Acta Scientific COMPUTER SCIENCES

Volume 5 Issue 10 October 2023

Research Article

An Ontology Model for Herbal healthcare Delivery in Southwestern Nigeria

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Received: September 21, 2023

Published: September 30, 2023

Abstract

Herbal medicine is holistic that addresses issues of the soul, spirit, and body. Easily accessible to most people in the southwestern Nigeria and it is very cheap in the rural areas. It consistently played a major role not only in Southwestern Nigeria but global healthcare, due to its indigenous natural history, easy access, and cost effectiveness. Herbal medicine (also known as botanical medicine) utilizes any of a plant's part such as leaves, seeds, roots, stems, flowers, fruits, bulbs, bark, tubers, rhizomes, gums, exudates, and nectars to promote health, prevent disease and treat illnesses. However, knowledge of this intellectual property is in danger of being lost when the herbal practitioners or healers are dead. It is either undocumented or documented. If documented, it is inaccessible, in local languages, non-standardized, and diverse. In healthcare delivery there is need to have detailed health information for proper understanding among the stakeholders on healthcare informatics terms used. Following this direction, this research work suggests a way to support the designing an ontology web-based application system that lessens this gap, using knowledge management and semantic structure. The application system is based on the development of a stakeholder medical forms concept which will be integrated with domain ontology into a herbal medicine ontology repository. This will support stakeholders' healthcare application system in providing numerous knowledge services to help herbal practitioners (professionals) in accessing and managing healthcare data.

Keywords: DSS; Herbal Healthcare Delivery; Information Systems; Knowledge Management; Knowledge Repository; Ontology Model; Southwestern Nigeria

Introduction

Herbal medicine is usually used in parallel to conventional medicine in Africa [1]**.** It is widely practiced in many countries based on indigenous theories, beliefs and experiences that are handed down from generation to generation through informal practices and self experiences [2]. Therefore, healthcare is the organized provision of medical care to individuals or people reside in a community. It consists of the management, practice, prescription, diagnosis and consultation for the treatment and curing of diseases [3]. Herbal medicine, based on herbs, can be used to enhance access to health care in many countries. The World Health Organization (WHO) defines herbal Medicine as "the sum total of the knowledge, skills and practices based on the theories, beliefs and experiences indigenous to different cultures, whether explicable or not, used in the maintenance of health. World Health Organization signifies the necessity to preserve and maintain this knowledge [4]. In this way, the terms "complementary medicine" or "alternative medicine" or "traditional medicine " were used alternatively with herbal medicine in different countries [5]. An avenue to ensure the safety and the efficacy of herbal medicine is by integrating herbal medicine with the formal health system, which can improve the follow-up process.

The herbal medicines and their preparations have been widely used for thousands of years in many oriental countries, such as in China, Korea, Japan, Nigeria etc. The process of manufacturing plant extracts (transforming freshly harvested medicinal plants into extract) [6] as shown in Figure 1. However, one of the characteristics of oriental herbal medicine preparations either presenting as single herbs or as collection of herbs in composite formulae, is that they are extracted with boiling water during the decoction process. This may be the main reason why quality control of oriental herbal drugs is more difficult than that of western drug, as pointed in "General Guidelines for Methodologies on Research and Evaluation of Traditional Medicines".

In general, one or two markers or pharmacologically active components in herbs or herbal mixtures are currently employed for evaluating the quality and authenticity of herbal medicines, in the identification of the single herb or herbal medicine preparations,

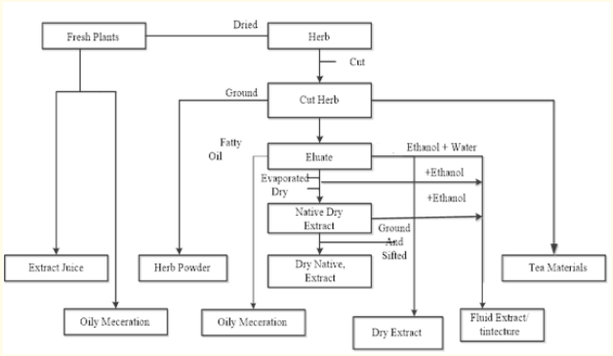

Figure 1: The process of transforming freshly harvested plant [6].

and in assessing the quantitative herbal composition of an herbal product. This kind of determination, however, does not give a complete picture of an herbal product, because multiple constituents are usually responsible for its therapeutic effects. Most of these multiple constituents may work 'synergistically' and could hardly be separated into individually active parts. Moreover, the chemical constituents in component of herbs in the herbal medicine products may vary depending on harvest seasons, plant origins, drying processes and other factors.

This integration can be realized by aligning medical knowledge structures with herbal medicine knowledge structures in order to achieve the semantic interoperability. Philosophically, ontology is a study of what exists. Formal ontologies have been exiting since the 18th century. In a computational perspective, it is used to formalizations and development of algorithms that support the generation of inferences from a given set of facts. Ontologies specify the semantics of a domain in terms of conceptual relationships and logical theories. For example, in a herbal healthcare-related knowledge, there is patient, disease, symptom, diagnosis, and treatment might be among the primitive concepts upon which one might want to describe the domain. These concepts define ontology for herbal health care. It is the specification of a conceptualization, a common knowledge that facilitates communication among the practitioners as well as development of information systems or decision support systems [8]. Ontological approaches are used to address semantic interoperability issues, flexibility of information management and integration, and complexity of information models [9].

