

Towards Networked eHealth: OMaT Project (Phase I)

Eustache Muteba A.*

Simon Kimbangu University, Kinshasa, DR Congo

Background and Purpose: A longtime ago, malaria was one of the most challenging infectious diseases caused by the parasite called Plasmodium and localized in areas of Asia, Africa, and Central and South America. It has affected developing countries' human resources and directly lowered its annual economic growth. The project OMaT is an online system, eHealth networked, to assist physicians at medical consultation in order to optimize the quality of care of the patients with malaria disease.

Methods: Our clinical decision support system for treatment of malaria is based on consensus guidelines and protocols for the management of malaria. Thus, the system only deals with medical theory and practice identified in advance, limited and structured so for its efficiency and completeness. The OMaT system provides the diagnosis and therapy aids of malaria's disease. But also, a Geographic Information System database that will store and will provide relevant information on malaria's patient case of different regions for the optimization of malaria's treatment.

Results: The prototype system presented is related to the phase I of the OMaT project. The proposed solution, in form of web applications includes a Generic Medical Decision Support System and is expected to assist Healthcare Professionals at medical consultation and decision of the patients with malaria disease. The prototype are developed using PHP, XML, HTML, JavaScript and CSS as front end and raw files, MySQL and NoSql Data base as the backend.

Conclusions: The OMaT Project under the decision support system is expected to optimize quality of care. The solution we offer meets several requirements such as the reliability of the information entered, protection against handling errors and lack of dangerous results, with respect to confidentiality and anonymity. We envisage again to proceed to the integration of smart technologies that can allow remote clinical examination, complementary examination and tests.

Keywords: Optimization of Diagnosis and treatments of Malaria, Networked eHealth and Interoperability, Geographic Information System, Smart healthcare technologies

1 Introduction

A long time ago, malaria was one of the most challenging infectious diseases caused by a parasite called plasmodium. The overall disease burden is devastating youth, women and health systems. It has affected developing countries' human resources and directly lowered its annual economic growth.

Nowadays, it is recognized in most modern hospitals and public health systems, an increasing concern to measure the quality of care. The quality of care [1], can be focused on the characteristics of hospital production and the indicators of performance. These indicators of performance will permit to decrease complication rate, morbidity, mortality and cost of care. One of the ways to optimize the quality of care is to use medical decision support systems [2-5] based on eHealth and mHealth to serve the unserved [6]. "E-health is commonly understood as the application of Internet and other related technologies to improve the health status of patients. It covers a broad range of tools such as electronic medical records (EMRs), Telemedicine, online or e-Learning tools, and Decision Support Systems." [7].

Thus, the emergence of Internet and others related technologies such as mobile devices and particularly medical devices allow, more and more, the development of the paradigm of globalization. In this con-

*Corresponding author: Simon Kimbangu University, Bongolo Street, n° 44, C/Kalamu, P.O. Box 1441, Kinshasa I, RD Congo. Email: emuteba@hotmail.fr, Tel: +243-812780105

© 2014 JHIA. This is an Open Access article published online by JHIA and distributed under the terms of the Creative Commons Attribution Non-Commercial License. DOI: 10.12856/JHIA-2013-v1-i1-34

text, Mars et al [8] argue that “the globalization is no longer driven by power full governments, Countries or large multinational companies, but by the new-found of individuals to collaborate and complete globally. “ And also, talking about the so-called a "Glocal Perspective" they say: "the inherent networked and virtual nature of eHealth that enables it to transcend geopolitical barriers does not fit easily with traditional domestic or local health systems. In this sense, in the magazine “The Economist” [9], it is stated that “considering the massive challenges facing Africa's healthcare systems, several major reforms will be need continent-wide to ensure their viability in long term: tightening controls over medicines, medical devices, and improving their distribution."

This paper discusses our project called OMAT for Optimization of Malaria’s Treatment, which is an online system, an eHealth networked, to assist physicians at medical consultation and decision of the patients with malaria disease. The proposed solutions, in form of web applications include anonymous medical records, a Geographic Information System and other relevant services such as remote complementary examination and tests.

The project is subdivided in three main phases. On the first phase, the system provides a medical consultation of malaria from clinical examination, complementary examination to treatments. It is, at this stage, a generic decision support system without optimization.

The second phase concerns the GIS that allow the optimization of medical decisions. And the third phase is dedicated to the remote laboratory that can integrate medical devices for complementary examination and tests, and telemedicine.

