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NTD Health: an electronic medical record system for neglected tropical diseases

NTD Health: un sistema de historias clínicas electrónicas para enfermedades tropicales desatendidas

NTD Health: EMR system for tropical diseases

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Rodrigo Ochoa: developed the NTD Health platform, led the dissemination strategies and wrote the draft of the manuscript.

Alessa Álvarez and Iván D. Vélez: edited the manuscript and supported the dissemination strategies.

Jordan Freitas and Saptarshi Purkayastha: were international contributors of the platform and educational content, and edited the final version of the manuscript.

Introduction: The use of technological resources to support processes in health systems has generated robust, interoperable and dynamic platforms. In the case of institutions working with neglected tropical diseases (NTD), there is a need for NTD-specific customizations.

Objectives: To establish a medical records platform, specialized for NTD, which would facilitate the analysis of treatment evolution in patients, as well as generate more accurate data about various clinical aspects.

Materials and methods: Here we developed a customized electronic medical record system based on OpenMRS for multiple NTDs. A set of forms and functionalities was developed under the OpenMRS guidelines, using shared community modules.

Results: All the customized information was packaged in a distribution called NTD Health. The platform is web-based and can be upgraded and improved by users without technological barriers.

Conclusions: The EMR system can become a useful tool for other institutions to improve their health practices as well as the quality of life for NTD patients, simplifying the customization of healthcare systems able to interoperate with other platforms.

Keywords: Neglected tropical diseases; electronic health records; public health informatics; software.

Introducción. El uso de recursos tecnológicos para apoyar procesos en los sistemas de salud ha generado plataformas robustas, interoperables y dinámicas. En el caso de las instituciones que trabajan con enfermedades tropicales desatendidas (ETD), existe la necesidad de personalizaciones específicas en herramientas de uso médico.

Objetivos. Establecer una plataforma de historias clínicas, especializada en ETDs, para facilitar el análisis de la evolución del tratamiento en los pacientes, además de generar datos más precisos sobre diversos aspectos clínicos.

Materiales y métodos. En este trabajo se desarrolló un sistema de registro médico electrónico personalizado basado en OpenMRS para múltiples ETDs. Se desarrolló un conjunto de formas y funcionalidades bajo las pautas de OpenMRS, utilizando módulos compartidos en la comunidad.

Resultados. Toda la información personalizada fue empaquetada en una distribución llamada NTD Health. La plataforma está almacenada en la web y los usuarios pueden actualizarla y mejorarla sin barreras tecnológicas.

Conclusiones. El sistema de historias clínicas electrónicas puede convertirse en una herramienta útil para que otras instituciones mejoren sus prácticas de salud, así como la calidad de vida de los pacientes con ETDs, simplificando la personalización de los sistemas de salud capaces de interoperar con otras plataformas.

Palabras clave: enfermedades desatendidas; registros electrónicos de salud; informática en salud pública; programas informáticos.

Neglected Tropical Diseases (NTDs) are a set of infectious diseases affecting mainly disadvantaged populations in tropical and subtropical areas of the world (1). The prevalence of NTDs is determined by various factors, including environmental conditions, social classifications, cultural conceptions, economic status, and the status of the sanitation infrastructure (2). In addition, there is a lack of economic resources for research and development on NTDs, and scarce interest of the pharmaceutical industry in response to the economic features associated with their population (3). This has resulted in multiple philanthropic agencies coming together to create organizations for improving the visibility of NTDs (4-6). The direct association of the scenarios where NTDs are prevalent, with limited economic resources, is also evident in the allocated budget for their health care centers. To improve the health management of NTDs under such conditions, one strategy is to provide tools which can transition clinical data from paper to digital, including Electronic Medical Record (EMR) systems. There are various free and open source (FOSS) EMR systems that have been designed with an emphasis on developing countries (7,8). The main advantages of these FOSS EMR are lower implementation costs, fewer restrictions around customization, improved sharing of knowledge and lower development efforts (9). In order to select the most appropriate platform to meet the needs of a NTD workflow, criteria such as the possibilities to customize without expert knowledge in computer programming and recording data offline to be later integrated into the web database are taken into consideration (10,11). Among the FOSS EMRs, OpenMRS has a modular system that can be adapted to the needs of various contexts, as well as create metadata according to the needs of each institution (<https://openmrs.org/>) (12). It has a large dictionary of concepts with ease of creating new ones based on clinical needs, such as disease-specific terms.