Nowadays, ontologies have become popular for organizing and sharing knowledge. Whereas "Ontology is a formal, explicit specification of a shared conceptualization" that provides the descriptions for classes in the domain of interest, relationship among class members and the attributes that these classes should possess. The software developers provide semantic structure and knowledge base through web-services interface for writing and coding computing applications. These provide knowledge discovery which includes principles, symptoms, diagnoses, patient, treatment and disease [10]. Building an herbal medicine knowledge information system requires formalization of herbal medicine concepts and its relationships. With the use of computer and internet facility, there is need for the specification of herbal medicine ontology, and the development of tools for allowing experts in herbal medicine to build a knowledge base, validate such knowledge, and recover it when needed [11]. In order to preserve the indigenous knowledge of herbal medicines it needs to be standardized and practiced in accordance with scientific methods and included in international healthcare systems regulations [12].

When constructing an ontology for herbal medicine, there is need start with the medicinal materials that expresses the relationship between patients' symptoms, diseases and treatments. Biologically, materials (plants) and mineral resources have been used traditionally for patient treatments. Therefore, the ontology includes various data related to these materials, such as the scientific and common names, parts of materials used, effectiveness and if possible oriental organ of the human body [13]. To provide information about practices and methods of using herbs various place of residence, among the older generation or relying on their own experiences. The transfer of knowledge between the demonstrators and participants resulted in a large amount of folklore material. The knowledge of herbal medicine and ethnography will depends on the superstitions, beliefs, and the role of plants in folklore texts [14].

In this ontology, the herbal medicine knowledge acts as a mediator between classes of knowledge. The knowledge consolidates the important information about the prescription of certain medicine to cure certain diseases, the required quantity of herbs, the disease cured, the detailed prescription and its method of medicinal plants are captured as herbal medicine knowledge [2,6]. Though, ontologies present a useful approach for representing the knowledge, processes and actors that comprise chronic disease management (CDM). It is particularly useful for people with chronic non-communicable disease (CNCD) whose health data is often distributed among a number of different health and social care providers and in different formats. The ontology can then be formalized and translated into software to automate the data and data quality management. In addition, the ontological approach can potentially be used to capture the essence of CDM and the chronic care model in primary care [15]**.** Ontology is a specification of a conceptualization and relationships within a domain and which is amenable to machine processing.

Related works

Ontology is an abstraction or a model of a domain that provides the relationships between different concepts that can easily be understandable by both humans and machines. It is difficult to browse by herbal practitioners. Though with aid of web-based ontology browsers, such as Protégé and BioPortals can now be used for browsing the ontologies and searching the concepts [16]. Herb-

al Medicine is characterized with lack formal structure and methodology for engineering and unifying the knowledge for common understanding and integration with other medical practice and ethic. It combines customs and knowledge about the use of naturally available resources to treat illnesses; the mode of transmission of indigenous knowledge is through oral tradition. Though, it provides up to 80% of primary healthcare needs in Africa [17].

Ontology plays a vital role in the diversity of knowledge and management methods that can simplify communication between expert domains and users. This makes it easy for people (user) to find information on expert systems. This provides a referral model that can simplify H. communication between expert domains and improve understanding and information sharing with the provisions model and application in the form of a mobile application using ontology created by Protégé ontology web language (OWL) to help users [18]. A semantic web standard languages was used to enables the interoperability of the composite ontology store to agents outside of the system for reasoning strategies applied in the system to explanation the diagnosis derived from the constructed ontology model [19].

Ontologies can be viewed as an effective way of representing the clinical knowledge used for the decision making process. The decision support for diagnosising disease is used for detecting the risk of disease, prescribing or other intervention decisions and prevention [15]. Medical ontology is a model of the knowledge from a clinical domain that contains all of the relevant concepts related to the diagnostics, treatment, clinical procedures and patient data. The ontologies are structure or designed in a way that allows knowledge inference and reasoning. The structures are in a hierarchy such as classes, properties or slots, relationships between classes and individuals that inherit properties from upper classes [20]. Modern formal ontology eases the creation of knowledge based systems that required for managing clinical information. Ontology is presently being used as an integration of heterogeneous sources. It started from the idea that are invariants in reality 'classes' which captures the general terms used in literature that instantiate by particular cases of such classes, along with its diseases or symptoms [21].

Knowledge sharing has become an important issue that challenges the efficient healthcare delivery in eHealth system. Knowledge data sharing facilitates discovery and innovation, transparency, and reproducibility, and, ultimately, trust in science. Especially during the COVID-19 pandemic, demands for data sharing have accelerated with increasing calls for more rapid dissemination, assessment, combination, and analyses of new medical research results [22]. Ontologies is the back bone for semantic web and semantic knowledge representation in realizing the knowledge management, data integration, data publishing, smart data access and analytics, these are not possible without the smart knowledge representation [23].

Therefore, the purpose of this research work is to support the designing of an ontological framework that will preserve, standardize, and validate this knowledge of herbal medicines as for every modern scientific ethics, regulations and then making it possible to include this system of herbal medicines in mainstream healthcare delivery. Also, an application system that will mitigates the knowledge repository and management between the stakeholder and patient domains. Mapping the medical forms concept that is useful in assisting the healthcare stakeholders to formulate queries and understand retrieved herbal medical documents, and also helps the stakeholders and application system to deal with patient necessary inputs. Generally, the main aim is to:

- Development of a stakeholder knowledge repository and management in healthcare delivery that will reflect the relationship between the stakeholders and patients healthcare satisfaction.
- Integration and information sharing for medical decision about patients.
- Formal Representation herbal medical knowledge ontology repository.
- Implementation of CTPHM to help the herbal professionals navigating and searching services to support the development of semantic-based healthcare systems which need interchanges with stakeholders and patients.

Methodology

Methontology is a methodology to build ontologies from scratch [24]. Therefore, methontology framework was used because it allows ontology to be developed from scratch, and suggests the reuse of the concepts from the existing meta-ontologies. In this methodology, the ontology development was done in phases. The first phase, a disease ontology was developed for Southwestern Nigeria herbal medicine, and the second phase, a collaborative and mobile-based application was written in C# to facilitate searching and navigating the necessary information for decision making by herbal practitioners. The approach is shown in Figure 2.

