Optimization of Malaria's Treatment: An Approach of Medical Decision Analysis

Eustache Ayumba Muteba[1]

[1] Independent Researcher and Correspondent of IMIA in DR Congo

Abstract

Objective: Nowadays, it is recognized in most modern hospital and public health systems an increasing concern to measure the quality of care. The quality of care can be focused on the characteristics of hospital production and the indicators of performance. The indicators of performance can permit, generally, to decrease complication rate, morbidity, mortality and costs of care. Therefore, one of the ways to optimize the quality of care is to use medical decision support system.

Methods: The optimization of malaria's treatment is based on an automatic extraction of a geographic information system database that can store and provide relevant information on malaria's patient case of different regions. The method proposed is consisted of height main steps namely: specification of the case, indications or problems, actions or treatments strategies, estimative outcomes (benefit and risk), performance measure, decision, result and optimization.

Results: One of the most important outcomes of this work is an understanding of the requirements on a medical decision analysis formalism and system. The case study presented for the simulation constitutes a theoretical component that consolidates the validation of the formalism before the implementation.

Conclusion: The work embodied in this paper formed the second part of a research project called 'OMaT'. OMaT is an online system that aims to assist physician at medical consultation in order to optimize the quality of care of the patients with malaria disease.

Keywords

Optimization, Malaria's Treatment, Medical Decision Analysis

Correspondence to:

Eustache Muteba A.
Independent Researcher and Correspondent of IMIA in DR Congo,
Address: P. O. Box 14769, Kinshasa, DR Congo
E–mail: muteusta@maesoft1.net

EJBI 2014; 10(1):2–5
received: July 1, 2013
accepted: February 9, 2014
published: February 28, 2014

1 Introduction

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 indictors 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, 3, 4, 5] based on eHealth and mHealth to serve the unserved [6].

Malaria was one of the most challenging infectious diseases caused by the parasite called plasmodium and localized mainly in areas of Asia, Africa, and Central and South America. The overall disease burden is devastating youth, women and health systems.

The technical capability to perform a correct and a timely diagnosis and an appropriate treatment of malaria infection in an ill patient is of critical importance since symptoms of complicated malaria may suddenly develop, possibly leading to death despite intensive care efforts. To decide what tests to order, what diagnoses to consider, and what treatments to administer, physicians draw on a large, rapidly growing body of knowledge. [7]

The concern of the present paper, is the development of a method of medical decision analysis specifically an optimization of malaria's treatment.

2 Methods

The essence of the adopted method is in one hand based on a differential diagnostic model since the signs and symptoms of malaria can be confused with others diseases. And in the other hand, it is based on an automatic information extraction of geographic information system of stored malaria's patient case for an optimization of malaria's treatment.

2.1 Medical Decision Analysis

In medicine, comes often situations of uncertainly on knowledge, facts and sometimes on the used language. Kenner et al [8] reveal that "for some diseases, definite and unique causes like certain infections may be found. For other diseases, multifactorial causes have to be assumed, mostly because of lack of knowledge." The rational approach to decision making for problems where uncertainty figures as a prominent element is a decision analysis.

Major information on the medical decision analysis model can be found in [9, 10, 11, 12]. The medical decision analysis method proposed is prescriptive, based on a multicriteria methodology and constructive induction method. It consists 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.

Step 1: Specification of the case. The specification of the case describes basics clinical information relative to a particular patient in consultation such as sex, age, weight, antecedents, allergies, ...

Step 2: Indications. The diagnostic indicates the problems found on the patient. Indication is a set of information related to problems concerning a particular patient.

Step 3: Actions. The actions are different possible treatments referring to the given indications.

Step 4: Estimative Outcomes. The estimative outcomes depend on the information related to similar patients' cases provided by clinicians and stored in the Geographic Information System. This information can be extracted at this step. Furthermore, it can be automatically updated at the optimization step and then increased the effective of population concerned by malaria. There are two kinds of estimative outcomes: the outcome with benefit and the outcome with risk.

Outcome with Benefit. The outcome with benefit expresses the degree to return to normal health. It is a value compute as frequency of reveal result at the optimization step.

Outcome with Risk. The outcome with risk expresses the complication or the death. It is a value compute as frequency of reveal result at the optimization step.

Step 5: Performance Measure. The performance measure is a benefit-risk ratio referring to the action chosen by the clinician.

Step 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 have a risk.

Step 7: Result. The result is the really 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 clinician can vote for one of the presented situation and the system automatically will be updated. This information may be considered sufficient and trusted.

Step 8: Optimization. The optimization can allow the clinician to analyze the results and if needed to readjust the actions.

