Ontology-Driven Information System Design for Women's Reproductive Health Education: Addressing

Oyinloye O. A.
University of Ilesa, Ilesa,
Osun State, Nigeria.
Oyinloefunke@gmail.com
+2348030565721

Emuoyibofarhe J. O.
Ladoke Akintola
University of Technology,
Ogbomoso, Oyo State,
eojustice@gmail.com
+2348033850075

Oladosu J. B.
Ladoke Akintola
University of Technology,
Ogbomoso, Oyo State,
jbladosu@gmail.com
+2348034556065

Ajala F. A.
Ladoke Akintola
University of Technology,
Ogbomoso, Oyo State,
faajala@lautech.edu.ng
+2348034080905

ABSTRACT
The widespread use of information systems has permeated healthcare, with telemedicine offering solutions for remote areas. This study aims to address knowledge gaps in women's reproductive health (RH) within the South-West region of Nigeria. A mixed-methods approach was employed to assess current knowledge levels and identify areas needing improvement. The first phase involved data acquisition through surveys targeting women of reproductive age (15-49 years) in the region. Statistical analysis was used to evaluate their understanding of key domains like menstrual cycles, family planning, and sexually transmitted infections (STIs). The second phase focused on designing an ontology-driven information system using the Protégé platform and Web Ontology Language (OWL). This system will cater to the identified knowledge gaps by providing readily accessible, accurate content based on user-defined queries. The proposed approach empowers women with the knowledge necessary to make informed decisions about their reproductive health, ultimately contributing to a healthier society.

Keyword*:* Information system, knowledge gaps, Nigeria, ontology, protégé ontology web language, publish-subscribe, Reproductive health, Women of reproductive age.

1. INTRODUCTION

In today's world, computers and information systems are constantly changing the way organizations conduct their day-to-day business practices. According to Correia *et al.* (2013) information systems can be defined as a set of interrelated components that can be used to collect, manipulate, and disseminate data and information for planning, control, coordination, analysis, and decision-making by an organization. Nowadays, the widespread use of information systems has permeated almost all aspects of life including the healthcare sector. Haux *et al.* (2006) described systems that process data and provide information Health information systems (HIS) refers to the interaction between people, processes, and technology needed to support operations, and management in delivering essential information to improve the quality of healthcare services (Goldschmidt, 2005).

Telemedicine helps eliminate distance barriers and can provide access to medical services that would often not be consistently available in distant rural communities (Froehlich, 2009). Thus, to facilitate the effective dissemination of information between public health experts, specifically obstetricians and gynecologists (OB/GYN) and patients (women of reproductive age), a publish-subscribe system is usually recommended. Obstetrics is a branch of medicine that specializes in the care of women during pregnancy and childbirth while Gynecology is the branch that deals with the diagnosis and treatment of diseases of the female reproductive organs. A specialist in obstetrics is called an obstetrician, while a specialist in gynecology is a gynecologist. Women of reproductive age are referred to as women within the child-bearing years of life between menarche and menopause, roughly from ages 15 years to 49 years (Collin *et al.,* 2020). The term 'content' refers to information obtained from medical experts, which are available but not formatted in certain ways easily accessible to the users upon request, thus there is need to facilitate the effective dissemination of information between public health experts and patients, hence the need for a user defined or content-based publish-subscribe system whereby the subscribers have more flexible and control of

subscription by allowing him/her to express his/her interest as an arbitrary query over the contents of the events (González *et al.,* 2022). Thus, subscriber is now able to define and describe the subscriptions based on content of the information such as symptoms of illness, causes, complications and possible treatment to mention a few. Reproductive health knowledge is a cornerstone of women's well-being throughout their lives. It empowers them to make informed choices and navigate their bodies with confidence, ultimately leading to better health outcomes, with the following significance:

a. **Informed Decisions and Empowerment:** Understanding menstrual cycles, fertility, and family planning methods equips women to make informed decisions about their reproductive health, knowledge empowers them to plan their families, prevent unintended pregnancies, and access appropriate healthcare services. United Nations Population Fund (UNFPA 2024)
b. **Improved Health Outcomes:** Reproductive health knowledge extends beyond family planning. According to the World Health Organization (WHO 2023), understanding sexually transmitted infections (STIs) and their prevention methods allows women to protect themselves and their partners. Similarly, knowledge about prenatal care and healthy practices during pregnancy, contributes to better birth outcomes for both mothers and babies. Lopez-Jurado et al. (2018).

Despite efforts to improve women's reproductive health (RH) in Nigeria, the following knowledge gaps persist in the South-West region:

a. Discrepancy between knowledge and behavior: Studies by Adebayo et al. (2022) suggest women may have some knowledge of contraceptives (e.g., HIV prevention) but low utilization rates indicate a gap between awareness and practice.
b. Limited knowledge of Sexual and Reproductive Rights (SRR): Research by Fawole et al. (2020) highlights a potential lack of comprehensive understanding of SRRs among married women in the South-West.
c. Socio-cultural influences: Traditional beliefs and gender roles may impact decision-making around family planning and seeking healthcare, as indicated in studies by Chigbu et al. (2015).

Empowering women with knowledge about their bodies and reproductive health choices. Reproductive health knowledge empowers women to take control of their bodies and make informed choices for a healthy and fulfilling life which is essential for healthier society Hence, this study assess the level of reproductive health knowledge among women and design an ontology-driven information system to address these gaps.

2 LITERATURE REVIEW

2.1 Publish-Subscribe Systems

Publish-Subscribe is a messaging paradigm where senders (publishers) of messages are not programmed to send their messages to specific receivers (subscribers). Rather, published messages are characterized into classes, without knowledge of what (if any) subscribers there may be (Awokola *et al.*, 2014). Subscribers express interest in one or more classes, and only receive messages that are of interest, without knowledge of what (if any) publishers there are. This paradigm helps to solve the problem of data redundancy, ensuring that only the required information gets to the end user. The most common approach in pub-sub systems is to consider that the matching procedure is performed by a set of dedicated machines, the brokers. The brokers, typically organized in an overlay, store the subscriptions received from subscribers and filter incoming publications, which are forwarded to the interested subscribers. Communication between publishers and subscribers is decoupled in time and space. Publishers do not need to know the identity of the interested subscribers, nor do they need to synchronize with them. The task of determining the subset of interested subscribers and routing the publications is the responsibility of the pub-sub system itself.

Figure 1 shows a diagram of a generic broker-based pub-sub system. The general objective of a publish-subscribe (pub-sub) system is to let information

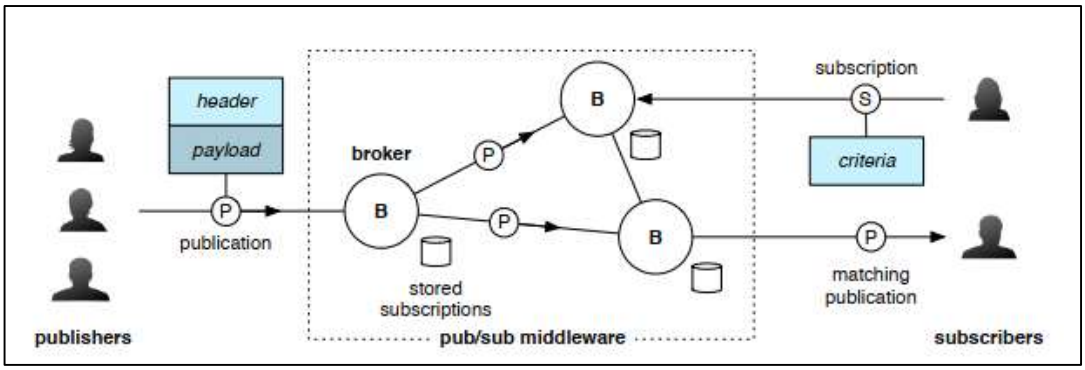

Figure 1: A Generic Broker-Based Pub-Sub System
Source: Onica *et al.* (2016)