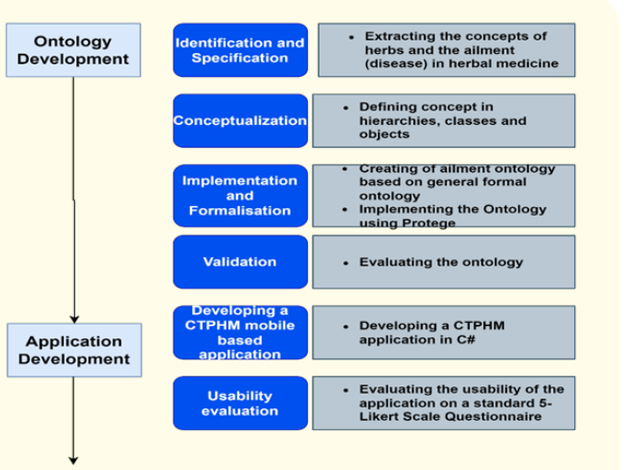

Figure 2: The research methodology flowchart.

Ontology development

This is the first phase which a well-structured method used for the ontology development. It covers the entire cycle of an ontology development process and consists of identification or specification, conceptualization, implementation or formalization, and validation.

Identification and specification

Initially, concepts and terms related to the diseases in herbal medicine were identified the literature reviewed. Identification and specification by expert users of the potentially heterogeneous data sources and dataset needed to identify cases, interventions, outcomes measures and any comparator group. These experts might be drawn from primary and secondary care, informatics, social care, workforce planning and other branches of management, academia and guideline developers; ideally with access to or knowledge of relevant routine data in their domain.

Conceptualization

A top-down approach was adopted to determine concepts and relationships in the ontology with initial categories of diseases in herbal medicine were identified. The concept of semantic can be used as a measure of the process or outcome of care. The contributing experts separately apply the ontology to the dataset to enable cases, interventions, outcomes and comparator data to be identified. The diseases were added to each category and a hierarchical structure of classes was created in Figure 2. From the above description and relationship, the relevant ontology concepts can be pointed out as:

- FUNCTION (for the actors of herbal medicine: practitioner and patient)
- PROCESS (for treatment of disease process)
- SYMPTOMS (for the role played on the symptoms)
- DISEASE (consideration of the herbs to use)

Implementation and formalisation

The ontology was formed based on the Formal ontology in a top-level ontology development approach for proper knowledge representation and standardization in the ontology development process. The formal approach will reflect the project's complexity, and use Protégé. A semantic mapping will combine the domain experts' data source specific ontologies into core ontology. The study outcomes would be derived from the relationships within this ontology. The diseases or ailments were defined as sub-classes of upper level classes and Protégé software were used for the designing of ontology class hierarchy structure shown in Figure 3 through Figure 5.

Validation: Domain experts will need to test the validity of the joint model using a three step process:

- Data flows (for key inclusion, exclusion and outcome variables).
- Process use-case models (interaction of key actors' impact on outcome variables).
- Business process models (affecting outcome variables).

Application development

This is the second phase that comprises of the development of a web and mobile-based application (CTPHM) and usability evaluation or assessment of the application.

Developing a Web and mobile-based application

An application, collaborative telediagnosis and prescription in herbal medicine (CTPHM) was developed in the C# programming environment for browsing the ontology. This herbal medicine ontology can be used in many expert medical applications that to infer the adequate herbal treatment according to patients' symptoms and ailments (diseases). It provides necessary information about diseases, symptoms, preparation and prescription of the herbs. In the CTPHM portal, herbal practitioner can easily navigate and interact with the system as shown in Figure 3 through Figure 7. The CTPHM was developed to facilitate knowledge sharing and management of herbal medicine in Southwestern Nigeria. It provide a platform to society, especially experts like botanists, pharmacologists, pharmacists, medical practitioners, and researchers to share and contribute knowledge on herbal medicine; to ensure that the related knowledge about herbal medicine is well documented and preserved; and encourage newer applications or systems to utilize the herbal medicine knowledge and promote the growing demand of the economic sector related to herbal medicine. CTPHM system is an online database

Usability evaluation (assessment)

The evaluation is done on the implementation of the algorithm and these metrics give an insight to the potential programmer of the ontology in terms of concepts and its relationships. The results obtained from the evaluation are based on the capabilities of the application, reliability and validity of the questionnaire.

Alternative Approach to herbal medicine ontology

The alternative approach for herbal ontology modeling provided by World health organization (WHO) shown in Figure 8 includes:

- **Herbal Medicines:** Herbal medicines include herbs, herbal materials, herbal preparations and finished herbal products that contain as active ingredients parts of plants, or other plant materials, or combinations. The conceptual framework of herbal medicine ontology structure is shown in Figure 8.

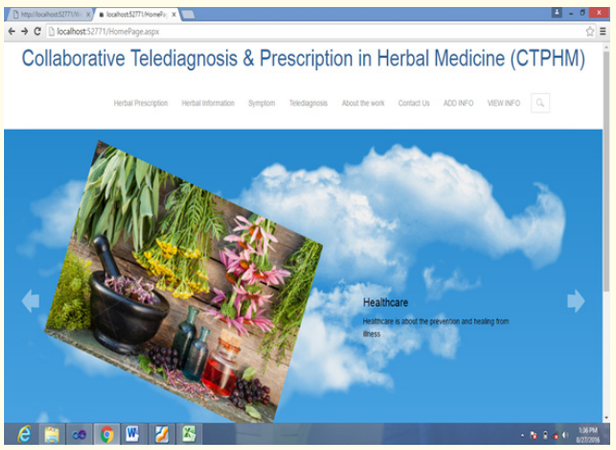

Figure 3: Home Navigation Page of CTPHM System.