2 Materials and Methods

Many existing systems of malaria decision support, we have served as the basis for our study. We quote: Malaria Decision Analysis Support Tool (MDAST) [10], Geographical Recognition [11] Malaria Decision Support System (MDSS) [12], Web-Based Medical Assistant System for Malaria Diagnosis and Therapy [13].

2.1 Malaria's Medical Diagnosis

In the following purpose we outline the generic protocols that are used in OMAT system for medical decision support.

Protocol 1: Clinical Diagnosis.

1. Patient available for consultation
2. Inquire about clinical history and symptoms
3. Make investigation
4. Probably malaria
 - (a) Yes, observe complication clinical features. Uncomplicated cases or Severe or complicated cases
 - (b) Ask a laboratory test to confirm the hypothesis
5. Probably not malaria
 - (a) Ask for a complementary examination
 - (b) Continue with others investigations

Protocol 2: Laboratory and Complementary Examination Diagnosis.

1. Patient available for testing
2. Testing is performed to help diagnose malaria, to monitor for relapses, and to determine drug susceptibility of the parasite causing the infection. It can be one of the following:
Thick and thin blood smears and/or Rapid diagnostic tests (antigen testing) and/or Molecular tests (Polymerase chain reaction, PCR) and/or Antibody tests (serology) and/or Rolling Circle-Enhanced Enzyme.
3. Are malaria parasites present?
 - (a) If yes, which species and stages do they belong to?

- (b) If yes, how many of them are present?
4. Patient with complicated cases
- (a) Yes, do others laboratory tests and complementary examination following investigations

Protocol 3: Treatment.

1. Patient available for treatment
2. Which species of malaria is reveal by the test? Plasmodium vivax or Plasmodium ovale or Plasmodium falciparum or Plasmodium malariae or mixed species
3. What is type of malaria is confirmed? Uncomplicated malaria or Severe malaria
4. Prescribe drugs following: Location of the patient, Condition disease (Pregnancy, Traveler, Newborns, Recurrent, ...), Age, Weight, Past medication and Allergy
5. The response to therapy is dependent generally:
 - (a) Medicines used (direct or indirect schizontocides), their dosage and route of administration;
 - (b) The parasite involved and the sensitivity of this parasite towards the schizontocides;
 - (c) The clinical and immunological status of the subject.
6. The characteristics of drugs are: - Name's drug - Presentation - Dosage - Duration of treatment - Indications – Drug incidents.

2.2 Optimization of Malaria Treatment

The optimization of malaria's treatment is based on a Geographic Information System database that can stores and provides relevant information on malaria's patient case of different regions. The method is developed in [14] and consisted of height main steps: specification of the case, indications or problems, actions or treatments strategies, estimative outcomes (benefit and risk), performance measure, decision, result and optimization.

1. Specification of the case: case description relative to a particular patient in consultation.
2. Indications: a set of information related to problems concerning a particular patient.
3. Actions: The actions are different possible treatments referring to the given indications.
4. Estimative Outcomes: The estimative outcomes depend on the information related to similar patients' cases provided by clinicians. There are two kinds of estimative outcomes: the outcome with benefit and the outcome with risk.
 - Outcome with Benefit: expresses the degree to return to normal health.
 - Outcome with Risk: expresses the complication or the death.
5. Performance Measure: is a benefit-risk ratio referring to the action chosen by the clinician. This is obtained after computation of available information in the database.
6. Decision: The benefit-risk ratio can permit the clinician to make a decision. Practically, if the ratio is > 1 then the action can give benefit otherwise, if the ratio < 1 then the action has a risk.
7. Result: is the objective consequence of the decision chosen at the light of the performance measure. The patient can be in the following situation: a. Benefit, b. Risk. The physician can vote for one of the presented situation and the system automatically will be updated. This information may be considered sufficient and trusted.
8. Optimization: allows the clinician to analyze the results and if needed to readjust the actions.

2.3 Formalization of Reasoning in OMaT

Formalization of Diagnosis and Therapy Aids.

The diagnosis and therapy aids of OMaT are carried out using mainly the heuristic and the rule-based systems. The general form of rules is:

- Type of rule: R_n
- Rule syntax: IF <CONDITIONS> THEN <CONCLUSIONS>
CONDITIONS: <CONDITION1> [OPERATOR]

<CONDITION2> ...

CONCLUSIONS: ACTION1, ACTION2, ...

- Operator: OR, AND

- Criteria of condition: <=, >=, <, >, <>

This is below the basic rules:

1. Clinical Diagnosis Rules (CDR): represent the effects of a specific profile and a symptom or a set of co-occurring symptoms with respect to a hypothesis.