Such a common general behavior is implemented with different flavors in actual systems known in the pub-sub literature. In particular, the three aspects that have to be specified are:

a. How subscribers' interest is expressed in relation to information? In other words, what is the query language used by subscribers for issuing subscriptions to the Notification Service. Therefore, only notifications should be delivered to a client that match one of its active subscriptions.
b. How the Notification Service is implemented? The Notification Service can be realized as a single, centralized entity or as a distributed set of processes. Therefore, each notification should be delivered to a client at most once.
a. How information is propagated from publishers to subscribers? That is, how the Notification Service exploits the underlying network levels in order to correctly dispatch information to interested subscribers. All notifications matching an active subscription should be delivered to the respective client

The first step in ontology development process is to find write the relevant terms that should appear in the ontology. In this stage we have exploited the XML-schema of the Continuity of Care Record (CCR) file, which is used in structuring the content of personal health records. That is, we have first developed an ontology (Peng *et al.*, 2020; Antoniou and Harmelen, 2004) suitable for PHRs and then we extend the ontology by other relevant features. In transforming the Extensible Markup Language (XML) Schema (Harold and Scott Means, 2002) of the CCR file to Web Ontology Language (OWL)-ontology (Dean and Schreiber, 2006), the following rules have been adopted by research studies.

a. The complex elements are transformed to OWL classes.
b. Simple elements are transformed to OWL data properties.
c. Element-attribute relationships are transformed to OWL data properties.
d. The relationships between complex elements are transformed to class-to-class relationships (object properties).

As OWL does not support structured attributes, all complex elements are transformed to classes while the complex elements that do not have identification are been transformed to a set of properties. After the schema of the CCR file is transformed, then personal health record (PHR) ontology is extended by information entity ontology (information therapy-ontology). It extends the PHR-ontology by the class *Information Entity*. Further it has sub-classes that are specified according to the concept they deal with. For example, subclass *DiseaseIE* is comprised of information entities that deal with diseases. The purpose of the personal health application (PHA)-ontology is to describe

the concepts of the domain in which blogs, PHRs and information therapy take place. Figure 2 graphically represents a subset of a personal health ontology (PHO). In this representation ellipses represent classes and sub-classes, and rectangles represent data and object properties. Classes, sub-classes, data properties and object properties are modelling primitives in OWL. In the graphical ontology shown in Figure 2, the classes:

a. *Patient* and *Medication* are connected by the object property *Uses*.
b. *BlogItem* and *Medication* connected by object property *Relates*.
c. *informationEntity* and *Medication* are connected by the object property *Associates*.

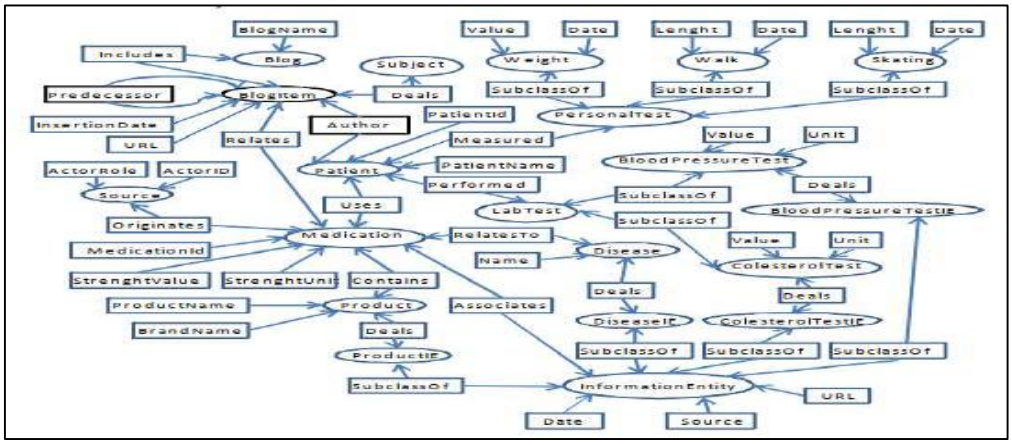

Figure 2: A Personal Health Ontology shown in Graphical Form
(Source: Puustjarvi and Puustjarvi, 2011)

2.2 REPRODUCTIVE HEALTH LITERACY IN DEVELOPING COUNTRIES: A FOCUS ON NIGERIA

Reproductive health literacy (RHL) plays a crucial role in empowering individuals, particularly women, to make informed decisions about their reproductive health. Research in developing countries, including Nigeria, highlights several key aspects of RHL:

Low Levels of RHL: Studies by Adedoyin et al. (2017) and Asaolu et al. (2018) suggest a consistent trend of low RHL across many developing countries. This translates to limited knowledge about contraception, sexually transmitted infections (STIs), safe sex practices, and maternal health.

Socio-Cultural Barriers: Research by Mberu et al. (2018) emphasizes the significant impact of socio-cultural factors on RHL. Traditional beliefs, gender roles, and taboos surrounding sexuality can hinder access to accurate information and healthcare services (Fawole et al., 2020).

Disparity in RHL: Research by Singh et al. (2019) indicates that RHL varies significantly within and between developing countries. Factors like education level, socioeconomic status, and geographic location all contribute to these disparities (Okojie et al., 2019).

The Case of Nigeria:

Nigeria, a developing country with a large population, faces specific challenges regarding RHL. Here's a closer look:

a. **Limited Access to Quality Education:** Akinmokun (2022) highlights poor educational attainment as a major barrier to RHL in Nigeria. This can limit access to accurate information and critical thinking skills needed to evaluate health information.
b. **Role of Media and Misinformation:** Studies by Adetunji et al. (2021) show that while media can be a tool for disseminating RH information, it can also be a source of misinformation. This underscores the need for reliable sources and media literacy.

Mberu et al. (2018) investigated RHL among women in rural Kenya. They employed a sequential mixed-methods design, starting with a quantitative survey to assess knowledge levels about reproductive health topics. In-depth interviews were then conducted with a smaller sample to explore the reasons behind knowledge gaps and decision-making around reproductive health. This study highlighted the influence of cultural norms on RHL and the need for culturally sensitive interventions. Asaolu et al. (2018) explored RHL among adolescents in southwest Nigeria. Their study employed a concurrent mixed-methods design. A survey assessed knowledge levels about contraception, STIs, and safe sex practices. Focus group discussions then provided a platform for exploring attitudes and cultural beliefs that might influence these topics. This research pointed out the disconnect between theoretical knowledge and actual behaviors, emphasizing the need for educational interventions that go beyond factual information. They used a convergent mixed-methods design. A survey assessed knowledge about HIV transmission and prevention. Semi-structured interviews further explored personal experiences, challenges, and coping mechanisms related to reproductive health. The study revealed limited knowledge and significant stigma surrounding HIV, emphasizing the need for targeted interventions for women living with HIV

2.3 ONTOLOGIES: ORGANIZING KNOWLEDGE IN HEALTHCARE INFORMATION SYSTEMS

In healthcare, managing vast amounts of complex and often siloed data is a challenge. An ontology is a formal representation of a domain's knowledge. It defines the concepts within a specific field, their properties, and the relationships between them. Imagine it as a structured vocabulary that clarifies meaning and fosters consistent data interpretation. For instance, a healthcare ontology might define concepts like "disease," "medication," "patient," and specify how they relate. It might specify that "diabetes" is a type of "disease," "insulin" is a type of "medication," and a "patient" can be "diagnosed with" a "disease" and "treated with" a "medication."