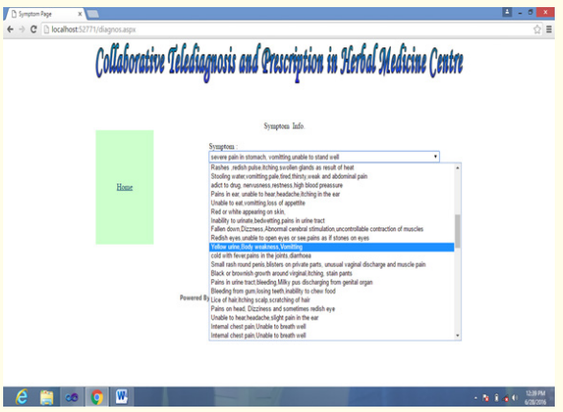

Figure 6: Navigation of Ailment symptoms for user's request for medication.

Figure 4: Navigation of Pictorial Update and Viewing Herb information.

SN	Ailment	Treatment	Prescription
1	Abdominal pain	Juice of aloe vera mix with honey.	Take 3times for 7days
2	Acne	Boil cuttup lemon grass,garlic,neem,vervain,tumeric , orange.	Take 1 table cup 3times daily
3	Acute dysentery	Chew leaves of Siam weed with urine	every morning for 3days
4	Allergies	Boil chalckweed,parsper leaves,peppermint,nettle,parsley with orange.	Take 1cup 3times daily
5	Arthritis	Boil mistletoe,garlic thorney pigweed,avocado leaves,chalckweed with honey.	Take 3times daily
6	Asthma	Mix powdered thorny pigweed,garlic tumeric & pepper with honey.	Take 3times daily
7	Bad Breath (Halitosis)	Mix powdered garlic,tumeric, pepper & thyme with honey.	Take 3times daily
8	Boldness	Mix Aloe vera juice,onion,horsetail,nettle with honey.	Rubb 3time daily
9	Bedwetting	Mix powdered plantus,nettle,mistletoe pepper,corn silk with honey.	Take 3times daily
10	Bladder Cancer	Mix powdered garlic,tumeric,corn silk,nettle & thyme with honey.	Take 3times daily
11	Breast Cancer	same treatment for bladder cancer but rubb same to the surface part of breast	3 times daily
12	Bronchitis(Cough)	Mix powdered garlic pepper,thorney pigweed,thyme bitter kola with honey.	Take 3spoon 3times daily
13	Burns	Apply honey on affected part then chew small quantity of garlic.	3times daily
14	Canker Sores (Cold Sores)	Mix powdered garlic pepper,tumeric,peppermint and vervain with honey,aloe vera juice and orange	Take 3times daily
15	Cataract	Apply Aloe vera juice directly until condition improve	2twice daily
16	Cervical Cancer	Same treatment to breast cancer but Aloe vera juice dipped at vaginal.	At night
17	Cholera	Squeeze scent leaves with little quantity of salt.	Take 3times daily
18	Chronic Obstructive Pulmonary Disease (COPD)	Mix aloe vera juice with orange	Take 3times daily
19	Colon Cancer	Boil,garlic,tumeric,aloe vera leaves,nettle ,parsper leaves & thyme mix with honey.	Take 3times daily
20	Congestive Heart Failure (CHF)	Mix powdered garlic pepper,thorney pigweed,thyme bitter kola with honey.	Take 3spoon 3times daily
21	Convulsion	Mix powdered garlic pepper,tumeric,pepper,nettle,mistletoe and vervain with honey or urine.	Take 3times daily
22	Conjunctivitis(Apollo)	Wash eyes with self urine then applied aloe vera	morning and night
23	Dandruff	Wash hair with urine then apply aloe vera gel to the hair	Daily after bath
24	Dehydration	Mix aloe vera juice with orange & neem leaves.	Take with salt 3times daily
25	Depression	Boil neem leaves,lime lemon grass,mistletoe and garlic.	Take 3times daily
26	Diabetes	Boil onion,garlic pepper,plantus,mistletoe,tumeric unripe pineapple,orange with bitter leaves.	Take at night
27	Diaper Rash	Mix aloe vera gel,honey and olive oil.	Rub to affected 3times daily
28	Diarrhea	Squeeze scent leaves with little quantity of salt or aloe vera juice with orange.	Take 3times daily
29	Drug Abuse	Boil onion,garlic pepper,mistletoe,tumeric cigarette(tobacco) leaves with honey.	Take at night
30	Ear Problems	Mix quantity of aloe vera juice & honey.	Drop into ear 3times daily

Figure 7: Navigation of showing Ailment and its medication and prescription.

Figure 5: Navigation of Herbal information list.

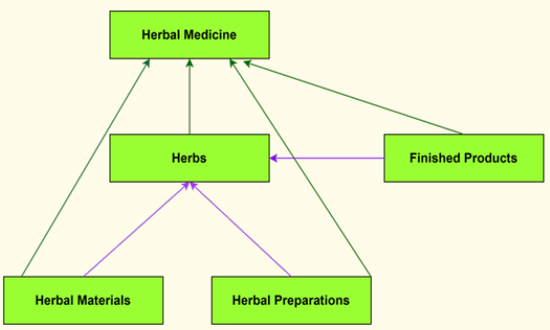

Figure 8: Conceptual framework of herbal medicine ontology structure.

Therefore, the herbal medicine ontology comprises of the followings:

- **Herbs:** Medicinal plant material such as leaves, flowers, fruit, seed, stems, wood, bark, roots, rhizomes or other plant parts, which may be entire medical plants as in Figure 9.

Figure 9: Medicinal plant material [17].