CDR: IF PROFILE AND (<SYMPTOM> AND <SYMPTOM-CONDITION>)
THEN <INITIAL- DIAGNOSIS>

2. Test Rules (TR): represent the effects test analyzed with respect to a test result.

TR: IF <TEST> AND <TEST-CONDITION> THEN <TEST-RESULT>

3. Medical Decision Rules (MDR): represent the effects of clinical diagnosis and test results with respect to a hypothesis.

MDR: IF < INITIAL-DIAGNOSIS> AND <TEST-RESULT> THEN
<DIAGNOSIS>

4. Therapy Rules (ThR): represent the effects of diagnosis with respect to a prescription

ThR: IF <DIAGNOSIS> AND <THERAPY-CONDITION> THEN
<PRESCRIPTION>

Formalization of Optimization.

The pre-processing of optimization can be doing as following:

- Each patient case at time t is represented by an attribute-value vector:

P= [UserId : V1, PatientId: V2, Sex:V3, AverageAge:V4, AverageWeight: V5, Country: V6, Status: V7, Conditions/Diseases: V8, PastMedications: V9, Allergies: V10, Symptoms: V11, ...]

- A patient case is n-dimensional vectors where each dimension corresponds to a distinct attribute and n is the total number of possible attributes.
- Identification of different patient communities in a population of patient cases.
- For that, two issues are suggested:
 - Determine meaningful subsets (communities/patients with similar case)
 - Determine meaningful concepts for each subset (stereotypes)
- The communities' stereotypes are built up by trying to identify patterns.
- Incrementally generates clusters (patient with common characteristics) representing patient communities as following:
 - Creating a new cluster
 - Placing a new patient case into an existing cluster
 - Combining two clusters into a new one
 - Dividing an existing cluster.
 - Extracting representative information

2.4 eHealth Networked Architecture

The system architecture is developed a round of three phases: Decision Support System, Geographic Information System (GIS) and Remote Laboratory (ILab).

