for all as populations tend to present high levels of variability. In order to account for these differences, it is important to tailor the interventions to suit the diverse characteristics of a given population (i.e., economic standards, schedules, and residential location). Given this variability, new technologies can be used to solve geographical-access problems, deliver timely interventions, reduce intervention costs, and to even help users exert better control over the intervention [2].

However, computer-based health interventions suffer from a high user attrition rate [3], which presents a severe problem in public-health actions related to medical informatics. This is why it is relevant to use tailored health interventions [4], which can increase user engagement [5]. Tailored health interventions can also ensure more effective outcomes as compared to non-tailor approaches [6–9], and the integration of computers can make them scalable and even more cost-effective [10,11].

As technology evolves, new ways to implement such tailored interventions are being adopted, and researchers and policymakers need access to the correct tools to help them assess their design and usage suitability. One such innovative approach to computer-based tailored health interventions is the use of recommender systems (RS) [12]. RS are machine-learning, information-retrieval software tools, which predict the relevance of an item (e.g., a health resource or a message) for a given user (e.g., a patient) [13]. RS can select, tailor, and send health messages that are relevant to users based on previously retrieved user information. Even though RS have gained popularity in the last decade [14] and have been applied in a wide range of domains, such as e-commerce and leisure, their application in the health-promotion domain—as health recommender systems (HRS)—is still in its infancy. Although some HRS are already in use, there is still a long way to go before they become commonly used in health-related environments [15]. One reason for this could be that the potential of these systems [16] is not clearly defined and known to health professionals. For instance, they could be used as clinical-decision support systems if the end user is a healthcare professional, and as engines to generate relevant healthy lifestyle recommendations when patients are the end users. This latter application could significantly contribute to the field of health promotion. Nevertheless, some challenges should be solved such as legal liability and regulatory compliance. Currently, the legislative frameworks are not fitted to deal with potential errors of HRSs [17].

When sending health-promotion messages to the population by running public health campaigns or, more specifically, by using health-promotion interventions, researchers in social marketing have reported that tailoring the content of these messages to the user’s context can improve their efficacy, as compared to the use of general content [18,19]. The added value of this strategy is that the user will then receive highly tailored messages tailored to his attitudes, social support system, self-efficacy, and the action plans needed to realize a particular health behavior. Yet, eHealth programs, including tailored eHealth programs, suffer from high dropout rates [3]. One strategy aimed to overcome this is to offer messages that are also optimally adapted to user preferences, a strategy used by HRSs. HRSs may optimize the message tailoring for each user by selecting the message contents as per the patient’s need, sending them on a timely manner, and adapting the messages with changes in the patients’ situation over time. Therefore, HRS may be a useful innovation over the current tailored systems as they may increase user engagement with the intervention and reduce

costs.

Considering the immense potential in applying RS to health promotion interventions, it is necessary to present a multidisciplinary overview of the results of using HRSs. To map the existing research literature pertaining to the use of HRS for patients, we conducted a comprehensive scoping exercise by exploring five different databases from different fields (technical, medical, and psychological). A preliminary search for previous scoping reviews that adopt a multidisciplinary approach to the topic of HRS for patients was also conducted in a variety of databases of different fields, but we did not find any relevant occurrences.

The primary objective of this scoping review was to create a body of knowledge about the current state of HRS for patients in the last 10 years, in an attempt to answer the following research questions: What are the actual experiences with HRS for patients? What aspects have been studied? What are the existing research gaps that still need to be covered? These questions will be comprehensively addressed by following a multi-disciplinary approach adopted previously by some authors [20]. We analyzed four aspects—their domain, methodology and procedures, the usefulness of health promotion theoretical factors and behavior change theories, and technical details—in performing an in-depth analysis from all angles, which is required to ensure the success of a tailored, computer-based health intervention. We proposed a scheme of classification for this analysis. It constitutes a new taxonomy which integrates both principles of traditional HRSs, and principles used in computer tailored eHealth approaches. The I-Change Model [21] was used to identify whether the HRSs also address these needed factors for behavior change. This taxonomy intends to facilitate the HRS classification, as there is no other taxonomy covering the those or similar aspects relevant for HRS to our knowledge. Therefore, both policy makers and researchers may easily identify knowledge gaps and common successful patterns in previous studies. For future studies such identification may contribute to increase the study fidelity by minimizing the possibilities of having undisclosed parts or overlooked aspects of the study that reduces their replicability. Future studies that complete the proposed taxonomy will be going through an exercise to include many of the needed requirements to meet SDG3, as it covers not only technical aspects, but also health communication aspects, and domain, and methodologies.

This paper aims to present a clearer picture about how the existing studies can help policymakers make better decisions in terms of public-health actions, including computer-based tailored health interventions, and to help researchers design future studies by building upon the existing knowledge.

2. Materials and methods

2.1. Design

We conducted a scoping review following the PRISMA framework [22] to identify studies relating to HRS in which the end users were patients who received recommendations that may influence their health.

2.2. Search approach

The main eligibility criteria were that the studies had to be articles published in journals over the last 10 years (from January 1, 2007, to October 18, 2016, when the search was performed), written in English, and dealing with RS that provided some sort of health recommendations to patients. The information sources selected were five databases, namely, PubMed, PsycINFO, Association for Computing Machinery (ACM), IEEEExplore, and ScienceDirect. Electronic searches were conducted using the following keywords: (“recommender systems”) OR (“recommender system”) OR (“recommendation systems”) OR (“recommendation system”) AND (health OR patient OR patients). When

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