Herbal materials

This is additional to herbs, fresh juices, gums, fixed oils, essential oils, resins and dry powders of herbs. In Southwestern Nigeria, these materials are processed by various local procedures, such as steaming, roasting, heating or stir-baking with honey, alcoholic beverages or other materials as in Figure 10.

Figure 10: Medicinal plant material [17].

Herbal preparations

Herbal medicines preparation may vary from place to place, culture, and belief. Medicinal plants materials may be used fresh or dry depend on the increase in efficiency and decrease in toxicity. The preparation is done through extraction, infusions, decoctions, tinctures, ashing, and other miscellaneous way such as liniments in liquid or oily forms or lotions or poultices. The finished herbal products may include comminuted or powdered herbal materials, or extracts, tinctures and fatty oils of herbal materials. Herbs are produced by extraction, fractionation, purification, concentration, or grinded in powdered form or chunks together or other physical or biological processes as in Figure 11. Preparations can also be made by steeping or heating herbal materials in alcoholic beverages and/or honey, or in other materials.

Figure 11: Herbal medicines preparation in progress [17].

Finished herbal products

Herbal preparations made from one or more herbs. If more than one herb is used, the term mixture herbal product can also be used. Finished herbal products and mixture herbal products may contain recipients in addition to the active ingredients as in Figure 12. However, finished products or mixture products to which chemically defined active substances have been added, including synthetic compounds or isolated constituents from herbal materials, are not considered to be herbal.

Figure 12: Product: Finished Herbal Products for Consumption [17].

Algorithm for building the herbal medicine ontology (HMO) with the Symptoms Ontology (SYM), ailments (diseases) ontology (ADO) and other necessary information about the herbal medicine as follows :

class algorithm1 Herb_with_Symptom(SYM Ontology) {
For all symptoms S in SYM {
Update S to HMO
Fetch all Herbs cure S from some reliable resource
For all H in Herbs {

```
For all herbs H1 in MeSH ontology {
IF ((H1.name or H1.synonyms) == H) {
 Update H1 to HMO
 Update (H1 is_a Herb) to HMO
 Update (H1 cure S) to HMO
} //IF
} //For all herbs
} // For all H
Fetch all Herbs cause S from reliable resource
For all H in Herbs {
For all herbs H1 in MeSH ontology {
IF ((H1.name or H1.synonyms) == H){
 Update H1 to HMO
 Update (H1 is a Herb) to HMO
 Update (H1 cause S) to HMO
} //IF
} //For all herbs
} // For all H
} //For all symptoms
Break HMO
}
class algorithm2 Herbal_Material_with_Symptom (SYM Ontology, HMO Ontology) {
For all symptoms S in HMO {
Fetch all Herbal-Material cure S from some reliable resource
 For all HM in Herbal_Material {
 Update HM to HMO
 Update (HM is a Herbal_Material) to HMO
 Update (HM cure S) to HMO
IF HM composed_of more than one herb {
 For all H in HM:
 Update (H is a Herb) to HMO
 Update (HM composed_of H) to HMO
} //For all H
} //If
}//For all HM
Fetch all Herbal-Material cause S from some reliable resource
 For all HM in Herbal_Material {
 Update HM to HMO
 Update (HM is a Herbal_Material) to HMO
 Update (HM cause S) to HMO
IF HM composed_of more than one herb {
 For all H in HM :
 Update (H is a Herb) to HMO
 Update (HM composed_of H) to HMO
} //For all H
} //If
}//For all HM
} //For all symptoms
Break HMO
}
class algorithm3 Herbal_Material_with_Symptom (SYM Ontology, HMO Ontology) {
For all symptoms S in HMO {
Fetch all Herbal-Material cure S from some reliable resource
 For all HM in Herbal_Material {
 Update HM to HMO
 Update (HM is a Herbal_Material) to HMO
 Update (HM cure S) to HMO
IF HM composed_of more than one herb {
 For all H in HM :
 Update (H is a Herb) to HMO
 Update (HM composed_of H) to HMO
} //For all H
} //If
}//For all HM
Fetch all Herbal-Material cause S from some reliable resource
 For all HM in Herbal_Material {
 Update HM to HMO
 Update (HM is a Herbal_Material) to HMO
 Update (HM cause S) to HMO
IF HM composed_of more than one herb {
 For all H in HM :
 Update (H is a Herb) to HMO
 Update (HM composed_of H) to HMO
} //For all H
} //If
}//For all HM
} //For all symptoms
Break HMO
}
class algorithm4 Symptoms_with_Diseases( ADO Ontology, HMO Ontology){
For all Symptoms S in HMO {
For all Diseases D in ADO {
 Update D to HMO
IF D has_symptom S
 Update (D has_symptom S)
}//For all Diseases
}//For all Symptoms
Break HMO
}
```

