Strategies for Content Recommendation in the Brazilian Rapid Response to Syphilis Project

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ABSTRACT

Syphilis is a Sexually Transmitted Infection (STI) which the Brazilian Ministry of Health has acknowledged an epidemic since 2016. To face such a problem, it is essential to develop and implement educational actions enhanced by information and communication technologies to qualify, train and raise awareness nationally. Considering the increasing number of Open Educational Resources developed, existing open health repositories and other digital platforms that allow interaction in the Brazilian Unified Health System (SUS) as well as the vast number of Healthcare Information Systems, it is essential to the develop solutions to efficiently and costly recommend content accordingly to the interest of health professionals and the current needs and priorities of the SUS, such as the epidemic of syphilis. This paper presents a discussion on the information systems and the data available and strategies of recommendation systems based on this scenario, integrating health surveillance, formative needs, georeference of health teams and professionals and epidemiological data to recommend content to health professionals all over the country.

CCS CONCEPTS

• **Information systems** → **Recommender systems**; • **Applied computing** → *Health care information systems*; *Learning management systems.*

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KEYWORDS

recommendation systems, unified health system, learning management systems, information and communication technologies

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1 INTRODUCTION

Syphilis is a serious public health problem that, in recent years, has been showing growth trends in most middle-income countries, as is the case in Brazil. Syphilis is a curable, systemic, Sexually Transmissible Infection (STI) caused by the bacterium Treponema Pallidum. Sexually transmitted infectivity is higher (about 60%) in the early stages (primary, secondary and recent latent), gradually decreasing over time (latent late and tertiary). It can also be transmitted from the mother to the fetus, causing consequences such as abortion, stillbirth, preterm delivery, neuropsychomotor development retardation, skin lesions and malformations, with a mortality rate of around 40% in infected children. According to the World Health Organization (WHO), syphilis affects more than 12 million people worldwide. One of its most damaging manifestations, congenital syphilis, accounts for 1.6 million cases [16].

Although syphilis control is within the reach of several countries, its elimination depends to a great extent on the willingness and political actions of local managers, the collaboration of health professionals and society, for a movement for quality of care pregnant women and their sexual partners during prenatal care, national

mobilization to increase access to diagnosis and treatment, and effective interaction with other sectors of government, with the community, especially with the networks of the popular women's movement, the grassroots and academic communities.

It is important to note that syphilis is among many other neglected diseases in the country. In addition, structural variables related to the worldwide decrease of penicillin raw material production led several countries to the shortage.

In October 2016, the Ministry of Health launched a national strategic agenda, where it established a set of priorities aimed at qualifying health care for prevention, care, treatment and surveillance of syphilis renewed in 2017, in line with the requirements of the federal control bodies to reverse the reported numbers [5].

In this sense, in order to reverse the current scenario of syphilis in Brazil, it is important to design strategies that go beyond the organizational decentralization of the system and incorporate health investments anchored in regional equity, in order to overcome the difficulties of health financing in Brazil's current scenario. In order to do so, we focus on the articulation and deepening of the response to syphilis in the attention networks, also presupposing the direct participation of community-based organizations in the territory and articulated to health services. In order to move in this direction, it is necessary that actions developed by community-based organizations be integrated into those networks. It should be noted that in general the actions developed by these organizations are targeted at vulnerable populations [4].

It is therefore important to establish means to strengthen a rapid response to the control of syphilis in health care networks, which is also mediated by technological tools both for use by health managers and professionals, and by the general population and key populations (or of greater vulnerability). Such tools will have a fundamental role to pass on information and maximize the efficiency of the national response to syphilis cases.

All these actions should be elaborated and implemented, whenever possible or applicable, through mechanisms based on information and communication technologies. To do so, technology-based learning-based models should be used as a means of qualifying and training the national response network.

In this sense, previously the Ministry of Health, in partnership with the Federal University of Rio Grande do Norte, launched a open education strategy to SUS professionals, namely, AVA-SUS. It is an environment developed for health professionals and students, whose main objective is to improve SUS training, management, and care. With government funding, educational modules prepared and facilitated by the several institutions are available. With more than 250.000 active students, the courses consist of several resources (such as texts, audios, and videos) addressing clinical issues and the organization of the work process in the SUS.

