Paper ID: 442

Ontology-Driven Decision Making for Subfertility of Female

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Abstract Failure to conceive after 12 months of unprotected and regular sexual intercourse is called as subfertility. In the medical domain, at first, males are checked for subfertility causes. Then, females need to check for their subfertility cause. Here, female subfertility is a vast area than male subfertility. So, it`s difficult to take decision making. So, ontology will help to make decisions to diagnose the cause and treatment method for causes in subfertility. Subfertility of female Information collected from the Doctors, Medical Students, and Books in the very first stage. After that, started to develop ontology and implemented using Protégé OWL Ontology Editor 5.5 was used for this purpose. Finally, the developed ontology was evaluated in two ways; by using inbuilt tools and by ontology experts as an iterative approach. This approach to subfertility of female ontology can support the medical students, doctors moreover their assistants to enhance their knowledge and helpful in decision-making

Keywords subfertility, ontology, decision support

Introduction

Natural conception occurs after ovulation, the egg usually lives up to 24 hours. After ejaculation, sperm can survive up to seven days in the genital tract and sometimes even longer. Erection, penetration, Ejaculation & deposit in the right place, no cervical hostility, normal uterus, normal fallopian tubes, and normal ovulation are important for successful conception (Stanford, et al., 2002). Doctors who counsel women for preconception concerns are in the best position to provide advice to couples regarding the optimal timing of intercourse to achieve pregnancy. Conception is feasible from intercourse beginning about 5 days before ovulation extending through the day of ovulation (Stanford, et al., 2002). (Joffe & Li, 1994).

A female's best reproductive years are in her age of 20s. Fertility gradually decreases in the age of 30s, particularly after age 35. Age of 30 female has a 20% chance of getting pregnant when each month that she tries, for a healthy fertile. A woman's chance is less than 5% per cycle by age 40. As a result, fewer than 5 out of every 100 women are expected to be successful each month of conceiving (Larsen, 2005). A Female's fertility period depends on menstrual cycle length. Alcohol, smoking, body weight, temperature & sperm counts, prescribed drug use are some factors that affect fertility (Vander Borght & Wyns, 2018).

A common definition of subfertility is needed for the better management of subfertility (Gnoth, et al., 2005). Subfertility is a disease that general term describes the failure to get clinical pregnancy after twelve months of unprotected & regular sexual intercourse (Vander Borght & Wyns, 2018). Ovulatory Problem, Tubal Disorders, Uterine Abnormalities, Endometriosis, and in advance female's age are general causes of subfertility in females (Adamson, 2003). 80% of pregnancies occur in the first six cycles with continuous intercourse in the

fertile phase. After that, doctors assume that in the remaining 20% of 10% of couples have serious subfertility. After calculating the total 12 unsuccessful cycles of continuous sexual intercourse, birth rates of persons will come to 55%. Thereafter 48 months, zero percentage chance to conceive is called infertility. Those infertility people are about 5% of people. Appropriate circumstances after six months of the unsuccessful cycle help to reduce the infertility of couples. It helps to avoid the age problem of conceiving. Couples with a good prognosis mostly encouraged to wait to conceive because even with the treatment they do not have a better chance of conceiving (Gnoth, et al., 2005).

Ontology provides a structured view of domain knowledge and acts as a repository of concepts in the domain (Walisadeera, et al., 2013). Besides, ontology is made machine-interpretable using knowledge representation techniques and therefore, can be used for establishing a common conceptualization to facilitate store, share, retrieve, decision making, and representing knowledge. Further, domain ontologies are highly powerful knowledge representation models for presenting and describing a set of relevant domain-specific concepts and their relationships informally. (Vasanthapriyan, et al., 2017).

Sometimes, this concept is expressed by using various terminologies because of the incomplete, unstructured, general nature, and different formats of the information and the knowledge are not reaching everybody (Haghigh, et al., 2013). Further, computers need to understand the meaning or semantics of the information clearly. The semantic web enables this understanding of computers. Ontologies are a powerful mechanism for representing knowledge presented in the semantic web. Therefore, ontology can be used to find a response to queries within a specified context in the domain of subfertility of females (Vasanthapriyan & Banujan, 2019).

This work aims to contribute to decision making in the female subfertility treatment in hospitals by developing an ontology-driven solution that organizes, describes, and helps to decision making clearly in the related knowledge also can get knowledge for medical students by developing an ontology-driven solution that describes all the treatment method from base to the top level. This would assist the doctors and their assistants in the gynaecological department in hospitals to decision making to find the causes and treatment methods.

The objective of this paper is the presentation of a new ontology for decision making in the subfertility domain. This paper is organized as follows; Section 2 describes the methodology and experimental design, section 3 provides the results of the ontology domain, section 4 presents the evaluation and methods of the proposed system and section 5 contains the conclusion and future work.