In addition, OpenMRS allows personalizing the forms and reports according to the health issue and the needs of information analysis. The implementation of an EMR leads to the evolution of other information systems inside the health care center, and in the health system of the territories (13,14). These include systems to report laboratory results, systems for management of clinical information, and apps for smart devices to collect data in isolated areas. In all scenarios, interoperability protocols are required to allow sharing data of patients among health care institutions in a safe and satisfactory manner (15).

A customized EMR system based on OpenMRS was implemented to address the management of information from patients affected by NTDs. The system was adapted to the needs of the Program for the Study and Control of Tropical Diseases (PECET) at the University of Antioquia in Medellín, Colombia, through forms specialized for NTDs and novel disease-associated concepts.

Materials and methods

Compiling requirements

We compiled a set of requirements to supply state-of-the-art forms, concepts and functionalities related to a variety of NTDs. Specifically, we adapted an OpenMRS distribution (reference application 2.3) to record data for diseases such as Dengue, Chikungunya, Zika and Leishmaniasis. According to the current OpenMRS modules and functionalities, we focused the deployment on four categories: disease-specific forms, authentication and roles, diagnosis, and drug orders. The topics were categorized based on the time required for development and implementation, complexity of each task and availability of functions previously created for OpenMRS.

Deployment of forms and concepts

Various disease-specific forms were built using the HTML Form Entry (HFE) module of OpenMRS. With the HFE module it is possible to develop forms using HTML, CSS, JavaScript, and new HTML5 features like offline storage and form validation, facilitating the entry of new data through any web browser. Epidemiological and clinical data were collected through a set of questions and add-ons, such as human body schemas to collect the location of lesions in the case of leishmaniasis reports. The EMR was adapted to the MCL/CIEL dictionary (<http://www.maternalconceptlab.com>) distributed along with some OpenMRS packages. In addition, a set of concepts not included in the original list were added, and consequently submitted to the concept project for sharing with the OpenMRS community. The concepts were mapped (if available) with other controlled medical vocabularies such as SNOMED CT (<http://www.snomed.org/snomed-ct>) and ICD-10 (<http://www.icd10data.com/>). Finally, we added forms to the patient dashboard and managed patient records based on defined roles.

For the platform infrastructure, the customized EMR system was deployed on a server running Debian Linux on Apache Tomcat v7 (<http://tomcat.apache.org/>), which is the recommended Java servlet container. Our EMR system can also be deployed to other Java application servers like JBoss or WebSphere. The OpenMRS data model and the concept dictionary were managed in a MySQL database server. The main languages used for the metadata were English and Spanish. Web-based access was provided to the health care personnel from PECET involved in the attention of patients affected by various tropical viral diseases and American Cutaneous Leishmaniasis (ACL). The forms for Dengue, Chikungunya and Zika virus

were compacted into one due to their similar symptoms, epidemiological conditions, and personal clinical histories.

Dissemination and training

To promote the open source technologies behind the EMR implementation, a local workshop called Health Informatics Tools (HIT) was conducted to train users and developers from Colombia and other Latin American countries (<http://ubmc-pecet.udea.edu.co/hitworkshop/>). Different tools such as OpenMRS, DHIS2 (<https://dhis2.org>), and Sana (<http://sana.mit.edu/>) were included for discussion and their connections with the NTD Health platform. Simultaneously, an open course was built for users, implementers, and developers of OpenMRS around the world. The course contains information reviewed by experts, with videos and various methodologies that can help guide the migration and implementation of platforms such as NTD Health in other scenarios.