Here are some key characteristics of ontologies (Ashok, 2022):

a. **Explicit:** Concepts and relationships are clearly defined.
b. **Formal:** A specific language (e.g., OWL) is used for representation.
c. **Shared:** The ontology serves as a common understanding for different systems.

Applications in Healthcare Information Systems

Ontologies offer numerous advantages in healthcare information systems:

a. **Improved Data Interoperability:** By providing a shared understanding of terms, ontologies enable seamless data exchange between different healthcare systems. This allows for a more holistic view of a patient's health. (Nyulas et al., 2017).
b. **Enhanced Clinical Decision Support:** Ontologies can be used to develop intelligent systems that can analyze patient data, suggest diagnoses, and recommend treatment plans. (Sohn et al., 2007)
c. **Knowledge Management:** Ontologies can be used to organize and codify medical knowledge, making it easier to access and utilize for research and education. (Bittmann, 2008)

Some specific examples of how ontologies are being used in healthcare:

a. **SNOMED CT (Systematized Nomenclature of Medicine - Clinical Terms):** A widely used ontology for representing clinical findings, procedures, medications, and body structures.
b. **LOINC (Logical Observation Identifiers Names and Codes):** An ontology for standardizing laboratory and other clinical observations.

Benefits of Publish-Subscribe Architecture for Disseminating Information

The publish-subscribe architecture offers a powerful and efficient approach for disseminating information, with the following key advantages:

a. **Scalability**: This architecture can handle a large number of publishers and subscribers without compromising performance (Oyinloye et al., 2024). This makes it ideal for real-time information dissemination to a broad audience.
b. **Loose Coupling**: Publishers and subscribers don't need to know about each other directly. They simply interact with a central message broker, promoting flexibility and maintainability (Oyinloye et al., 2024).
c. **Decoupled Delivery:** Information delivery is not dependent on individual subscribers being online. Messages are stored and delivered when subscribers become available (Hutcheon and McNeill, 2011). This ensures reliable information delivery even with fluctuating network conditions.
d. **Topic-Based Filtering**: Subscribers can choose to receive information only on topics relevant to them. This reduces information overload and improves user experience (Oyinloye et al., 2024).
e. **Dynamic Content Delivery**: The architecture allows for dynamic updates to content being disseminated. Subscribers receive the latest information as soon as it becomes available (Hutcheon and McNeill, 2011).

Some real-world applications of the publish-subscribe architecture for information dissemination includes, Breaking financial news can be published once and delivered to all interested subscribers simultaneously, Real-time stock price changes can be disseminated to traders and investors through a publish-subscribe system, Information about traffic jams and accidents can be published and delivered to drivers in real-time using this architecture.

2.4 REVIEW OF RELATED WORKS

Awokola *et al.* (2014) worked on the development of a context-aware publish-subscribe information system for the public health service delivery. The study adopted a hybrid of implicit and broker models of publish-subscribe systems and the information filter combined both topic-based and content-based filtering. The architectural design was specified using UML diagrams such as flowcharts, use-case, and activity diagrams. The model was implemented as a mobile application in order to serve mobile users. The study was limited to the development of a publish-subscribe system which serves mobile users within the public health service. Narus *et al.* (2018) developed an event-based publish-subscribe architecture for supporting event processing workflows for an electronic medical records (EMS) system. The study developed a workflow for various events within a health care center's information system based on the publish-subscribe model. The results of the study showed that the event-based publish-subscribe model proved to be reliable, flexible and high scalability to heterogeneous devices. Belguith *et al.* (2018) developed an efficient revocation technique for content-based publish-subscribe systems. The revocation technique developed could efficiently remove compromised subscribers without requiring regeneration and redistribution of new keys as well as re-encryption of existing data with those keys. The technique required ensuring that subscriber's interest was not revealed to curious brokers and published data could only be accessed by the authorized subscribers. The study was limited to the modeling of an improved service delivery process for publish-subscribe systems required for ensuring confidentiality and privacy. Peral *et al.* (2018) an ontology-oriented architecture required for dealing with big data from heterogeneous sources for telemedicine systems. The ontology-oriented architecture consists of a core ontology used as a knowledge base which allows the integration of data from different heterogeneous sources. The study also applied natural language processing and artificial intelligence methods for process and mining data in the health sector for extracting hidden knowledge from diverse data sources. The

study was limited to the development of an ontology-architecture required for implementing a personalized telemedicine system for diabetes patients. Eken (2020), developed a topic-based publish-subscribe messaging scheme for supporting the detection of COVID-19 in X-ray image. The study adopted the use of a topic-based publish-subscribe model for the transfer of information between communication nodes over a distributed scalable network of collaborative computational nodes. The study showed that using the topic-based publish-subscribe model architecture as a middleware, information transfer is delivered within a shorter time thereby facilitating the development of an early warning system. Rodrigues *et al.* (2021). The study developed Publish-subscribe Digital Imaging and Communications in Medicine (PS2DICOM) model. The study adopted the combination of a cloud-based Pub-Sub infrastructure with high-level topics, including multilevel cloud elasticity and adaptive data compression features to facilitate the contribution and collaboration capacity of distant medical specialists who are engaged in a particular study by sharing access to medical images and correlated metadata The study achieved the transmission of high quality, storage capabilities, querying, and retrieval of DICOM images was. However, in the study, the security measure to mitigate intrusion by cyber attackers wasn't considered. Also, the system was not tested to validate the veracity of the data sent and received. The packaged might have been damaged during compression, and transmission. Abdul and Hasan. (2020). The study developed an Enhanced MQTT (Message Queue Telemetry Transport) Protocol by Smart Gateway a software/hardware between sensors and IoT platform for sharing healthcare information. The study adopted IoT application protocols based on publishing/subscribing patterns and uses a broker to manage the communications between the publishers and subscribers over the internet. The study was limited to simulated environment with small number of users which would lead to delay in traffic if large number of users considered. Xu *et al.* (2021). The study presented a decentralized and expressive novel Publish-Subscribe scheme for secure and flexible data sharing. Publish-Subscribe scheme achieves a good balance between security goals and practical efficiency. Agrawal *et al.* (2023). The study presented a decentralized pub–sub-based framework which addresses data sharing issues among multiple subscribers. Publish-Subscribe model allows sharing of data but yet to be deployed in real world application for scalability and veracity. Lohitha and Pounambal (2023). The study presented a framework for publishing and subscribing data to the cloud in the real time. Facilitate data exchange and reduces computing overhead but could not handle media requiring seamless synchronous streaming between pub-sub like audio and videos.