Methodology and Experimental Design

Modeling ontology is a time-taking process and it requires appropriate tools. Further, constructing a domain ontology from the beginning is a complicated task. After reviewing all the methodologies in literature, Grüninger and Fox's methodology (Gruninger & Fox, 1995) was used for the ontology modeling of female subfertility (Vasanthapriyan & Banujan, 2019). The methodology for modeling the ontology for female subfertility is shown in Figure 1.

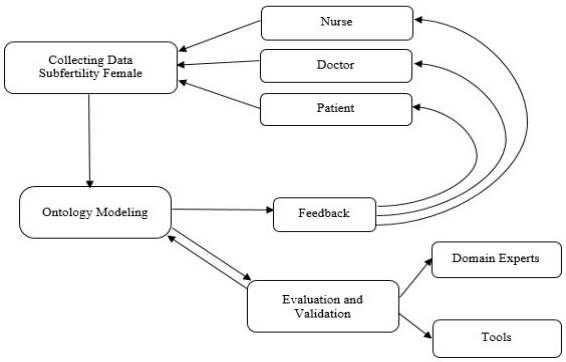


Figure 1. High-level methodological framework

We chose Grüninger and Fox's methodology (Gruninger & Fox, 1995) as it gives a formal approach for ontology designing and it gives a framework to the developed ontology for the evaluation. It mainly focuses on building ontology-based on first-Order Logic (FOL) by providing strong semantics. Web Ontology Language was used for modeling ontology. It was used for formalizing relationships between concepts. OWL is chosen because it is a mark-up language with a formal, logical semantic. Data type properties link to an individual eXtensible Mark-up Language (XML) Schema Data type value or a Resource Description Framework (RDF) literal. In other words, it describes relationships between data values and individuals. A data type property can also be used in a restriction to relate individuals to members of a given data type primitive FOL. (Vasanthapriyan & Banujan, 2019).

The focus was on the female subfertility decision-making process because this subfertility problem plays a major role in most of the couples. Grounded theory was used for data collection in this field. One Doctor with extensive knowledge of subfertility, five final year medical students who are studying in various universities, and the books provided by the medical students were used to get the domain knowledge in the subfertility area. After interviewing them, subfertility treatment decision-making problems were identified. The Competency Questions (CQs) were developed after the collection of information from the interviewees. The ontology could be capable of answer the set of questions that is called CQs by using its axioms. CQs work as a requirement specification of the female subfertility ontology. Ontology tries to answer competency questions (Indika Walisadeera, et al., 2014) (Choraś, et al., 2010). Some of them are shown in Table 1. Ontology hierarchy developed by using the ontology knowledge and using CQ Questions & answers. Figure 2 describes the high-level hierarchy of ontology of subfertility by using the competency questions which is developed to help the decision-making process of the subfertility of the female.

The contents of the ontology need to be validated after designing the ontology. Otherwise, incorrect relationships in the ontology will spread errors to subsequent design and implementation activities in future work. The ontology model was evaluated by ontology experts and all the pitfalls were planned to rectify by their comments. Here, OOPS! The evaluation used to find the pitfalls and corrected. CQs were evaluated using the DL expressions. The DL query tool is available in the Protégé- OWL Ontology Editor 5.5 was used for this purpose. Description Logic (DL) was used for this work because OWL2 Web Ontology Language is used for modeling the ontology. DL is a decidable fragment of FOL and is more expressive than primitive FOL. The greatest advantage of DL models is not representing the information model only but reasoning with the model. The meaning of the DL is unambiguous and precise and is capable to check the consistency of any entire ontology model. DL query checked the accuracy and quality of the ontology by using the Fact++ Reasoner and SPARQL Queries also used to evaluate.

Table 1. Some Competency Question

Subfertility Information	Female's Subfertility (i.e) Competency Question	Generalizing Contextualized Information
What is the first thing that has to do with the doctor when treating a patient?	What is the Order of Collecting Medical History? What are the categories collect under present medical history? What are the Menstrual History collected in Gynaecological history? What are the system Enquiry in gynaecological history?	What are the details collect under all histories?
How can doctors find causes of subfertility using examinations?	What are the various ovulatory disorder? What are the disorder in tubal? What are the examination used to find every disorder?	What are the subfertility major subfertility causes?
What are the treatment for subfertility causes?	What are the treatment used for ovulation disorder? What are the treatment used for every ovulation disorder? What are the tubal surgeries done for tubal disorders? What is the order of treatment if previous treatment is not successful? What are the medical and surgical treatment for uterine disorders? What are the treatments and what is the order of unexplained factor treatment? What are the other treatments for subfertility problem?	What are the main phases in treatment for subfertility?