C# programming coding (part of source codes) to implement herbal medicine ontology application (CTPHM) with the Symptoms, ailments (diseases), herbs, prescriptions or dosages as below:

```
using System;
using System.Collections.Generic;
using System.ComponentModel;
using System.Data;
using System.Drawing;
using System.Linq;
```

```
using System.Text;
using System.Windows.Forms;
using System.Data.SqlClient;
namespace Herbal
{
 public partial class Form1 : Form
 {
 public Form1()
 {
 InitializeComponent();
 }

 private void button1_Click(object sender, EventArgs e)
 {
 try{
 string query = "SELECT Name FROM Table1 WHERE (Name='" +
textBox1.Text + "' AND Password='" + textBox2.Text + "')";
 SqlCommand cmd = new SqlCommand(query, conn);
 SqlDataReader dr = cmd.ExecuteReader();
 string see = "";
 while (dr.Read())
 {
 see = dr[0].ToString();
 }
 dr.Close(); cmd.Dispose(); dr.Dispose();
 if (see == "") MessageBox.Show("Invalid Login", "Herbal Manage-
ment System");
 else
 {
 groupBox2.Visible= true;
 menuStrip1.Visible = true;
 }
 }
private void button6_Click(object sender, EventArgs e)
 {
 try
 {
 string query = "INSERT INTO HerbInfo(ScientificName,CommonN
ame) VALUES('" + textBox10.Text + "','" + textBox7.Text + "')";
 SqlCommand cmd = new SqlCommand(query, conn);
 cmd.ExecuteNonQuery();
 textBox7.Clear(); textBox10.Clear();
 }
 catch { MessageBox.Show("Error! Check your input."); }
 }
private void deleteToolStripMenuItem_Click(object sender, Even-
tArgs e)
 {
 if (dataGridView1.SelectedRows.Count > 0)
 {
 dataGridView1.Rows.RemoveAt(dataGridView1.SelectedRows[0].
Index);
 string q = "delete from table2";
 SqlCommand cmd = new SqlCommand(q, Form1.conn);
 cmd.ExecuteNonQuery();
 for (int k = 0; k < dataGridView1.Rows.Count; k++)
 {
 dataGridView1.Rows[k].Cells[0].Value = (k + 1).ToString();
 q = "INSERT INTO Table2(Disesase,RequestID,Treatment,Prescr
iption) VALUES('" + dataGridView1.Rows[k].Cells[1].Value + "','"
+ dataGridView1.Rows[k].Cells[2].Value + "','" + dataGridView1.
Rows[k].Cells[3].Value + "','" + dataGridView1.Rows[k].Cells[4].
Value + "')"; cmd.CommandText = q;
 cmd.ExecuteNonQuery();
 }
 }
 }
namespace herbal
{
 public partial class WebForm1 : System.Web.UI.Page
 {
 SqlConnection conn;
 protected void Page_Load(object sender, EventArgs e)
 {
 conn=newSqlConnection(@"Data Source=.\
SQLEXPRESS;AttachDbFilename=C:\Users\OGIRIMA\
Desktop\latestcode\Dr ogirima\Herbal.mdf;Integrated
Security=True;Connect Timeout=30;User Instance=True");
 conn.Open();
 }
  protected void DropDownList1_SelectedIndexChanged(object
sender, EventArgs e)
 {
 string q = "select treatment,prescription from table2 where ail-
ment='" +
 DropDownList1.Items[DropDownList1.SelectedIndex].ToString().
Trim() + "'";
 SqlCommand cmd = new SqlCommand(q, conn);
 SqlDataReader dr = cmd.ExecuteReader();
 while (dr.Read())
 {
 Label2.Text = "Treatment : " + dr[0].ToString().Trim() +
 ". Prescription : " + dr[1].ToString().Trim();
 }
 dr.Close(); cmd.Dispose(); dr.Dispose();
 }
 }
}
```

Knowledge modeling of CTPHM

The CTPHM consists of four main categories of knowledge, herb, herbal medicine, process and pharmacology. Each plays specific roles and incorporates significant functions.

Herbs knowledge plays a role that enables the practitioner to capture the essential knowledge about herbs that is potentially useful for medicinal purposes. Other information about herbs are scientific name, common name, origin, distribution location, suitability of climate, rainfall requirement, soil type, propagation parts and management information, are captured as herb knowledge. This information enables the herbal practitioner to have a good understanding about the herb. This will ensure that the benefits of the medicinal plant can be utilized wisely and at the same time able to support the growing demand for herbal medicine. The only way to prevent the growing demand for herbal medicine from causing the extinction of endangered herbal species is to plant these herbs commercially. In order to make sure that these herbs can be grown commercially without losing their medicinal properties, good understanding of the growth requirements of these crops is important. These include the understanding of their natural growth habitat, collection techniques, propagation of the planting materials, harvesting, and post harvest handling of the herbs.

Herbal medicine knowledge acts as a mediator between other fields of knowledge. This knowledge will consolidate important information about the prescription of certain medicine to cure certain diseases. The required quantity of herbs, the disease cured, detailed prescription and prescription method of the medicine are captured as herbal medicine knowledge. Herbal medicine knowledge is closely related to process knowledge.

Process knowledge explains the sequence of interdependent and linked procedures for herbal medicine preparation. Proper steps and clear explanation in medicine preparation will ensure the food safety or quality control of herbs and the efficiency in treating certain diseases.

Pharmacology knowledge is important as an evaluation may be carried out to prove scientifically on the experience on the safety and efficacy of herbal medicines. This can be conducted to validate a newly found plant material or a new combination of herbal medicines, or even a new indication, a new dosage form or a new administrative route for an existing herbal medicine. There are two major pieces of information in pharmacology knowledge base. It includes pharmacology activity and toxicity. Pharmacological activity shows procedures involved in developing and modernizing herbal products into standardized and evidence based medicines. This will help the people to understand herbal medicine from the modern scientific perspective. Toxicological investigations are necessary to supplement human experience in defining possible toxicity from short-term and long-term use, it is vital in detecting toxicity that may occur either after prolonged exposure or long period of time after the exposure has been discontinued.

In the developed world, the dramatic revolution in healthcare was facilitated by the discovery of pharmacologically active chemical entities (supported by evidence-based safety and efficacy testing) and this has shifted the emphasis away from herbal medicine. Based on the importance of knowledge explained above, the CTPHM model consists of herb, herbal medicine, process, and pharmacology ontology which represent knowledge in Figure 13 that depicts the interaction between these four ontologies.

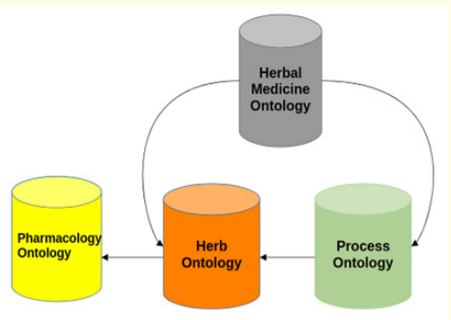

Figure 13: Overview of CTPHM Knowledge Repository.