The implementation strategy covered in NTD Health is summarized in figure 1.

Ethical approval

This project did not involve any studies with human participants or animals performed by any of the authors.

Results

Deployment strategy

The enterprise version of the OpenMRS reference application 2.3 was used for NTD Health. To personalize the system, the *ReferenceApplication* and the *UICommons* modules were modified to include the NTD Health logo and other stylesheet changes in the source code. We used the Spanish translation because the implementation was originally intended for Latin American institutions. At the time of the deployment, most of the terms were not translated appropriately due to the new release of the

reference application. For this reason, we supported the translation of terms from multiple implemented modules. Specifically, the *OrderEntryUI* module was completely translated and made publicly available to the entire OpenMRS community.

To capture local and personalized patient data, the registration form app was modified from the source code and additional questions about country ID, occupation, and health institution where the patient is affiliated were included (figure 2). Questions about the diseases were organized in forms and added to the deployment through the *HTMLFormEntry* module, following OpenMRS and general EMR guidelines (16). Three forms were designed to obtain information about tropical viruses, personal history, and epidemiological background of the patients. All the information required was designed by health personnel involved in the management of these diseases, aiming at providing all the necessary data to improve the diagnosis and future treatments.

The created forms, together with the defined MCL/CIEL concepts are available in the GitHub repository: https://github.com/rochoa85/NTDHealth_Forms. Using this controlled vocabulary to add new medical concepts associated with the NTDs is crucial to allow the interoperability of the platform with other local EMR systems, facilitating the potential communication between the platforms. Regarding the storing of data, this is managed through local installations of the platform, which means that nothing is stored in public servers, providing the security and confidentiality necessary to manipulate clinical information, as well as provide safe and long-term storing conditions. In addition, OpenMRS generates during certain time intervals copies of the information to avoid losing sensitive data.

Regarding the tropical viruses, we focused our attention to those transmitted by the same insect vector (*Aedes aegypti*), which present similar symptoms and are usually difficult to diagnose by health professionals from endemic territories (17). This set of diseases includes Zika, Dengue and Chikungunya, and all three have been characterized by general and specific disease-related data captured through physical exam questions, symptomatology and diagnostics inferences (figure 3). To obtain a broader panorama of the diseases, data from personal history with epidemiological background was captured including information about living conditions, traveling sites, duration of the travel, and potential exposure based on frequent activities. Finally, due to the expertise of the PECET research group in leishmaniasis, we used the *OpenWebApp* functionalities contained in OpenMRS to include a human body canvas on which the location of cutaneous lesions can be recorded graphically, along with descriptions. A snapshot of the application is provided in figure 4. The platform provides an open and useful way to document updated reports and improve the management of these diseases in isolated institutions which require automatized health information tools.

Dissemination impact

Two strategies were carried out in order to reach personally and virtually a group of users and developers in Colombia and other countries around the world. A summary of the strategies is shown in figure 5.

In the local workshop, we had the participation of various attendees from different sectors including engineers, health professionals, students, and entrepreneurs. The topics were distributed among different methodologies such as conference sessions, hands-on training, lightning talks, and a hackathon related to the needs and possible

solutions of health informatics tools for real problems, including the NTD Health platform (18).

The online course provides valuable and updated resources for people entering the world of OpenMRS, containing information about how to install the latest releases of OpenMRS under different environments, and more elaborate topics such as the customization and overriding of system variables, and manipulation of the data model. In the end, the goal is to provide sustainable and community-driven support to the project to facilitate in the future inclusion of novel modules and functionalities required by the NTD Health users.

Discussion

The implementation of EMRs has been useful to improve the efficiency of storing and analyzing clinical data, enabling meta-analysis and execution of data mining protocols for learning about epidemiological conditions, drug side effects and other evidence to improve disease diagnosis (19). Due to the lack of data associated with NTDs, the use of electronic platforms to store and manage clinical information is particularly relevant in order to improve research, curate novel datasets, and provide better healthcare services to the affected populations (20,21).