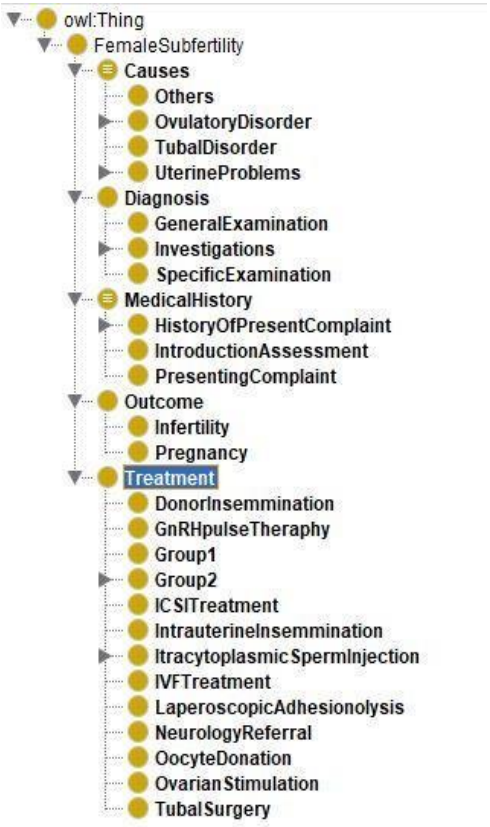


Figure 2. High-level Hierarchy

Results

Ontology for subfertility was created using Protégé Ontology Editor 5.5. This Ontology was redeveloped after the comments of doctors and medical students' evaluation of the ontology pitfalls. Part of the Female Subfertility Ontology shown in Figure 3. Some DL queries and answers shown in Table 2.

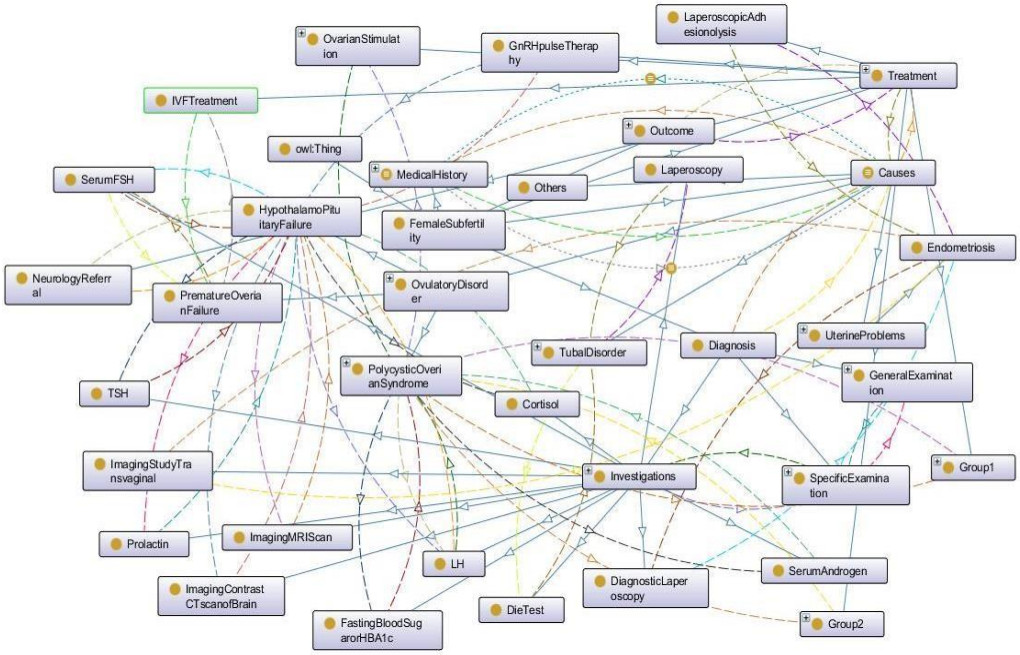


Table 2. DL Queries and Answers

Competency Questions	DL Query	Answers
What are the treatment method for Tubal Disorder Cause?	TubalSurgery and hasSurgeries only TubalSurgery	• Labaroscopic_Tubal_Surgery • Surgery_for_hydrosalpinges • Tubal_catheterisation_or_cannulation • Tubal_microsurgery
What are the medical history that helps to find Tubal Disorder?	TubalDisorder and is select some MedicalHistory	• Scar_Tissue • Pelvic_Inflammatory_Disease • History_of_Gonorhea_or_Chlaymydia

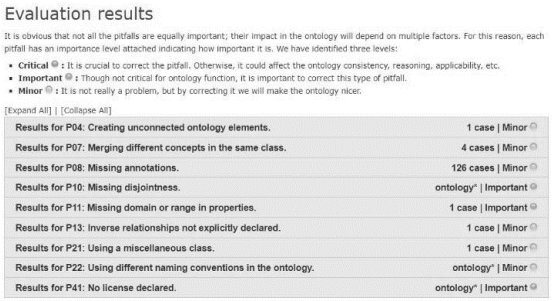
Discussion

Female Subfertility is the vast area in the gynaecological part in the medical area that mainly depends on the experience and knowledge of the doctors. All the important areas are covered in the ontology, which is used to decision making in the diagnosis of the causes and treatment for the causes. An ontological approach is used to represent the needed part is covered in the research.