3 METHODOLOGY

3.1 DATA ACQUISITION AND ANALYSIS

The interviews was conducted with medical experts in order to understand and identify the various medical issues that are associated with obstetrics and gynecology especially as it is related to women of reproductive ages. The medical issues were grouped into categories namely: pregnant women, nursing mothers and reproductive women (none). Information about the types of complaints, symptoms and observations concerning women of reproductive ages were identified. Also, the various user and system requirements of the system were identified from the medical doctors. The population considered for this study was 200 respondents selected from four states in south-western Nigeria namely: Lagos, Ogun, Oyo and Osun State. The city capital of each state was considered, namely: Ikeja from Lagos State, Abeokuta from Ogun State, Ibadan from Oyo State and Osogbo from Osun State, because the targeted scope are literate women who can give accurate and highly informed response from the specified areas. The respondents selected for this study consisted of women of reproductive age between the ages 15 and 50 years, also 50 respondents were selected from each state. The systematic simple random sampling technique was adopted for the selection of the respondents from the study locations considered in this study. This was done by visiting two

LGAs in each selected city, in this manner 25 women were randomly selected from each LGA visited for the survey considered in a city. The data required for this study was acquired using a structured questionnaire which was designed based on information relating to obstetrics and gynecology as identified from the medical experts. The questionnaire designed was validated by the medical experts and the research supervisor of this study before being used for data collection from the identified respondents, by assessing qualitatively through face validity and content validity. The acquired data was analyzed using descriptive statistics techniques which were used to assess the distribution of the responses provided by the respondents alongside the use of inferential statistics techniques that were used to interpret a number of research hypotheses that were posed in this study. The system design was specified based on the use of ontology modelling to describe the content-based filter modeling approach required for assessing information.

3.2 MODELLING OF PUB-SUB INFORMATON SYSTEM

A publish-subscribe O&G information system is modelled using protégé ontology web language (OWL). Ontologies are a formal and explicit representation of knowledge, a model of concepts and the relations among them in a specific domain (Guarino, 1998). It can also be seen as a shared conceptualization and formal specifications (Cao *et al.,* 2024). Ontology-based development methodology allows for the identification of suitable system components and reduction of complexity of domain models (Albani and Dietz, 2011). As a result of this, various components of the information systems were represented using ontological descriptions. These descriptions are presented in the following paragraph. First, the various terms which are available in the information systems are presented. Term elicitation involved producing a seminal list of terms that are relevant for the particular domain of knowledge. Nouns were used to describe the starting set of concepts that were used as candidate ontology modules. The various terms identified in this study are: publishers, subscribers, patients, gynecologists, obstetricians, disease, signs and symptoms, medications, administrations, treatments, signs, laboratory test, posts, document, audio, video, and webpage. Secondly, modules identification consists of defining the set of individual ontologies that will conform to the ontology system. In order to produce the set of ontology modules, it was necessary to group similar terms together by using as input the list of terms. This was, a structural relationship that existed between the various terms which formed part of the information system constructed. Finally, for each ontology module that was identified, their hierarchies, data properties and object properties were designed and formally stated using Description Logics notation. The various ontology concepts for this study are presented in the following sub-sections.

3.2.1 User ontology

The user ontology was used to describe the primary uses of the system which includes the publishers and the subscribers. The publishers are the providers of information on the system while the subscribers are those who have access to the information provided by publishers based on their content. The users are sub-classified as subscribers and publishers. Publishers were sub-classified as gynecologists and obstetricians while the subscribers were sub-classified as pregnant women, nursing mothers and expecting (neither pregnant nor nursing).

3.2.2 Post ontology

The post ontology was used to describe the information that were provided by the publishers (gynecologists and obstetricians) of information. These posts contain information that are relevant to women of reproductive age and contain information regarding the female reproductive health, pregnancy and motherhood.

The posts are classified into various type of contents depending on the source of the information. The various contents were described as sub-classes of the posts. Therefore, the various

sub-classes of posts were identified as: text, image, document hyperlink, audio hyperlink, video hyperlink and webpage hyperlink.

3.2.3 Disease ontology

The disease ontology was used to describe the information about the various diseases that are associated with female reproductive health as provided by the publishers. For every disease, information was provided by the publisher cutting across the definition, description, signs and symptoms, medication, laboratory tests, administration and treatments. In the disease ontology, the sub-classes are definition, signs and symptoms, laboratory tests, and medications. The sub-class of definition is description, the sub-class of signs and symptoms is laboratory tests, while the sub-classes of medications are administrations and treatments.

3.2.4 Access ontology

The access ontology was used to describe the relationship between subscribers and publishers of information that are subscribed to. For example, a subscriber can only subscribe for information for whose content must have been searched for, they can only receive notification or comment on information that has been subscribed for and a subscriber can choose to unsubscribe to an information. Therefore, the access ontology has the sub-classes, subscribe, not subscribed and unsubscribe. The subscribe sub-class has the sub-classes called, notification and comment while the not subscribed sub-class has a sub-class called, search/filter.

3.3 ONTOLOGY REPRESENTATION

As stated earlier, a number of terms had been identified which were used to represent the functional and non-functional requirements of the information system in this study. The description of these terms was made by describing four ontologies, namely: the user ontology, post ontology, disease ontology and the access ontology. Figure 3 shows description of ontology representation for the four (4) main terms identified in this study, while Figure 4 shows the ontology representation diagram of the system. The top-left diagram in Figure 3 shows the user ontology which was used to describe the primary users of the system which includes the publishers of information and the subscribers to information alongside their respective sub-classes. The top-right diagram in Figure 3 shows the post ontology which was used to describe the contents of the various information that was posted by the publishers alongside their various sub-classes. The bottom-left diagram in Figure 3 shows the disease ontology that was used to describe the various information about diseases as provided by the publishers. The alongside the sub-classes of each sub-class term of the disease ontology. The diagram presents the sub-classes of the diseases which are the basic information alongside the sub-classes of each sub-class term of the disease ontology. The bottom- right diagram in Figure 3 shows the access ontology which was used to describe the way in which information is being accessed by the subscribers. The diagram presents the sub-classes of the access ontology alongside their respective sub-classes. The four ontology designs were finally combined in order to generate the ontology design that was used to represent the functional and non-functional requirements of the information system in this study. In the Figure 4, the user ontology connects the publishers to the post ontology since they are required to provide contents to the system for the subscribers.

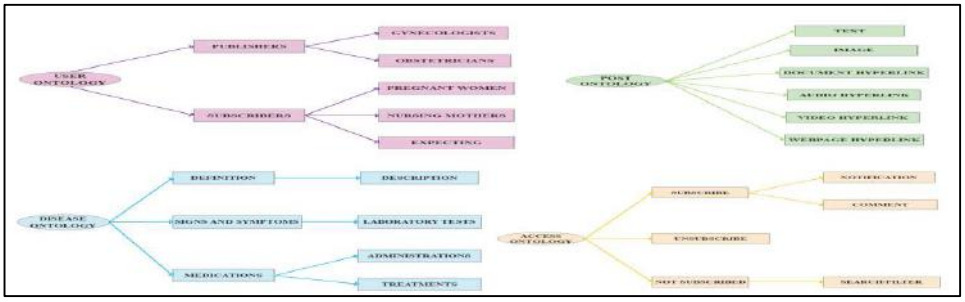

Figure 3: Description of ontology representation for the four main terms identified.