In addition to the educational courses available in AVA-SUS, the system encourages the use of other Ministry of Health learning tools linked to the single sign-on Sabiá ecosystem, such as the Community of Practice (CdP). Financed with public resources, CdP is a virtual space where health managers and workers, especially those working in primary healthcare, can meet and share experiences. Setting up such a collaborative network aims at improving working conditions and quality of healthcare for the population. With more than 60,000 users, the community has chat rooms, case reports, and spaces for thematic discussions created by participants.

Considering the increasing number of educational objects and interactions contained in Sabiá's information systems as well as the number of students, it is essential that solutions be developed to recommend content efficiently and according to the interest of users and the current needs of SUS.

The following sections will cover the background of the information systems available along with a description about it's data, then about the recommendation systems and their models, and a discussion on which model is best suited for this scenario.

2 BACKGROUND

2.1 Information Systems

In the proposed strategy of recommendation, epidemiological data will play a key role in pointing the syphilis situation throughout the national territory and recommending content relevant to the public health professionals located in priority regions, while the behavioral data are individualized information per user and will reflect their interests and related content. Below are presented both types of information system.

2.1.1 CNES. The first information system to give a panorama on the health system is CNES. CNES is the acronym for the National Registry of Health Establishments, which is a determination of the Ministry of Health for all establishments that provide some type of health care, including identification of the establishment, physical structure, services provided, available equipment and human resources (professionals). The CNES database, contains geolocalized data of health establishments, including information to identify the health worker teams [18].

The analysis of this database allows us to map health professionals and the environment where it is inserted. Crossing this information with other systems, it is possible to see which health cases are occurring more frequently in the establishment, what is the trend and what is the available functional framework.

2.1.2 SINAN. SINAN is a national platform of the Ministry of Health responsible to concentrate the notification of cases of diseases that are included in the national list of diseases of compulsory notification, as described in the ministerial order no. 204, February 17, 2016 [2].

Its effective use allows for the dynamic diagnosis of the occurrence of an event in the population, and can provide subsidies for causal explanations of the aggravations of compulsory notification, in addition to indicating risks to which people are subject, thus contributing to the identification of reality geographical area. It is, therefore, a relevant instrument to assist health planning, to define priorities for intervention, and to allow the impact of interventions to be evaluated [12].

The SINAN database contains information on several notifiable diseases, including syphilis. From the notification it is possible to obtain data such as ICD-10, age, education, occupation, gestation period (in the case of pregnant women), type of treatment adopted and notifying establishment. By correlating these data with CNES data, it is possible, for example, to create a notification map by

establishment, which allows us to indirectly infer the pattern of cases by neighborhood of a city.

2.1.3 PMAQ. The National Program for the Improvement of Access and Quality of Primary Care, PMAQ-AB, aims to encourage managers and teams to improve the quality of health services offered to citizens of the territory. For this, it proposes a set of qualification strategies, monitoring and evaluation of the work of the health teams [14].

This database contains information on the service provided in a facility, availability and access to the rapid syphilis test and the serological test (VDRL) in primary care facilities. It also provides information on the availability of penicillin in establishments and whether treatment is available at this location. The most recent data corresponds to the third cycle of PMAQ and is available for analysis.

2.1.4 SIH and SIA. During the process of constitution of the Brazilian public health system, there were several stages of dismemberment of sectors that were formerly part of the social security system of the country, were relocated to integrate the new format of the Ministry of Health. 1980s and early 1990s. At that time, given the great predecessor influence of the social security system, there was a managerial vision focused on the financial role of health institutions.

Thus two systems were created at that time, the SIA (Outpatient Production Information System) and the SIH (Hospital Production Information System). At first both were focused only on public health facilities, only in the last decade supplementary health facilities (private sector) have become part of the systems [15].