2.2 Information Extraction

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

1. 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, testResult: V12, treatments: V13, ...]

2. A patient case is a n-dimensional vector where each dimension corresponds to a distinct attribute and n is the total number of possible attributes.

3. Identification of different patient communities in a population of patient cases.

4. For that, two issues are suggested:
   - Determine meaningful subsets (communities/patients with similar case).
   - Determine meaningful concepts for each subset (stereotypes).

5. The communities' stereotypes are built up by trying to identify patterns.

6. 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 in two or several new cluster.
- Extracting representative information.

2.3 Method Validation

A given specification case S and an indication $\{I_n, n = 1, \dots, N\}$ area root of solution; where n is an integer between 1 and N.

An action $\{A_m, m = 1, \dots, M\}$ is a set of treatments strategies possible and admissible knew as applicable, obtain by means of selected multiple criteria reflecting the specification of the indication:

$$max\langle S.I_n = A_m \rangle \tag{1}$$

The action A_m implies estimative outcomes; Let the outcome with benefit (OB) be a time series and recursive function defined as following:

$$OB_t = \left(A_m, \left(\sum_{t=1}^{T} OB \right) \right) \tag{2}$$

where t is an integer between 1 and T. And, let the outcomes with risk (OR) be a time series and recursive function defined as following:

$$OR_t = \left(A_m, \left(\sum_{t=1}^{T} OR \right) \right) \tag{3}$$

where t is an integer between 1 and T.

The decision to choose an action A depends on the benefit-risk ratio call the performance measure (PM); If the ratio is > 1 then the action can give benefit otherwise, if the ratio < 1 then the action have a risk;

Let the performance measure (PM) be a function that associate an action to the ratio of the estimative outcomes

Table 1: Case study of malaria.

Specification of the problem		
Sex: Female Age: 40 Weight: 72		
Antecedents : - Allergies: Chloroquine		
Associated conditions or diseases: 2 months of pregnancy		
Localisation: Central Africa		
Symptoms and signs: Febrile paroxysms with body ache, nausea		
Indication		
Type of Infection: Plasmodia Falciparum (CIM-10, B-52)		
Severity of infection: Typical malaria		
Status: No recurrent		
Action		
Typical *P. falciparum* malaria is treated by Coartem, Quinine, Clindamycin and Chloroquine		
Estimative Outcomes		
Action 1 Coartem	Action 2 Quinine + Clindamycin	Action 3 Quinine
Estimative Benefit 1 405 effectives	Estimative Benefit 2 677 effectives	Estimative Benefit 3 318 effectives
Estimative Risk 1 212 effectives	Estimative Risk 2 312 effectives	Estimative Risk 3 241 effectives
Performance Measure		
Performance Measure 1 1.9	Performance Measure 2 2.2	Performance Measure 3 1.3
Decision based on estimative outcomes and its performance measure at time t		
Decision 1 (t) Choice: No	Decision 2 (t) Choice: Yes	Decision 3 (t) Choice: No
Real Result at time t+1		
-	Real Result 1 (t+1) Voted: Risk	-
Optimization at time t+1		
Choice: Yes		

OB and OR:

$$PM = (A_m, (OB_t/OR_t)) \tag{4}$$

It comes therefore: If, $A_1, \ldots, A_m$ implies effectively, by explicit verification, the estimative outcomes OB or OR; Then if, $A_{k+1}, \ldots, A_{k+m}$ considers as giving the outcomes OB, then, A_{k+m+1}, the real result will be OB, necessary by constructive induction demonstration; Or then if, $A_{k+1}, \ldots, A_{k+m}$ considers as giving the outcomes OR, then, A_{k+m+1}, the real result will be OR, necessary by constructive induction demonstration.

3 Results

3.1 Simulation: A Case Study

Malaria is one of the world's most deadly diseases. Even though it is highly preventable and treatable. More information can be found in [13, 14, 15].

The case study presented in Table 1 allows the simulation of our system, the data set used is fictive but it is approximately a reality.

4 Conclusion

On the first phase of the development of the project OMaT [16, 17], we are only proposed generic decisions without optimizations. We have been using the HTML, the JavaScript and the CSS for programming the client-side or the interface. OMaT is an online system that aims to assist physician at medical consultation in order to optimize the quality of care of the patients with malaria disease. We envision to contribute also to the realization of malaria vaccine by providing relevant information for vaccine malaria research such as virulence, antigenicity, evolution, and gene and protein interactions.

The work embodied in this paper formed the second part of our research project and provides a theoretical approach of the optimization of malaria's treatment.

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