Designing this type of ontology is not a small task, because we need to gain vast domain knowledge and this domain is new to the author. Therefore, the author needs to read many books in this field and have to get knowledge from doctors and medical students. In this paper, we have clearly explained how ontology designed, implemented in the protégé, and developed the ontology to organize domain knowledge to take particular decisions in treatment.

The evaluation (Ferenc, 2016) and validation have been done separately. FaCT++ reasoner is used to validating the accuracy and quality of developed ontology. Protégé-OWL Ontology Editor 5.5 has the FaCT++ reasoner as an inbuilt tool. Moreover, we used OOPS! which is a web-based tool. Figure 4 describes the OOPS Evaluation Results. All the Critical, Important errors were identified using this evaluation and all were rectified. Ontology expert's massive help used to evaluate the ontology by testing the false feeding of the terms and relationship we used. Ontology was redeveloped by the ontology experts'

responses, comments, and suggestions that, Even though there are some works on a decision support system such as Cancer Treatment (Shen, et al., 2018), Diabetic (Sherimon & Krishnan, 2016) etc. Tiny research has been conducted on the subfertility of the female domain. So we plan to develop a Decision Support.


Evaluation results

It is obvious that not all the pitfalls are equally important; their impact in the ontology will depend on multiple factors. For this reason, each pitfall has an importance level attached indicating how important it is. We have identified three levels:

- **Critical** : It is crucial to correct the pitfall. Otherwise, it could affect the ontology consistency, reasoning, applicability, etc.
- **Important** : Though not critical for ontology function, it is important to correct this type of pitfall.
- **Minor** : It is not really a problem, but by correcting it we will make the ontology nicer.

[Expand All] | [Collapse All]

Results for P04: Creating unconnected ontology elements.	1 case | Minor
Results for P07: Merging different concepts in the same class.	4 cases | Minor
Results for P08: Missing annotations.	126 cases | Minor
Results for P10: Missing disjointness.	ontology* | Important
Results for P11: Missing domain or range in properties.	1 case | Important
Results for P13: Inverse relationships not explicitly declared.	1 case | Minor
Results for P21: Using a miscellaneous class.	1 case | Minor
Results for P22: Using different naming conventions in the ontology.	ontology* | Minor
Results for P41: No license declared.	ontology* | Important

Conclusion

In the subfertility area, Female subfertility is a vast area than male subfertility of the gynaecological part in the medical area. So Normally, Doctors and medical students have some confusions about decision making in the area. This Ontology design helps to how to find the causes and to find treatment methods for every cause.

Subfertility of female Domain ontology designing is not a simple task. Designing the ontology in the subfertility of the female domain is not an easy task because this is a vast area than male subfertility. The difficulties in the female subfertility domain and the need to gain vast domain knowledge made this task more tedious. This research female subfertility treatment method decision-making ontology, which represents female subfertility domain knowledge. It includes female subfertility treatment method concepts, their properties such as object property and data property, and their relationships. We confidently believe that our female subfertility ontology can help the gynaecological area, doctors and medical students, and other active researchers in this field to improve not only decision-making and also the knowledge sharing and experiences.

We have two future work to expand this research work. Firstly we are planning to enhance our research on the subfertility of females. After that as second, Development of Decision Support System which helps to take decisions such as finding causes using medical history & diagnosis and finding treatment for female subfertility. More than that, Even though there are some works on a decision support system such as Cancer Treatment (Shen, et al., 2018), Diabetic (Sherimon & Krishnan, 2016) etc. Tiny research has been conducted on the subfertility of the female domain. So we plan to develop a Decision Support System for the subfertility of females.

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Acknowledgement

We pay our heartfelt gratitude to the Doctor Shinthuja Ranjit of Nation Hospital of Sri Lanka. Further, we acknowledge medical students Miss. Karthiga Rajasingam, Mr. Sithambarabanan Kathirgamanathan, Mr.Thanistan Raj, Mr. Ajith Jerom Mathuranayagam and the other domain experts who have directly and indirectly tangled in order to finish the research work effectively and successfully.

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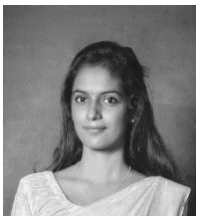

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