Despite its origins pointing focus to the financial management of the institutions, the systems have become extremely important for the SUS management in general. They record every medical procedure performed in the care network, from primary to tertiary care. From these systems can extract stocking indicators of hospitals, clinics trends, tests, hospital admissions, procedures performed during surgery and many others.

2.1.5 SIM. As one of the first health information systems in Brazil, the Mortality Information System (SIM) dates from the late 1970s. However, it was only with the advent of the internet and large data processing centers that this system passed to be used in all cities of the country, in the 1990s [8].

Only the last two decades are available for analysis, however they provide information such as age, main cause and secondary causes of death, and place of occurrence. All causes are listed according to ICD-10.

2.1.6 Sabiá. Sabiá is a Single Sign-On System (SSO) mainly responsible to concentrate the user profiles and provide authentication on all of the following systems [13]. It identifies the users through their Natural Persons Register (CPF) number and cross references with the IRS and the professional councils to certify the profiles are legitimate.

The number of learning-based information systems from the brazilian government linked to Sabiá is growing as it has become a trustworthy platform. AVASUS, Community of Practice, Evidence Based Health Portal and many others already rely on Sabiá as a primary authentication service.

2.1.7 AVASUS. The SUS Virtual Learning Environment, namely AVASUS, is a Distance Education platform of the Ministry of Health, which allows the qualification and updating of health workers and professionals. The courses are available free of charge and can be accessed by professionals and technicians, students and health managers, as well as by the general public [9].

AVASUS has 202 courses available with more than 400,000 active students [3]. Through the platform's database it is possible to obtain from each student the following information:

- Course search results
- Viewed courses
- Enrolled courses
- Finished courses
- Frequency of access in courses
- Time of online presence

2.1.8 Community of Practice. The Community of Practice (CdP) is a social network where health professionals can create their profile, spread their skills and interests, share experience reports in daily work practice and interact with other professionals from all over Brazil on common themes. [17]

The reports are equivalent to blog posts, public for all users and with defined questions that must be answered accordingly. Users can interact by commenting, evaluating, and following reports from other users. There are currently about 8.368 reports from the CdP and the interactions between users and reports have potential be used to infer explicit interests.

2.1.9 Evidence Based Health Portal. The Evidence Based Health Portal (PSBE) is a platform from the Ministry of Health, in partnership with the Coordination of Improvement of Higher Education Personnel of the Ministry of Education (Capes / MEC) and the Federal University of Rio Grande do Norte, aimed at the professional qualification of SUS workers [7].

The platform provides healthcare professionals with quick and easy access to scientifically reviewed content and evidence. This information, provided with scientific evidence, is used by health professionals to support them in clinical practice and decision making in health management and qualification of care, as well as in teaching-learning processes, strengthening the teaching-service integration-community.

Currently there is a search engine is provided by PAHO (Pan American Health Organization) as an Application Programming Interface (API) and PSBE being the client. In this version, the meta search engine enables the rapid search of the information in the following databases Dynamed, Nursing Reference Center, Epistemonikos, Virtual Health Library, REBRATS, Access Medicine, Micromedex, Electronic Bulletin and Proqualis and the search results are categorized by Clinical Evidence, Scientific Articles and Tools.

As this portal does not hold information content but rather relies on a search engine, it can be used to make searches on metadata from main topics of interest from users and recommend content.

2.2 Recommendation systems

The computational field of recommender systems include a set of algorithmic approaches in order to handle with the amount

of information on these systems and predict how strong a user's interest in an object is, with personalized, exclusive content and service recommendations [10].

There are many different algorithms and techniques which can be used to provide custom-user recommendation. These are divided in three main categories:

- Collaborative Filtering (CF)
  Makes recommendations looking for what users similarity. It is based on the idea that people who likes or dislikes certain items in the past are likely to agree again in the future. Notwithstanding, the recommendations are weighted by the users proximity. There are few troubles with this idea, like cold start, scalability, sparsity and new items [6].
- Content-based Filtering (CB)
  This approach recommends items based on the content of the items and the user. The items, or objects, could be images, videos, messages in forums, etc. Similarity between items and users can be established based on the user ratings or interactions. The objects' content is a set of terms or descriptors. Meanwhile, CB has difficulties like overspecialization and cold-start
  [1][11].
- Hybrid methods (HB)
  Theses systems take advantages from both content-based filtering and collaborative filtering. Using content representation and user similarities with other techniques, HB can handle the issues mentioned on the others two approaches, whereas has more accurate recommendations [19].