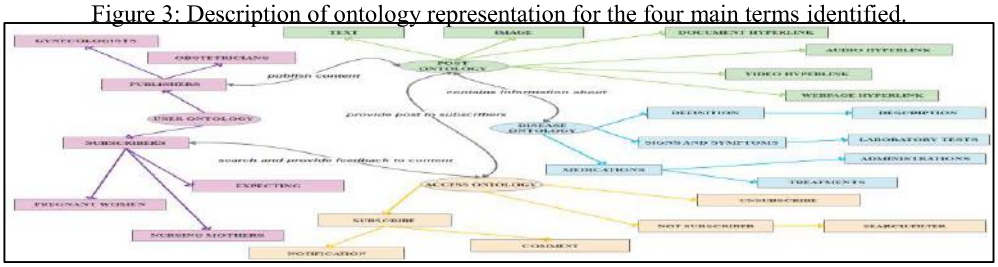

Figure 4: Diagram showing the ontology representation of the entire system

The post ontology is connected to the disease ontology since the post contains the information required about various diseases that are relevant to women of reproductive age. The subscribers have access to the post through the access ontology by ensuring that it is only subscribers whom are subscribed to information that have access to such information there by allowing them to provide feedback via comments.The class **owl: Thing** is the class that represents the set containing all individuals. Because of this all classes are subclasses of owl:Thing. There are four subclasses of owl: Thing; Access Ontology, Disease Ontology, Post Ontology and User Ontology, as depicted in Figure 5, Figure 6, Figure 7, and Figure 8 respectively. The ontology-driven information system emphasizes the flow of information between modules, describing how processes interact and the operations they perform. It focuses on the high-level functionality rather than the low-level implementation details of these processes.

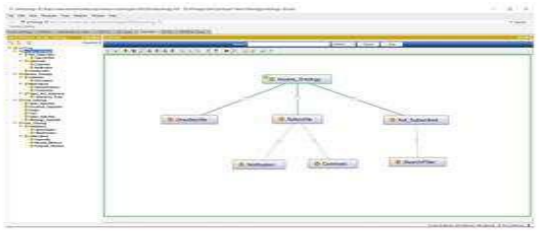

Figure 5: Ontograf of the Class hierarchy of Access_Ontology and its subclasses

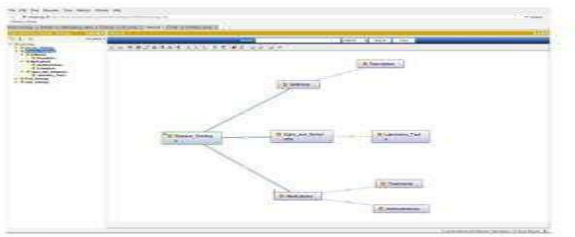

Figure 6: Ontograf of the Class hierarchy of Disease_Ontology and its subclasses

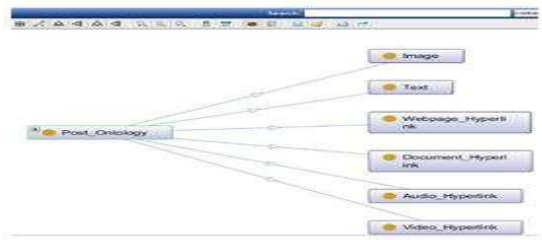

Figure 7: Ontograf of the Class hierarchy of Post_Ontology and its subclasses

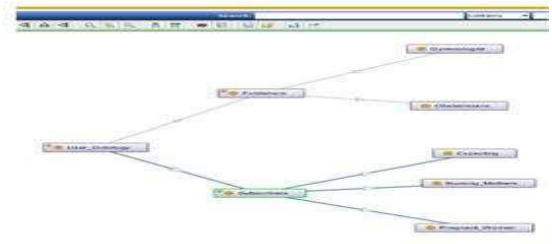

Figure 8: Ontograf of the Class hierarchy of User_Ontology and its subclasses

4 RESULTS AND DISCUSSION

4.1 RESULT OF DESCRIPTIVE ANALYSIS ON PERCEPTIONS OF PREGNANT WOMEN

The information required for assessing the perception of the respondents about the health conditions affecting pregnant women was collected using the section B part of the questionnaire which consists of ten items. Table 1 shows the distribution of the responses provided by the respondents for each of

the items provided in the section alongside the mean of each item and the overall mean of the section. The mean value of 4.29 for item 1 shows that the respondents agree that *hypertension in pregnancy can lead to seizure and poses threat to unborn child*. The mean value of 3.48 for item 2 shows that the respondents are undecided that *threatened abortion could be nature's way of getting rid of malformed fetus*. The mean value of 3.62 for item 3 shows that the respondents agree that *malaria could lead to severe aneamia*. The mean value of 3.66 for item 4 shows that the respondents agree that *morning sickness can lead to severe dehydration or shock*. The mean value of 3.36 for item 5 shows that the respondents are undecided that *chemotherapy is a treatment for molar pregnancy which has been evacuated*. The mean value of 4.21 for item 6 shows that the respondents agree that *burning sensation or pain during urination could be a sign of urinary infection in pregnancy*. The mean value of 2.89 for item 7 shows that the respondents are undecided that *rhesus negative women may not need rhogan injection after first delivery*. The mean value of 2.83 for item 8 shows that the respondents are undecided that *a woman who has history of safe/normal delivery may make use of traditional birth attendant in delivery*. The mean value of 4.29 for item 1 shows that the respondents agree that *hypertension in pregnancy can lead to seizure and poses threat to unborn child*. The mean value of 2.64 for item 9 shows that the respondents are undecided that *early antenatal visit is a sign of anxiety*. The mean value of 3.40 for item 10 shows that the respondents are undecided that *malaria can be a major cause of death in pregnancy*. The overall mean value of 3.44 reveals that the perception of respondents about health conditions affecting pregnant women fall within 'Undecided' threshold which simply implies that the respondents are indecisive. In other words, the results showed that the respondents lack adequate knowledge about what they know as regards the various health problems affecting pregnant women

Table 1: Distribution of respondents' perceptions about pregnant women

S/N	Items	SA	A	U	D	SD	Mean	SD
1	Hypertension in pregnancy can lead to seizure and poses threat to unborn child	92	73	9	6	20	4.29	0.944
2	Threaten abortion could be nature's way of getting rid of malformed fetus	50	78	18	19	35	3.48	1.358
3	Malaria could lead to severe anemia	56	75	21	35	13	3.62	1.247
4	Morning sickness can lead to severe dehydration or shock	58	53	40	36	13	3.66	1.078
5	Chemotherapy is a treatment for molar pregnancy which has been evacuated	33	71	56	25	15	3.36	1.100
6	Burning sensation or pain during urination could be a sign of urinary infection in pregnancy	72	85	28	10	5	4.21	0.842
7	Rhesus negative woman may not need rhogan injection after first delivery	21	45	52	65	17	2.89	1.265
8	A woman who has history of safe/normal delivery may make use of traditional birth attendant in subsequent delivery	31	44	10	64	51	2.83	1.479
9	Early antennal visit is a sign of anxiety	23	39	17	70	51	2.64	1.414
10	Malaria can be a major cause of death in pregnancy	52	71	21	35	21	3.40	1.370
	OVERALL						**3.44**	**0.550**