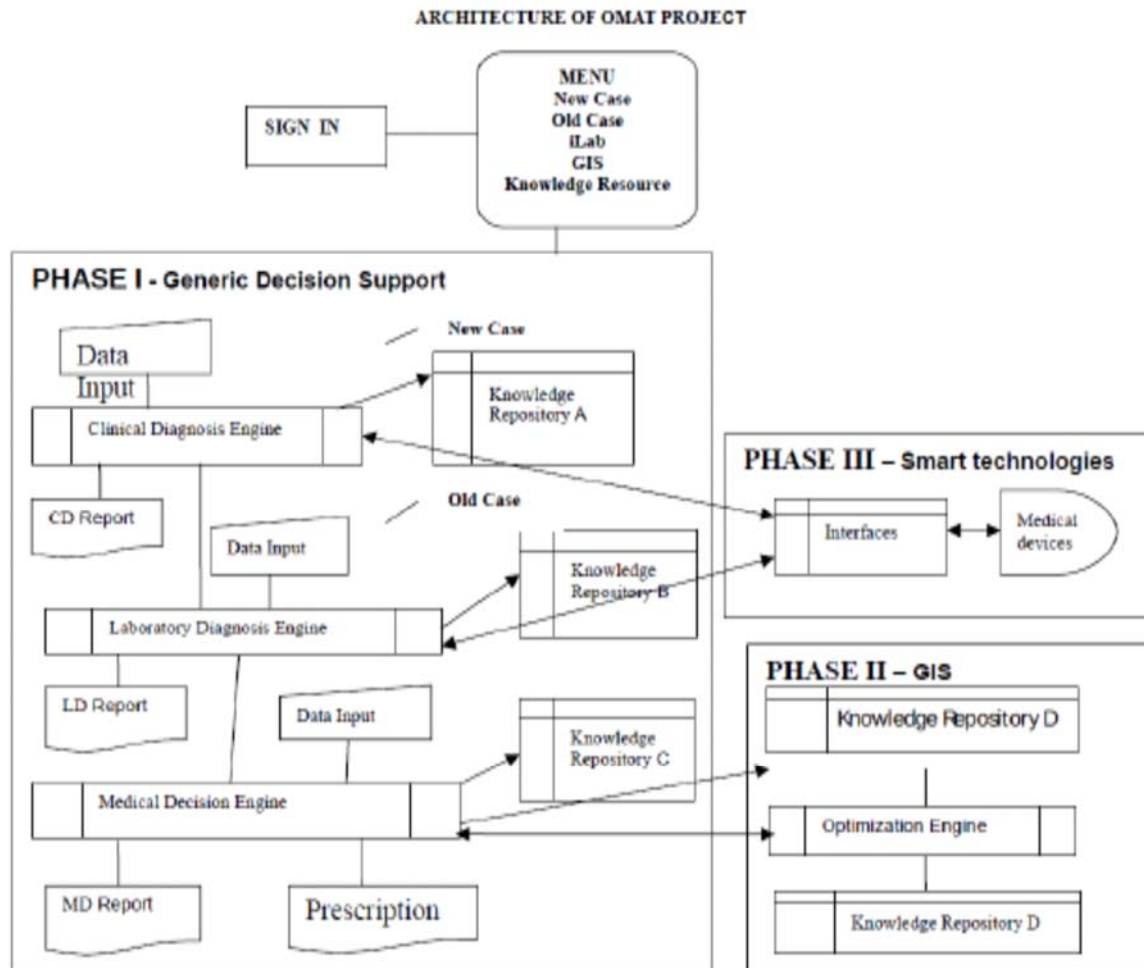


Fig. 1. Architecture of the OMaT project

3 Results

3.1 Phase I Implementation

In this section, we present the basic functionalities and show how they act in the OMaT system. The actual website for OMaT Project[14] is developed using Php, XML, HTML, JavaScript and CSS as front end and raw files, MySQL and NoSql Data base as the backend.

The OMaT system contains five basic components that constitute the main menu:

- newCase Component;
- openCase Component;
- iLab Component;
- GIS Component,
- Knowledge Repository.

We present in the following specifically the components that allow medical consultation saying the new-Case and openCase components. These two components allow medical decision support.

The newCase, as its name indicated, creates a new patient record in four steps:

1. Clinical Examination: Patient Profile and Signs and symptoms
2. Laboratory examination and Generated clinical diagnosis report
3. Treatment and generated reports of laboratory test, symptomatic treatments and treatment proposal, and the proper prescription of the Physician.
4. Generation of the full report of the case

The openCase is like the Newcase to the difference that the records already exist. It is recognized that the Healthcare Practitioner (HCP) to use our system must register himself and wait for the approval of the committee that granting the access identifier, figure 2.



Fig. 2. Interface of Registration

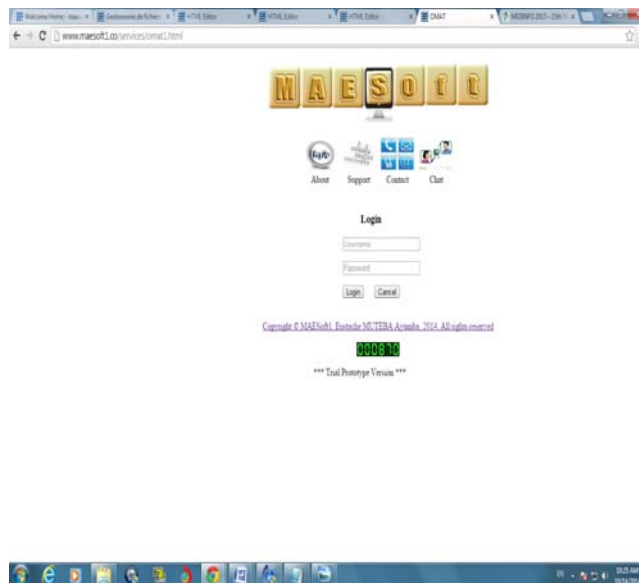


Fig. 3. Login interface

After that the HCP can login into the system via the Login interface, figure 3. If the login is successful then the HCP can accessed to the main menu and begin to interact with the system. The main menu, figure 4, has five options:

- newCase: allows the HCP to supplied information related to the clinical consultation (first consultation);
- openCase: allows the HCP to progress with the consultation and possibly optimize if needed the treatment. This allows the HCP to benefit added value of the GIS and the iLab components;
- iLab: allows the HCP to remotely access to distance laboratory or to submit image of species of Plasmodium for laboratory diagnostic;
- GIS: it is a Geographic Information System of case of patient with malaria in different area and it allows to the HCP advices by searching similar case;
- Knowledge Resource: allows the HCP to learn more about matter related to malaria by different articles or documents.