After surveying some users of the platform, we noticed that most of the health professionals still use paper forms and excel files to store clinical data, although the process is commonly disrupted due to the rigid structure of the storage system and lack of efficient synchronization across the users. As a secondary finding of this work, it was clear that a multidisciplinary team is a key element for establishing efficient data collection techniques. The participation of diverse groups composed of physicians, microbiologists, chemists, engineers, nurses, and platforms able to

facilitate their exchange of information enhances the process of managing NTD-related research and patient care.

As perspectives in the case of the system implementation, we highlight how its cloud-based accessibility could be useful in zones where clinicians are normally collecting the data. This will allow them to store data in real time and synchronize it quickly with information stored by other professionals. In fact, the system can operate in surroundings with lower connectivity resources, given the light HTML content included in the interface that usually does not demand a high bandwidth size to be accessed. This is also supported by the option of installing NTD Health as a standalone application in the healthcare center.

Regarding the usability of the interface, the OpenMRS reference application provides friendly functionalities for people that are not familiar with this kind of technology, which is one of the main barriers for health professionals to adopt such platforms in their daily activities. The platform can be subsequently customized to add user-friendly HTML forms covering other tropical diseases, as well as to adapt the questionnaires and data acquisition pipelines based on the internal country regulations.

Overall, NTD Health is a customized EMR system based on OpenMRS that provides forms and concepts required for the clinical care of patients diagnosed with tropical diseases. The collaborative and open nature of the project allows us to share the information with the community, and consequently incorporate their feedback and contributions to improve the system. The project is supported by a set of novel forms and concepts under the CIEL dictionary definitions, aiming to easily integrate them into OpenMRS implementations around the worldwide community of developers interested in NTDs.

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Competing interest

The authors declare that they have no competing interest.

Availability of data and material

General information about the NTD Health project is publicly available at:

<http://ubmc-pecet.udea.edu.co/ntdhealth/>. Training material about OpenMRS is provided here: <http://ubmc-pecet.udea.edu.co/hitworkshop/memorias/>. Tutorial videos are available in the YouTube channel:

<https://www.youtube.com/channel/UCwVkJPoM2Lhxj225jEaDMGA>. The generated metadata is distributed with all the code available in the GitHub repository:

https://github.com/rochoa85/NTDHealth_Forms.

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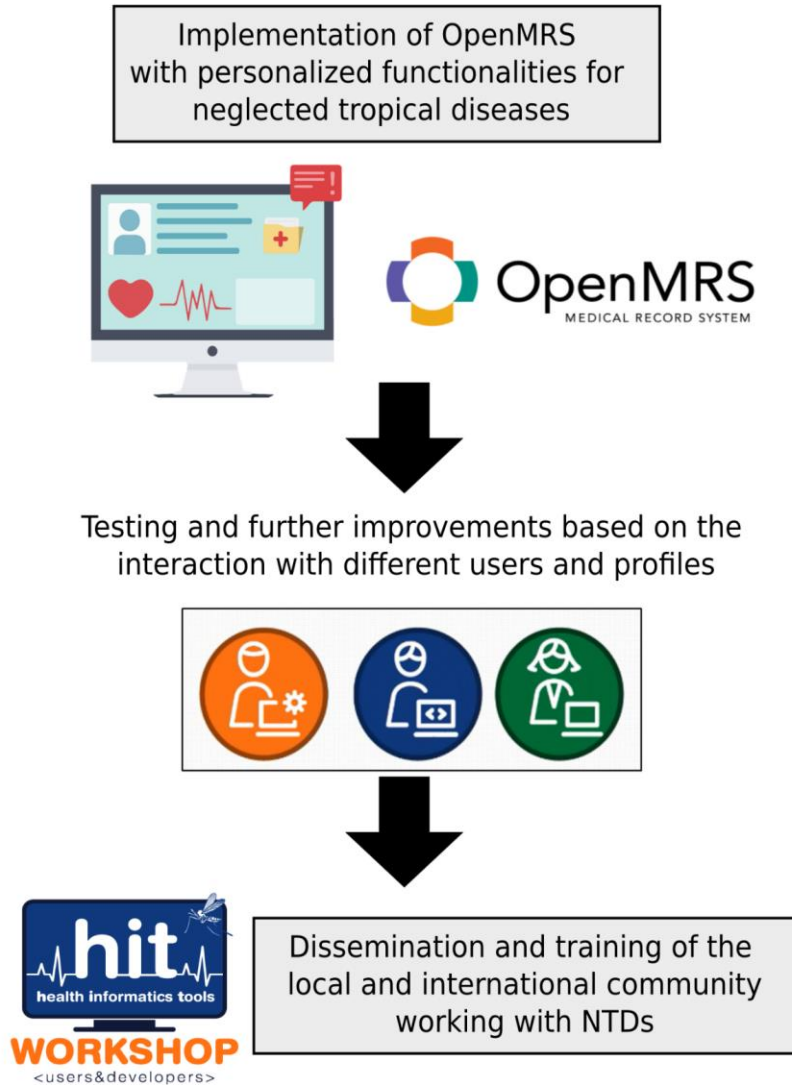