4.2 RESULTS OF THE INDEPENDENT T-TEST ON PERCEPTIONS OF WOMEN WITH AND WITHOUT CHILDREN

This section showed the results of the analysis of the difference between the mean perception of women with and without children regarding health problem affecting women. The analysis was done using the student's t-test analysis since two groups were used as a basis of comparison, namely those with children and those without children. The analysis was done by comparison the two groups using sections B, C and D which were used to assess the perception of health problems affecting pregnant women, nursing mothers and women of reproductive age respectively. Table 2, showed the results for the independent sample t-test of difference between mean perception of respondents with and without children regarding health problems affecting pregnant women. Among the ten items, the table 2, showed that there were statistically significant differences between mean perception of the groups for item 2 (Threaten abortion could be nature's way of getting rid of malformed fetus), ($p = 0.020$) and item 8 '*A woman who has history of safe/normal delivery may make use of traditional birth attendant in subsequent delivery'*, ($p = 0.010$). Table 2, showed the results for the independent

sample t-test of difference between mean perception of respondents with and without children regarding health problems affecting pregnant women. Among the ten items, the table showed that there were statistically significant differences between mean perception of the groups on item 2 'Threaten abortion could be nature's way of getting rid of malformed fetus', t(*198*) = 2.351, *p*<.05; and on item 8 '*A woman who has history of safe/normal delivery may make use of traditional birth attendant in subsequent delivery*', t(*198*) = -2.620, *p*<.05. Table 3, showed the group statistics of the mean perception between the groups for health problems affecting pregnant women. Regarding perception of item 2 '*threaten abortion could be nature's way of getting rid of malformed fetus,'* the study found that respondents with children had a statistically significantly higher perception (3.71 $\pm$ 1.24) than respondents without children, (3.13 $\pm$ 1.48), $t(198) = 2.351, p = 0.020$. Also, regarding perception of *item 8 'woman who has history of safe/normal delivery may make use of traditional birth attendant in subsequent delivery',* the study found that respondents without children had a statistically significantly higher perception (3.10 $\pm$ 1.55) than respondents with children (2.57 $\pm$ 1.38), $t(198) = -2.620, p = 0.010$.

Table 2: Independent Sample t-Test of difference between mean perception of respondents with and without children regarding health problems affecting pregnant women

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Hypertension in pregnancy can lead to seizure and poses threat to unborn child	Equal variances assumed	6.160	.014	-.7950	198	.344	-.165	.174	-.509	.179
	Equal variances not assumed			-1.093	120.848	.277	-.165	.151	-.464	.134
Threaten abortion could be nature's way of getting rid of malformed fetus	**Equal variances assumed**	**4.962**	**.028**	**2.351**	**198**	**.020**	**.582**	**.247**	**.092**	**1.071**
	Equal variances not assumed			**2.260**	**87.329**	**.026**	**.582**	**.257**	**.070**	**1.093**
Malaria could lead to severe anemia	Equal variances assumed	.172	.679	.835	198	.405	.191	.229	-.262	.644
	Equal variances not assumed			.846	106.473	.400	.191	.226	-.257	.639
Morning sickness can lead to severe dehydration or shock	Equal variances assumed	1.880	.173	.740	198	.460	.148	.200	-.248	.544
	Equal variances not assumed			.720	90.984	.473	.148	.206	-.260	.556
Chemotherapy is a treatment for molar pregnancy which has been evacuated	Equal variances assumed	.182	.671	-.655	198	.514	-.138	.211	-.555	.279
	Equal variances not assumed			-.649	90.372	.518	-.138	.212	-.559	.284

Table 3: Group statistics of mean Perception between respondents with and without children for health problems affecting pregnant women

Items	With Children	N	Mean	Std. Deviation	Std. Error Mean
Hypertension in pregnancy can lead to seizure and poses threat to unborn child	Yes	122	4.23	1.116	.126
	No	78	4.40	.574	.083
Threaten abortion could be nature's way of getting rid of malformed fetus	**Yes**	**122**	**3.71**	**1.239**	**.143**
	No	**78**	**3.13**	**1.482**	**.214**
Malaria could lead to severe anemia	Yes	122	3.70	1.278	.146
	No	78	3.51	1.210	.173
Morning sickness can lead to severe dehydration or shock	Yes	122	3.71	1.030	.118
	No	78	3.56	1.165	.168
Chemotherapy is a treatment for molar pregnancy which has been evacuated	Yes	122	3.31	1.102	.127
	No	78	3.44	1.139	.170
Burning sensation or pain during urination could be a sign of urinary infection in pregnancy	Yes	122	4.26	.700	.080
	No	78	4.12	1.033	.148
Rhesus negative woman may not need rhogan injection after first delivery	Yes	122	2.72	1.236	.146
	No	78	3.10	1.262	.180
A woman who has history of safe/normal delivery may make use of traditional birth attendant in subsequent delivery	**Yes**	**122**	**2.57**	**1.381**	**.157**
	No	**78**	**3.27**	**1.552**	**.222**
Early antennal visit is a sign of anxiety	Yes	122	2.49	1.274	.148
	No	78	2.91	1.589	.234
Malaria can be a major cause of death in pregnancy	Yes	122	3.58	1.324	.150
	No	78	3.10	1.418	.205

4.3 RESULTS OF THE ANOVA ANALYSIS BASED ON HEALTH STATUS

This section showed the results of the analysis of the difference between the mean perception of pregnant women, nursing mothers and reproductive women (none). The analysis was done using the one-way Analysis of Variance (ANOVA) analysis since more than two groups were used as a basis of comparison, namely: pregnant women, nursing mothers and reproductive women (none). The analysis was done by comparing the three groups based on the information in sections B, C and D of the questionnaire, which were used to assess the perception of health problems affecting pregnant women, nursing mothers and women of reproductive age respectively. Table 4, showed the results for the ANOVA analysis of difference between mean perceptions of respondents regarding health problems affecting pregnant women. Among the ten items, the table shows that there was statistically significant difference between mean perception of the groups for item 1 which was used to assess perception of *hypertension in pregnancy leading to seizure and posing threat to unborn child* by one-way ANOVA (F (*2,198*) = 4.039, p = .020). As shown in Table 5, a Tukey post hoc test revealed that the mean perception of respondents who were neither pregnant nor nursing mothers (none) was statistically significantly higher than respondents who were pregnant (p = 0.186) but there was no statistically significant difference with the mean perception of respondents who were nursing mothers (p = 0.144). There was no statistically significant difference between the mean perception of respondents who were pregnant and nursing mothers for Item 1.

The analysis indicates a Publish-Subscribe Knowledge Management System (KMS) for Obstetrics and Gynecology (OB-GYN) holds significant promise for addressing critical knowledge-sharing challenges by ensuring reproductive women only receive updates relevant to their specific areas of interest, preventing information overload and improving efficiency. OB-GYN professionals

can publish to specific contents (e.g., high-risk pregnancies, minimally invasive surgery) to stay current on the latest research and best practices. The system can foster collaboration among OB-GYN professionals by enabling them to share knowledge, ask questions, and discuss complex cases. This exchange of expertise can lead to improved patient care and better outcomes. The system can serve as a central repository for OB-GYN knowledge, including clinical guidelines, research papers, and case studies. This facilitates easy access to past information and fosters a culture of continuous learning. It can facilitate real-time updates on critical clinical guidelines, drug information, and emerging medical trends. This ensures OB-GYN professionals have access to the most up-to-date knowledge for optimal patient care. A robust Publish-Subscribe system can serve as a mechanism to ensure the accuracy and credibility of published information is crucial. This may involve a peer-review process or verification by designated experts. By addressing these considerations, a Publish-Subscribe KMS can become a valuable tool for improving knowledge sharing, collaboration, and ultimately, patient care in the field of Obstetrics and Gynecology.