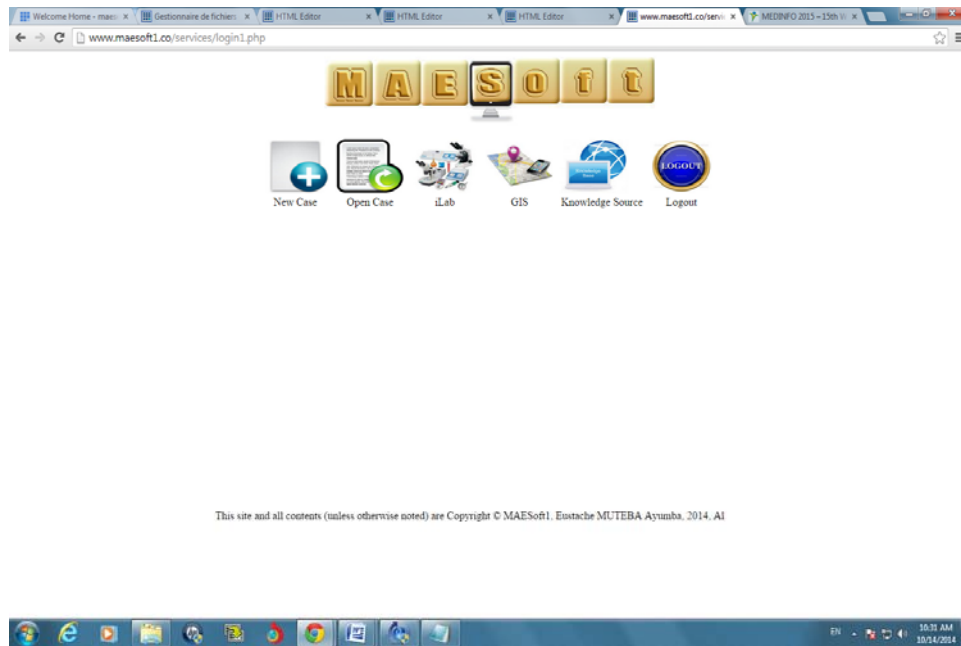


Fig. 4. Main Menu Interface

We describe in the following only the functioning of the system in the component newCase that allows the HCP to supplied information related to the clinical and laboratory consultation (first consultation). The component newCase is a succession of sub components namely: newCase1, newCase2, newCase3, and newCase4.

The newcase1, figure 5 & figure 6, allows the HCP to supply first information on the clinical consultation.