Figure 1. NTD Health implementation strategy. The process included the implementation of a customized OpenMRS platform with self-generated metadata. The project also involves dissemination and training for the local and international community through events and online educational material.

NTD Health

INICIO DE SESIÓN

Nombre de usuario: Contraseña:

Lugar de esta sesión:

Iniciar sesión

[¿No puede ingresar?](#)

NTD Health admin Consulta Externa Finalizar sesión

Registrar un paciente

Registrar un paciente

Datos demográficos

- Nombre**
- Género
- Fecha de nacimiento
- Estado civil
- Ocupación

Información de contacto

- Dirección
- Número telefónico

Entidad de Salud

- EPS

Identificación

- Tipo de identificador
- Número

Confirmar

¿Cuál es el nombre del paciente?

Nombre (necesario) Segundo Nombre Apellido(s) (necesario)

Paciente sin identificación

Figure 2. Screenshots of the login and registration forms from the NTDHealth implementation of the program for study and control of tropical diseases (PECET). The forms describe the specific data required in Spanish for the people affiliated with this EMR platform.

Formulario para Virosis Tropicales

En este formulario podrá reportar los síntomas al igual que el examen físico de pacientes febriles con sospecha de estar infectado con alguna virosis tropical como Zika, Chikungunya y Dengue

Fecha
(dd/mm/yyyy)

Lugar de la consulta

Profesional

EXAMEN FÍSICO


Cabeza y cuello

Ictericia Deshidratación

Piel

Petequias Equimosis

Cianosis Rash



Dengue
Zika
Chikungunya

SINTOMATOLOGÍA

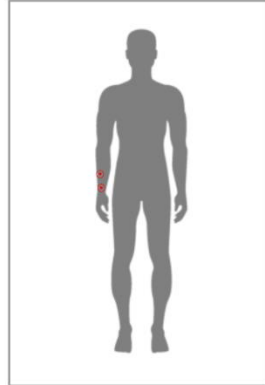
Mialgias

Artralgias

Figure 3. Screenshot of the tropical virus form for Dengue, Zika and Chikungunya. General information in Spanish with specific questions about physical examination, symptoms and diagnostics is included.

Localización de lesiones - Leishmaniasis

En este aplicativo tendrá la opción de señalar en el diagrama las partes del cuerpo donde se han detectado las lesiones de leishmaniasis cutánea



- Lesión cutánea N1
- Lesión cutánea N2
- Lesión cutánea N3
- Lesión cutánea N4

Cancelar

Guardar

Figure 4. Screenshot of the *OpenWebApp* canvas for the localization of cutaneous leishmaniasis lesions in a human body scheme.



Figure 5. Scheme describing the local workshop and the online course for OpenMRS training. Both activities were aligned to improve the knowledge of health informatics tools in Latin America, looking to create a regional OpenMRS community.