\

Table 4: ANOVA Analysis of difference of mean perception of respondents regarding health problems affecting pregnant women

		Sum of Squares	Df	Mean Square	F	Sig.
Hypertension in pregnancy can lead to seizure and poses threat to unborn child	**Between Groups**	**6.933**	**2**	**3.466**	**4.039**	**.020**
	Within Groups	**104.699**	**198**	**.858**		
	Total	**111.632**	**200**			
Threaten abortion could be nature's way of getting rid of malformed fetus	Between Groups	.112	2	.056	.030	.971
	Within Groups	224.380	198	1.886		
	Total	224.492	200			
Malaria could lead to severe anemia	Between Groups	2.920	2	1.460	.925	.399
	Within Groups	192.648	198	1.579		
	Total	195.568	200			
Morning sickness can lead to severe dehydration or shock	Between Groups	4.575	2	2.288	1.969	.144
	Within Groups	139.392	198	1.162		
	Total	143.967	200			
Chemotherapy is a treatment for molar pregnancy which has been evacuated	Between Groups	2.687	2	1.343	1.085	.341
	Within Groups	144.905	198	1.239		

Table 5: Post Hoc Tests using Tukey HSD for the difference of mean perception of respondents regarding health problems affecting pregnant women

Dependent Variable	(I) Fertility Status	(J) Fertility Status	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Hypertension in pregnancy can lead to seizure and poses threat to unborn child	**Pregnant**	Nursing Mother	-.358	.308	.477	-1.09	.37
		None	**-.711**	**.288**	**.039**	**-1.39**	**-.03**
	Nursing Mother	Pregnant	.358	.308	.477	-.37	1.09
		None	-.352	.186	.144	-.79	.09
	None	**Pregnant**	**.711**	**.288**	**.039**	**.03**	**1.39**
		Nursing Mother	.352	.186	.144	-.09	.79
Threaten abortion could be nature's way of getting rid of malformed fetus	Pregnant	Nursing Mother	.098	.459	.975	-.99	1.19
		None	.103	.427	.968	-.91	1.12
	Nursing Mother	Pregnant	-.098	.459	.975	-1.19	.99
		None	.006	.281	1.000	-.66	.67
	None	Pregnant	-.103	.427	.968	-1.12	.91
		Nursing Mother	-.006	.281	1.000	-.67	.66
Malaria could lead to severe anemia	Pregnant	Nursing Mother	-.563	.417	.371	-1.55	.43
		None	-.465	.390	.461	-1.39	.46
	Nursing Mother	Pregnant	.563	.417	.371	-.43	1.55
		None	.098	.252	.920	-.50	.70
	None	Pregnant	.465	.390	.461	-.46	1.39
		Nursing Mother	-.098	.252	.920	-.70	.50
Morning sickness can lead to severe dehydration or shock	Pregnant	Nursing Mother	-.528	.359	.309	-1.38	.32
		None	-.130	.335	.920	-.93	.67
	Nursing Mother	Pregnant	.528	.359	.309	-.32	1.38
		None	.398	.219	.167	-.12	.92
	None	Pregnant	.130	.335	.920	-.67	.93
		Nursing Mother	-.398	.219	.167	-.92	.12

5 CONCLUSION

Publish-Subscribe is a suitable architecture for a Knowledge based system. It allows for efficient information dissemination, which is crucial in a field like Obstetrics and Gynecology where staying current with research and best practices is essential. This study investigated the level of reproductive health knowledge among women of reproductive age in southwest Nigeria and designed an ontology-driven information system to address identified knowledge gaps. The findings suggest that respondents have limited knowledge about various health conditions affecting pregnant women. The

study identified a gap between knowledge and behavior, even with some awareness of health issues, respondents lacked a comprehensive understanding, leading to a gap between what they know and how they manage their health. An ontology-driven publish-subscribe information system was designed to bridge the knowledge gap. The system categorizes information using ontologies, allowing for targeted content delivery based on user needs. The analysis of respondents' perceptions about health conditions during pregnancy revealed a significant level of inadequate knowledge on vital reproductive health. This highlights the need for reliable and accessible reproductive health information. This study emphasizes the importance of improving reproductive health literacy among women. The designed ontology-driven information system, if implemented effectively, can empower women with accurate and relevant knowledge, leading to better health outcomes.

I. 6 RECOMMENDATIONS

This study highlights the need for improved access to accurate and reliable reproductive health information among women of reproductive age in southwest Nigeria. Based on the findings, here are some recommendations:

i. Develop and implement the proposed ontology-driven information system: The designed system, with its content categorized using ontologies, can provide targeted information based on user needs. This can address the identified knowledge gaps and empower women to make informed choices about their reproductive health.
ii. Promote user education and awareness: Efforts should be directed towards raising awareness about the information system and educating women on its functionalities. This can be achieved through targeted campaigns, community outreach programs, and collaborations with local healthcare organizations.
iii. Address socio-cultural factors: The system's design should consider socio-cultural contexts that might influence reproductive health decision-making. This could involve incorporating culturally appropriate language and addressing traditional beliefs that might hinder optimal health outcomes.
iv. Continuous monitoring and evaluation: The information system's effectiveness in improving reproductive health knowledge should be monitored and evaluated. This will allow for ongoing improvement and adaptation based on user feedback and emerging needs.
v. Collaboration with healthcare providers: Collaboration with healthcare providers like gynecologists, obstetricians, and nurses is crucial. They can play a vital role in promoting the system to their patients and ensuring the information provided is medically accurate and up-to-date.
vi. The system's user interface should be intuitive and user-friendly to encourage adoption by OB-GYN professionals with varying technical expertise.
vii. Integration with Existing Systems: Consideration should be given to integrating the KMS with existing electronic health record (EHR) systems to streamline workflow and improve data accessibility.

By implementing these recommendations, this study's findings can be translated into a practical solution to bridge the knowledge gap and empower women in southwest Nigeria to make informed decisions about their reproductive health.

REFERENCES

[1] Abdul, H. R., and Hasan, H. M. (2020). Enhanced MQTT Protocol by Smart Gateway. *Iraqi Journal of Computers, Communications, Control and Systems Engineering*, *20*(1), 53-67.
[2] Adebayo, F. A., Adetunji, T. A., and Adebayo, O. M. (2022). Assessing the relationship between knowledge and the actual use of contraceptives among childbearing women in South-South Nigeria: evidence from the 2018 Nigeria demographic and health survey. BMC Public Health, 22(1), 1472. https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-022-14728-y