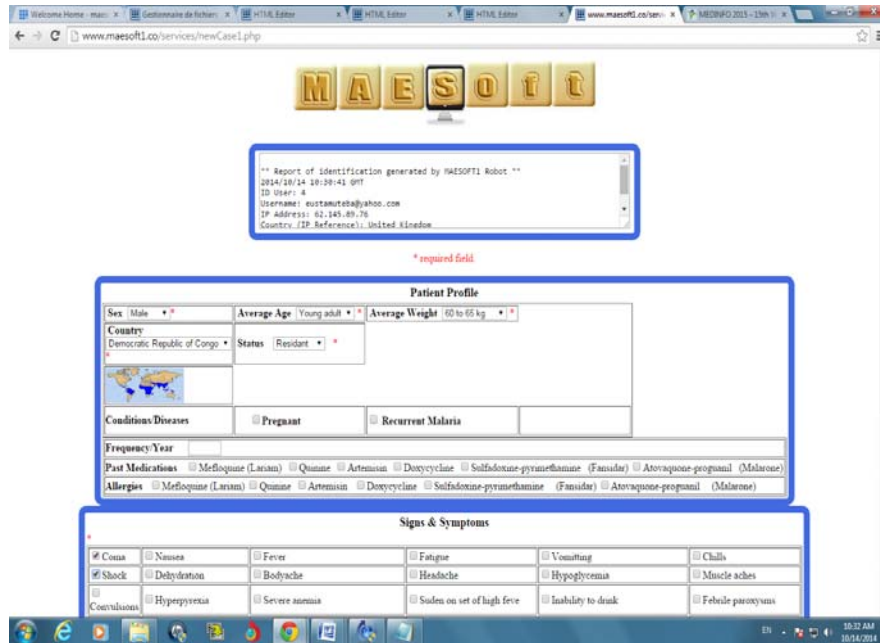


Fig. 5. Clinical consultation

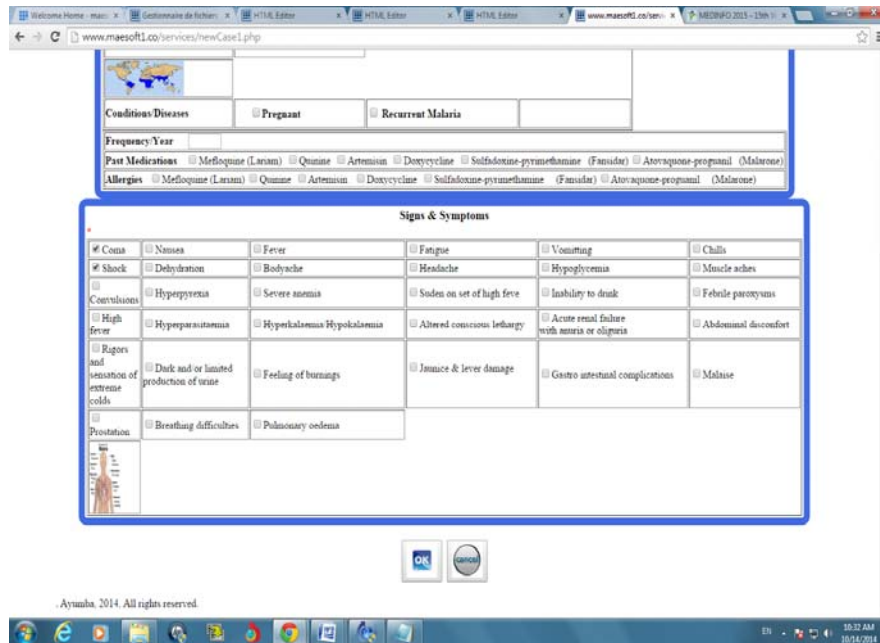


Fig. 6. Clinical consultation

The newcase2, figure 7, generates a Clinical Diagnosis Report and allows the HCP to supply information relative to the Laboratory Test.

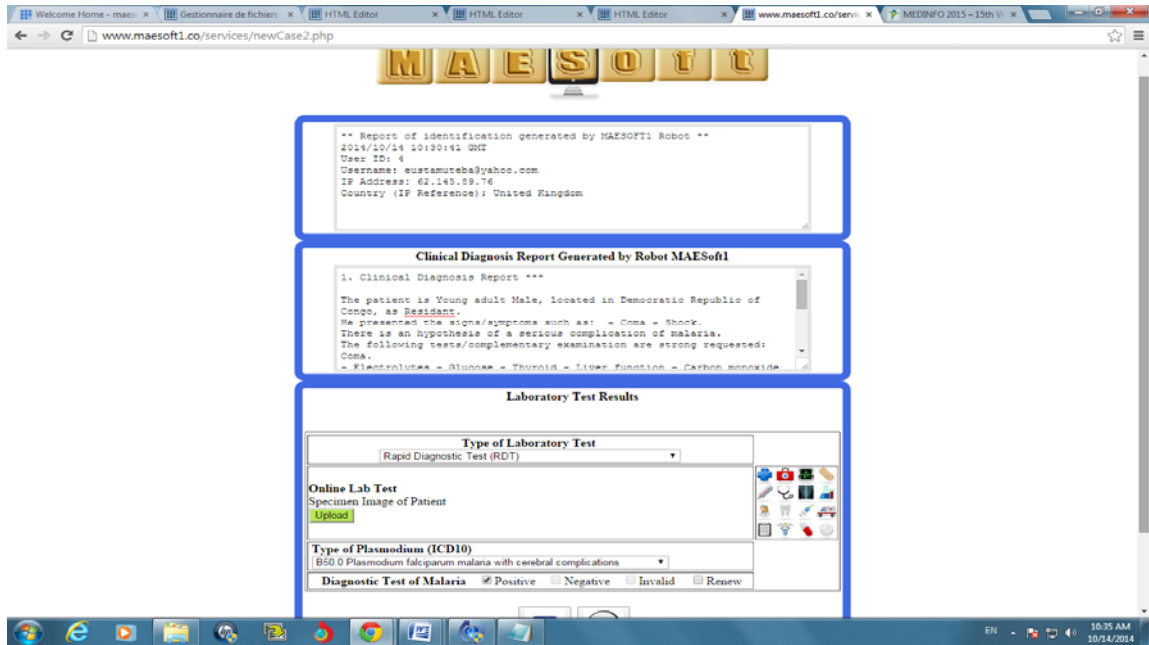


Fig. 7. Generated Clinical Diagnosis Report and Interface for Laboratory Diagnostic

The newCase3, figure 8 and figure 9, generates the Reports of Diagnosis, of Symptomatic Report and of Therapy Strategies. And it allows the HCP to write his own medical Prescription based on the reported information.