Collaborative knowledge management

The CTPHM is an online, web-service-based system for collaborative and adaptive ontologies. It includes features like navigation, search, authoring, data validation, herbal practitioner management and ontology management which are significant functionalities for knowledge management activities. This research work focuses on the novel key features like customized class-hierarchy view, knowledge enrichment methodologies and the semantic data access layer. The navigation view consists of a class tree with an instance list and details of triples designed with aid Web Protégé, the CTPHM system displays class-hierarchy as in the nature of class modeling, which follows the inheritance. The structure of the ontology tree in a logical structure via Web Protégé in Figure 16 to provide better conceptual logical relationship for stakeholders in focusing on the herbs, herbal medicine and pharmacology tree respectively.

The classes and their hierarchy is not enough to preserve all the semantics of the domain. For this purpose, there exists an association between every instance of a class in the form of properties (or attributes). Data properties are of two types. It includes simple or complex. Simple properties contain primitive data of concepts that comprises of strings, numbers, etc. whereas a complex data property contains other objects. In the CTPHM ontology, there are several simple data properties as shown in Figure 14. Some of the data properties are:

- Ailment (Disease) Name. This property is of string type and it maintains the name of the disease.
- Symptoms' Signs. These are signs of any diseases attached to ailments
- Herb Common Name. It is string type and saves herb name.
- Herb Scientific Name. It is saves the scientific name of herb
- Herb part used. This is the part of medicinal plant to be used, either the leaves, root, bark, step or flowers
- Dosage. This is the of string that hold the prescription.

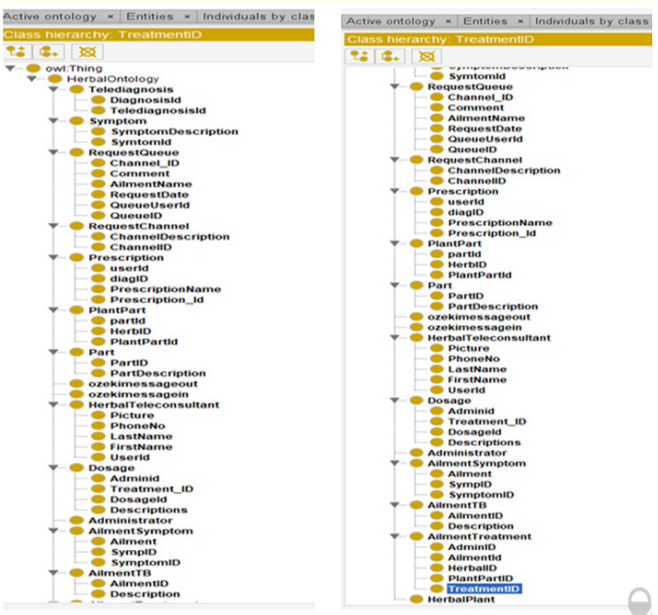

Figure 14: Basic Class Hierarchy and Concepts (Entities) structure of CTPHM Ontology.

This ontology model shows the functions and dimensions can be visualized in Figures 15 and16. It is a formal representation of concepts within a certain domain, and its relationships between concepts in a tree like structure. Thus, ontology provides a shared vocabulary for modeling a domain and its hierarchies and other relations.

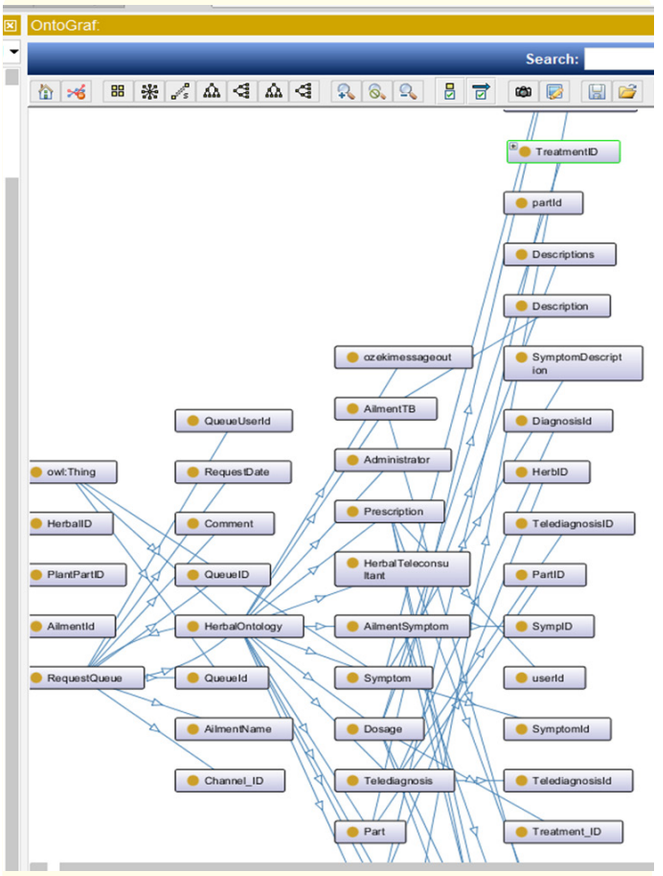

Figure 15: Class Hierarchical Tree structure of CTPHM System Ontology.