[3] Adedoyin, O. A., Adebayo, O. M., and Ekanola, O. O. (2017). Assessment of reproductive health literacy among women attending antenatal clinic in a tertiary hospital in Southwest, Nigeria. Annals of African Medicine, 16(4), 232–237.
[4] Adetunji, T. A., Odebode, O. O., Ajayi, O. I., and Adebayo, F. A. (2021). Social media and its influence on reproductive health information-seeking behaviors among young adults in Southwest, Nigeria. International Journal of Women's Health, 13(1), 127.
[5] Agrawal, A., Choudhary, S., Bhatia, A., and Tiwari, K. (2023). Pub-SubMCS: A Privacy-Preserving Publish–Subscribe and Blockchain-Based Mobile Crowdsensing Framework. *Future Generation Computer Systems*, *146*, 234-249.
[6] Akinmokun, O. I. (2022). Poor Health Literacy in Nigeria: Causes, Consequences and Measures to improve it. Reasearchgate
[7] Albani, A., and Dietz, J. L. (2011). Enterprise ontology based development of information systems. *International Journal of Internet and Enterprise Management*, *7*(1), 41-63.
[8] Antoniou, G., and van Harmelen, F. (2004). A semantic web primer (2nd ed.). MIT Press.
[9] Asaolu, M. F., Afolabi, M. M., Olaniyan, T. Y., and Owolabi, O. A. (2018). Reproductive health literacy among in-school adolescents in Abeokuta, southwest Nigeria. International Quarterly Journal of Community Health Education, 39(1), 67–74.
[10] Ashok, M., Madan, R., Joha, A., and Sivarajah, U. (2022). Ethical framework for Artificial Intelligence and Digital technologies. *International Journal of Information Management*, *62*, 102433.
[11] Awokola J., Emuoyibofarhe O., Awokola B., Alamu F., Awokola E., and Akomolafe O. (2014). Development of a Context-Aware Publish-subscribe Information System for Public Health Service Delivery. *Journal of Information Engineering and Applications, 4*(9), 23-30.
[12] Belguith, S., Cui, S., Asghar, M. R., and Russello, G. (2018). Secure publish and subscribe systems with efficient revocation. In *Proceedings of the 33rd Annual ACM Symposium on Applied Computing*, 388-394.
[13] Bittmann, J. (2008). Knowledge management for healthcare. Studies in Health Technology and Informatics, 136, 23–38.
[14] Cao, B., Lin, H., Han, X., and Sun, L. (2024). The life cycle of knowledge in big language models: A survey. *Machine Intelligence Research*, 1-22.
[15] Chigbu, C. O., Onyebuchi, A. K., Onwudiwe, E. N., and Iwuji, S. E. (2015). Denial of women's rights to contraception in southeastern Nigeria. International Journal of Women's Health, 7(3), 321-329. Int J Womens Health: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5941455
[16] Collin, J., Byström, E., Carnahan A., and Ahrne, M. (2020). Public Health Agency of Sweden's brief report: pregnant and postpartum women with SARS-CoV-2 infection in intensive care in Sweden. Acta Obstet Gynecol Scand 2020. Epub May 9, 10.1111/aogs.13901 - DOI - PMC - PubMed.
[17] Correia, B., Chiodini, J., Dalfovo, O., Silva, L, and Teske, R. (2013). The use of information systems in health care facilities: a Brazilian case. *Journal of technology management and innovation*, *8*, 72-72.
[18] Dean, M., and Schreiber, G. (2006). OWL Web Ontology Language Reference. World Wide Web Consortium. http://www.w3.org/TR/2004/REC-owl-ref-20040210/ (Latest version available at: http://www.w3.org/TR/owl-ref/, http://www.w3.org/TR/owl-ref/)
[19] Eken, S. (2020). A topic-based hierarchical publish-subscribe messaging middleware for COVID-19 detection in X-ray image and its metadata. *Soft Computing*, 1-11.
[20] Eugster, P., Felber, P. A., Guerraoui, R., and Kermarrec, A. M. (2003). The gossip architecture for reliable and scalable group communication. ACM Transactions on Computer Systems, 21(4), 311–346.
[21] Fawole, O. O., Ajayi, O. I., and Fawole, A. I. (2020). Full article: Knowledge and perception of sexual and reproductive rights among married women in Nigeria. Gender and Development, 28(2), 339-354.
[22] Froehlich, W., Seitaboth, S., Chanpheaktra, N., and Pugath, D. (2009). Case Report: An Example of International Telemedicine Success. *Journal of Telemedicine Telecare, 15*, 208-210
[23] Goldschmidt, P. G. (2005). HIT and MIS: implications of health information technology and medical information systems. *Communications of the ACM*, *48*(10), 68-74.
[24] González M, D., López M, M. J., Pérez, P., and Villegas, A. (2022). Tcp-based distributed offloading architecture for the future of untethered immersive experiences in wireless networks. In *Proceedings of the 2022 ACM International Conference on Interactive Media Experiences* (pp. 121-132).
[25] Harold, E. and Scott Means, W. (2002) XML in a Nutshell, O'Reilly and Associates.
[26] Haux, R., E. Ammenwerth, A. Häber, G. Hübner-Bloder, P. Knaup-Gregori, G. Lechleitner, F. Leiner, R. Weber, A. Winter, and A. C. Wolff, (2006). "Medical informatics education needs information system practicums in health care settings." *Methods of Information in Medicine* 45, no. 03 294-299.

https://www.researchgate.net/publication/305407133_Poor_Health_Literacy_in_Nigeria Causes and Measure_to_improve_it

[27] Hutcheon, G., and McNeill, K. (2011). Using publish-subscribe architectures for real-time collaboration in e-learning systems. IEEE Transactions on Learning Technologies, 4(2), 123–133.
[28] Lohitha, N. S., and Pounambal, M. (2023). Integrated publish/subscribe and push-pull method for cloud based IoT framework for real time data processing. *Measurement: Sensors*, *27*, 100699.
[29] Lopez-Jurado, M., Baez, D., and Cabero-Garcia, J. (2018). WHO recommendations on antenatal care for a positive pregnancy experience. World Health Organization. https://iris.who.int/bitstream/handle/10665/206006/B0464.pdf
[30] Mberu, B., Mwangi, M., and Ota, M. C. (2018). Women's reproductive health literacy in rural Kenya: A mixed methods study. BMC Public Health, 14, 1232.
[31] Narus, S. P., Rahman, N., Mann, D. K., He, S., and Haug, P. J. (2018). Enhancing a commercial EMR with an open, standards-based publish-subscribe infrastructure. In *AMIA Annual Symposium Proceedings* (Vol. 2018, p. 799). American Medical Informatics Association.
[32] Nyulas, C., Hess, T., and Bakken, S. (2017). Standards and interoperability for improving health information exchange. Yearbook of Medical Informatics, 26(1), 9–18. https://www.nlm.nih.gov/healthit.html
[33] Onica, E., Felber, P., Mercier, H., and Rivière, E. (2016). Confidentiality-preserving publish-subscribe: A survey. *ACM computing surveys (CSUR)*, *49*(2), 1-43.
[34] Oyinloye, O. A., Emuoyibofarhe, J. O., Oladosu, J. B., and Ajala, F. A. (2024). *Design of a Scalable Content-based Publish-subscribe Model for Efficient Information Dissemination in Obstetrics and Gynaecology.* Asian Journal of Advanced Research and Reports, 18 (6). pp. 68-83. ISSN 2582-3248
[35] Peng, Y., Wang, Z., and Li, X. (2020). Development of an ontology for knowledge representation in obstetrics and gynecology. Journal of Biomedical Informatics, 108, 103452.
[36] Peral, J., Ferrández, A., Gil, D., Munoz-Terol, R., and Mora, H. (2018). An ontology-oriented architecture for dealing with heterogeneous data applied to telemedicine systems. *IEEE Access*, *6*, 41118-41138.
[37] Rodrigues, V. F., Paim, E. P., Kunst, R., Antunes, R. S., Costa, C. A. da, and Righi, R. da R. (2020). Exploring publish-subscribe, multilevel cloud elasticity, and data compression in telemedicine. Computer Methods and Programs in Biomedicine. https://doi.org/10.1016/j.cmpb.2020.105403.
[38] Sohn, T., Kim, Y., and Won, S. (2007). Ontology-based context-aware clinical decision support system. Applied Intelligence, 27(1), 71–89.
[39] United Nations Population Fund. UNFPA (2024). https://www.unfpa.org/about-us
[40] World Health Organization**.** WHO (2023). Sexually transmitted infections (STIs). Retrieved April 26, 2024, https://www.who.int/news-room/fact-sheets/detail/sexually-transmitted-infections-%28stis%29
[41] Xu, Q., Zhang, Q., Yu, B., Shi, N., Wang, C., and He, W. (2021). Decentralized and expressive data publish-subscribe scheme in cloud based on attribute-based keyword search. *Journal of Systems Architecture*, *119*, 102274.