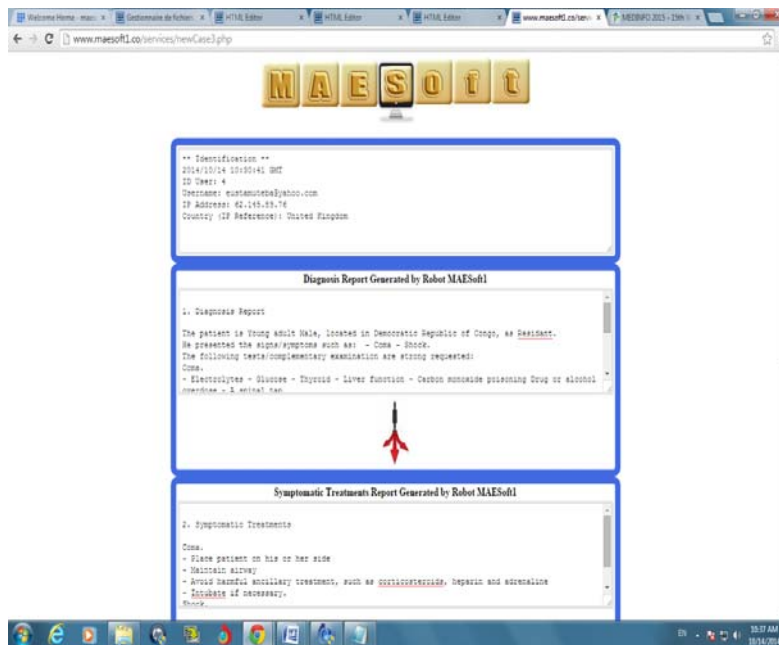


Fig. 8. Generated Reports of: Diagnosis, Symptomatic Treatments and Malaria Therapy Strategies, and Prescription

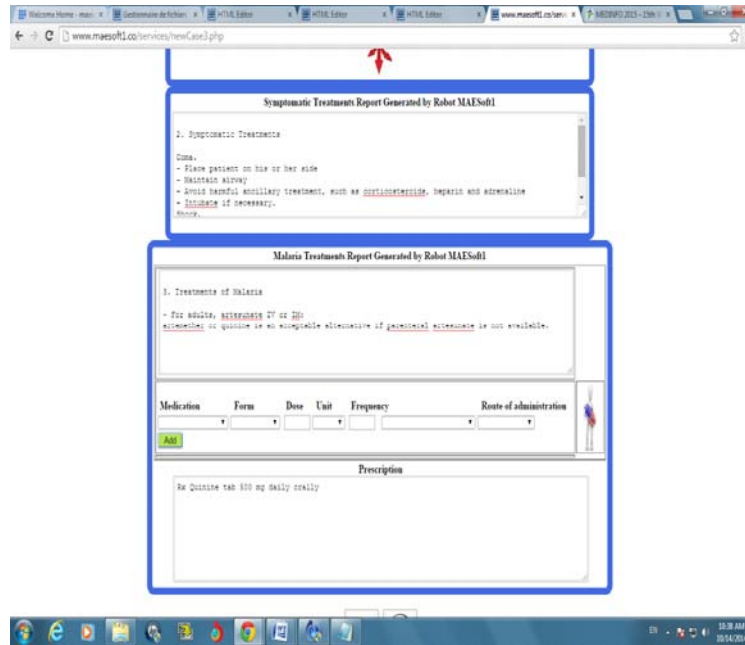


Fig. 9. Generated Reports of: Diagnosis, Symptomatic Treatments and Malaria Therapy Strategies, and Prescription

The newCase 4, figure 10, allows the HCP to print the Medical Decision Report and to receive an email with an attached file in form of Electronic Medical Record (csv format).



Fig. 10. Medical Decision Report

4 Discussion

The evaluation of our system as a medical decision support covers several aspects that we discuss below. The quality of the system depends on the reliability of the information entered, protection against handling errors and lack of dangerous results. Therefore, the human machine interface that we have proposed is quite responsive and easy to use to facilitate the work. A click allows the user to enter data. Error checking handling is based on internal constraints such as "a newborn cannot weigh more than 10 kg", or, for example, "a man cannot be pregnant." The Smart healthcare technologies [15-18], can be added to our system as active devices for diagnosis that are the key to enable people greater and more equitable access to health services and facilitate to collect and share health both in urban and rural areas. And the interoperability is a hottest issue challenging the Internet for interconnecting heterogeneous objects (systems, software components, devices). For the lack of dangerous results, it is to ask the following questions:

- Does the system do what I want it to do?
- Does what I want it to do work?