3 STRATEGIES FOR CONTENT RECOMMENDATION

Faced with the current syphilis crisis in the country, there are professionals who are not qualified in the management of patients with this disease or even lack information that the territory where this professional is inserted is at risk. Thus, there is room to fill this vacuum of access to information and training of health professionals to respond quickly to this situation.

The central idea is to develop a recommendation system that can combine data from both groups of information systems to recommend public health-relevant content in whatever disease or health condition is occurring in a specific location. In this way, health professionals will have quick access to courses that could potentially improve their work process and improve the management of patients with any endemic conditions, including syphilis, which is considered in this case study.

As can be seen from the information systems shown in the previous section, there are two groups of systems: learning environments and contextual systems. In the first group, learning systems contain user information, behavior and learning objects. In the second group, we have the epidemiological data that can provide information on diseases that are affecting the population, indicators of public health. The Figure 1 presents both groups as necessary to create the recommendation data.

In order to create a recommendation system it is important to establish a architecture where it is possible to gather and organize the necessary data, create a database for metadata information on

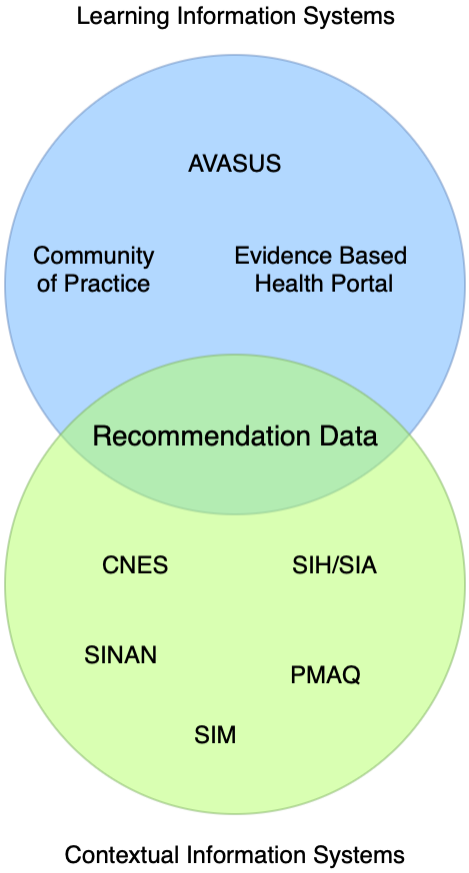

Figure 1: Groups of informations systems in order to generate recommendation data.

all the available learning resources, process the information and return that information to all the systems.

Regarding the recommendation system engine itself, it's being considered the behavior and the interests of the users but also the epidemiological data. The content-based filtering technique is best suited when the users has been interacted and evaluated items in the past, which is the case of AVASUS and CdP. Meanwhile, there's also the public health data recommendation which will be provided to weight against the content-based one, according to the relevance.

As one of the starting points of input for the architecture, it will be necessary to obtain the data from the Brazilian Ministry of Health's epidemiological data sources, as well as the behavioral data of the Sabiá Platform associated systems such as AVASUS, Evidence Based Health Portal (PSBE) and Community of Practice (CdP). Figure 2 presents the general view of the architecture.

Another important starting point crucial for the project is the item catalog. The main idea is to create a catalog that references all of the items from AVASUS, PSBE and CdP, along with it's metadata.

Along this paper, the definition of item is the biggest to the smallest piece of information or content that can be available to the user, whether it's a full course or a text, image, video, document or even a module from a course.