Results

Scientific information database was created to store all the necessary information about herbs, Ailments, symptoms, and treatments (prescriptions). To facilitate browsing the disease ontology, a CTPHM web and mobile-based application was developed using C# programming language in the Visual Studio environment to interface the covering the diseases (ailments), medicinal plant used, mode of preparation, and prescription (dosage). The domain coverage of the ontology for the research work was purely in English. A snapshot of the application is illustrated in Figure 3 through Figure 7. The usability of the application was evaluated with aid of Microsoft Excel on 5 likert scale questionnaire. The results showed that the mean values of and the overall capabilities of the application 2.69. The reliability and validity of the questionnaire have been examined in previous research concerning the herbal practitioners' perception of the use of modern technology in herbal medicine in Southwestern Nigeria [25].

Therefore, it can be concluded that the stakeholders' assessment of the application is at a satisfactory level. The hierarchical structure of the ontology was development with Protégé (version 5.5) for implementing the ontology in the Web Ontology Language (OWL).

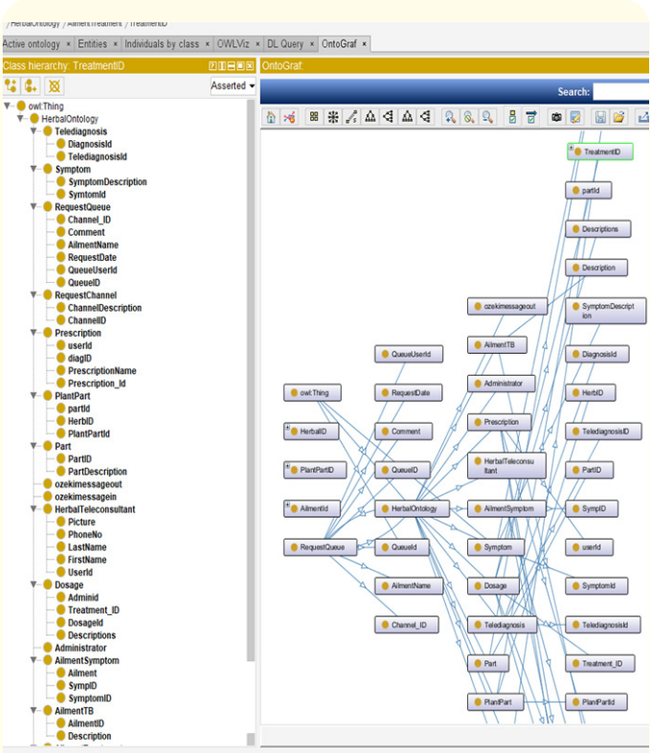

Figure 16: Class Hierarchical entity with the tree structure of CTPHM System Ontology.

Discussion

Herbal medicine has been seen as an effective way of healthcare delivery globally due to its accessibility and cost-effectiveness of services, though often undocumented or collected in a non-standard format. The expressing herbal medicine knowledge repository in a formal way helps in preserving the domain knowledge and facilitates information sharing. Ontology is therefore a way of expressing knowledge in a formal language. A Formal Ontology framework was used for developing the diseases ontology with underlying framework to improve the quality of knowledge representation, to construct the ontology, and to promote standardization in the ontology development process. This will allows detection of errors and helps in improving the quality of the ontology. With the ambiguity in herbal medicine knowledge, therefore, the assessment of ontology seems to be inevitable. A web and mobile-based CTPHM application was developed to facilitate obtaining access to the diseases ontology. It provides rapid access to information for decision taking regarding medication. The usability of the mobile-based application was evaluated, and the results showed that the usability was considered at a sufficient level from the specialists' perspectives. Overall, the development of herbal medicine ontology for Southwestern Nigeria was an attempt to represent the herbal knowledge in a standard format.

Conclusion

The collaborative and telediagnosis and prescription in herbal medicine (CTPHM) system was developed as an online platform to preserve, share and discover new herbal medicine knowledge among the communities in the Southwestern Nigeria herbal medicine practice. It serves as a vital tool in promoting and accommodating the growing demands of healthcare and economic sector in herbal medicine. This demonstrated the technical aspects and features of the CTPHM system. This system could be expanded to a more complex knowledge base such as the biodiversity repository for States in Nigeria. The ontology model was designed and developed for herbal healthcare delivery in Southwestern Nigeria in treatment of diseases. The evaluation was done based results of practitioners' satisfaction, degree of reliability, and the accuracy level of the diseases treatment. A mobile-based application was developed to facilitate obtaining access to the ontology, and the herbal medicine practitioners evaluated it at a reasonable level. The application can facilitate using the ontology by the specialists and for clinical decision support systems. This CTPHM web portal will be made available for public access to information on pharmacology or pharmacognosy, herbs and herbal medicine. The community of Southwestern Nigeria herbal practitioners will be able to contribute their knowledge and inputs in the related fields. The impact study is an ongoing system assessment process. As soon as the outcome of the study will be published out immediately the data is finally analyzed. The study will address two types of impact: economic and socio economic. Among the ways in which CTPHM can impact the economy includes:

- Encourage the cash flow in herbal medicine industry.
- Encourage exploration and production of medicinal plantation farming to herbal medicine industries in the Southwestern Nigeria.
- Employment opportunity in herbal medicine production or medicinal plant plantation to meet the herbal medicine demand.
- While the impacts to socio economic can includes:
- Reduction in the time required by the practitioners in collecting and accessing herbal medicine knowledge as it is available online in the system anytime and anywhere.
- Enhance awareness among the practitioners and patients on the use of herbal medicine as compared to modern medicine.
- Promote the usage of herbal medicine as alternative medicine among the populace.
- Promote the commercialization of herbal medicine to fulfill the user's demand.

Therefore, the impacts will be determined based on the outcome of the above mentioned impact carried studies. Besides herbal practitioners, other stakeholders may as well benefit from the developed CTPHM system. Pharmaceutical companies, academia or researchers and organizations that specialized in selling medicinal plants will definitely recognize the value of herbal medicine as a source of potential drugs and alternative providers of primary healthcare delivery in the society.

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