The methodology adopted to address these major constraints is the formalization of reasoning such as:

IF < INITIAL-DIAGNOSIS> AND <TEST-RESULT> THEN <DIAGNOSIS>

expresses as "If (Malaria is Severe And Plasmodium is Suspected) And (Location is Central Africa And Condition Disease is Recurrent malaria And Age is Adult And Weight is 65 to 70 kg) Then Quinine is recommended".

It turns that our clinical decision support system for treatment of malaria is based on consensus guidelines [19] and protocols for the management of malaria. Thus, the system only deals with information theory and medical practice identified in advance, limited and structured so for its efficiency and completeness.

The prototype system presented above is suitable for case of emergency and it is available online [20]. The proposed solution, in form of web applications includes a Generic Medical Decision Support System and is expected to assist Healthcare Professionals at medical consultation and decision of the patients with malaria disease.

References

- [1] S. Feld, What is the Definition of Quality Medical Care? Online: http://stanleyfeldmdmace.typepad.com/repairing_the_healthcare_/2007/03/what_is_the_def.html
- [2] J. Zvarova, H. Heroutova, H. Grünfeldova, K. Zvara, Empowering Clinicians by eHealth Technologies in Decision - Making Tasks, In IOS Press, Medical Informatics in a United and Health Europe, K-P. dlassnig et al. (Eds), 2009
- [3] M. Tribus, Rational Descriptions, Decisions and Designs, Pergamon Press, New york ,1969
- [4] D J. White, Fundamentals of Decision Theory, North-Holland, New York, 1976
- [5] E. Karni, Decision Making under Uncertainty, The Case of State-Dependent Preferences, Harvard University Press: Cambridge, 1985
- [6] S. Akter, P. Ray, mHealth - an Ultimate Platform to Serve the Unserved, IMIA Yearbook of Medical Informatics, 2010, p 94-100
- [7] T. Gerber, V. Olazabal, K. Brown, A. Pablos-Mendez, An Agenda for Action on Global E- Health, In Health Affairs, Vol. 29, NO. 2, 2010, p 233-236
- [8] M. Mars, R.E. Scoh, Global E-Health Policy: A Work In Progress, In Health Affairs, Vol. 29, NO. 2, 2010, p 237-243
- [9] The Economist, A report from the Economist Intelligence Unit, The future of healthcare in Africa. Online: <http://www.janssen-emea.com/sites/default/files/The%20Future%20of%20Healthcare%20in%20Africa.pdf>
- [10] R. A. Kramera and others, Using decision analysis to improve malaria control policy making, Health Policy 92,133–140, 2009
- [11] C. Gerard and others, Malaria elimination: moving forward with spatial decision support systems, Trends in Parasitology, Vol. 28, No. 7, Pp 297- 304, 2012
- [12] IVCC, Malaria Decision Support System (MDSS). Online: http://www.ivcc.com/documents/mdss_information_leaflet.pdf
- [13] A.O. Adetunmbi, A. Oguntimilehin, S.O. Falaki, Web-Based Medical Assistant System for Malaria Diagnosis and Therapy, GESJ: Computer Science and Telecommunications 2012, No.1(33)
- [14] E. Muteba, Optimization of Medical Decision: An Approach of Medical Decision Analysis, European Journal for Biomedical Informatics (EJBI). Volume 10, Issue 1,

PP 2-5, 2014

- [15] D. West, How Mobile Devices are Transforming Healthcare. Online:
<http://www.brookings.edu/~media/research/files/papers/2012/5/22%20mobile%20health%20west/22%20mobile%20health%20west.pdf>
- [16] S. Warren, R.L. Craft, Designing Smart Health Care Technology into the Home of the Future, 1999. Online:
<http://smxq.sharepoint.com/Documents/futurehomeSandia.pdf>
- [17] Y. Athavale, Potential applications of smart healthcare technologies - a literature survey report. Online:
<http://sarnexj.wikispaces.com/file/view/Potential+applications+of+smart+healthcare+technologies.pdf>
- [18] European Commission DG Health and Consumer, Medical Devices: Guidance document - Qualification and Classification of stand alone software. Online: http://ec.europa.eu/health/medical-devices/files/meddev/2_1_6_ol_en.pdf
- [19] World Health Organization, Guidelines for the Treatment of Malaria, Second edition. Online:
http://whqlibdoc.who.int/publications/2010/9789241547925_eng.pdf
- [20] E. Muteba, OMaT Project. Online: <http://www.maesoft1.co/services/omat1.html>