During the creation of the catalog it's important to establish links between those items. For example, make explicit that a video belongs to a module and then this same module belong to a course.

Metadata of an item can be a textual description or a set of tags that can be used to relate the item with a determined context. The item's metadata will be used by the recommendation system.

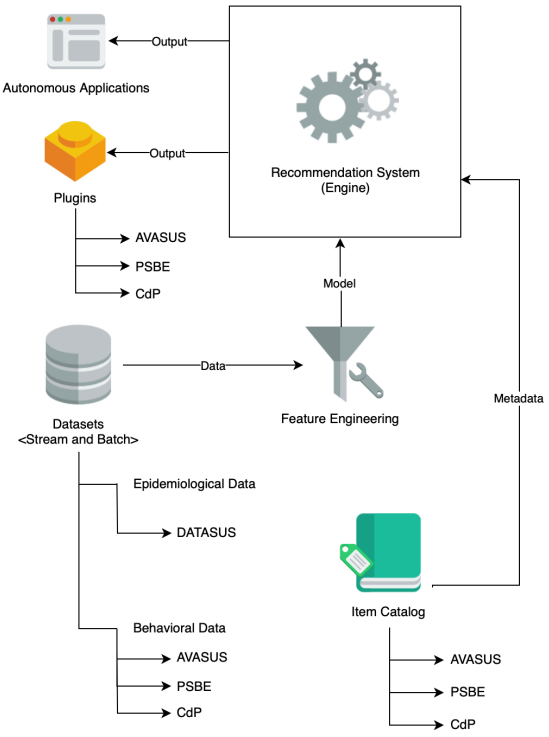

Figure 2: Proposed architecture for the recommendation system.

Extracting the metadata of items on AVASUS learning objects, Community of Practice experience reports and PSBE articles is one on the primordial actions to measure and make content available in the recommendation system. The hierarchy of items and their link in between should be accounted for extraction, as it would give meaningful information for recommendation.

Afterwards, the data will be provided by a data lake that aggregates all the data, becoming possible to enter the feature engineering phase. The purpose of this phase is to measure the data and to analyze the optimal approach to develop an accurate and fitting recommendation model.

As this work will make extensive use of data from real users of the information systems, there is a concern to not use or have access to any personal data that could be used to identify a person. It is important to follow Brazil's General Law of Protection of Personal Data (LGPD) and European Union's General Data Protection Regulation (GDPR). Every data must be anonymized by using industry standard techniques in order to enter conformity.

Finally, when the recommendation system has been done, it will become a standalone system with an API plug-in support. The plug-in API will allow to output the recommendation data to other systems. On all learning platforms, such as AVASUS, CdP and PSBE, there will be a plug-in that must connect to the recommendation system to retrieve the recommended content and then present it to the user interface.

4 DISCUSSION AND CONCLUSION

The impact of this project might be significant not just for the open health education, but for public health in Brazil. For example, AVASUS is a platform funded by the Brazilian government that has a very high usage by students and professionals. If those users have access to relevant content that could improve the health of the population, then the health system could be more resilient and more prepared not just for syphilis, but any endemics.

The particularity of the proposed recommendation system is that it is aimed at syphilis. In all the information systems presented in the previous sections there is relevant data on syphilis that will potentially contribute to this project. Once the recommendation model for this case study is made, it will be possible to make adaptations for other diseases.

This project is faced with a challenging scenario. As seen in this paper, in Brazil there is a great diversity of health information systems, covering all levels of health care, but with mismatched information and poor data integration between these systems. To extract, process and correlate information from such heterogeneous information systems requires a significant effort.

There is, therefore, the imperative to produce a methodology in recommendation systems that allows integrating the universe that involves health surveillance with educational aspects that connect the territory and aggravating diseases. This model should aggregate the various health data in the field of syphilis and correlate them with social, demographic and economic data. These correlations should be spatialized and oriented to decision making. Such mechanisms and tools, once implemented, can contribute to the challenges of health surveillance in Brazil, which will be directed to the logic of network operation. It is in this direction and with this purpose that this work presents itself.

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