

PATIENT CENTRIC SOLUTIONS TO MITIGATE INFORMATION NEED OF OBSTETRIC  
ULTRASOUND EXAM AMONG PREGNANT WOMEN: DESIGN-THINKING APPROACH

by

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## ABSTRACT

### PATIENT CENTRIC SOLUTIONS TO MITIGATE INFORMATION NEEDS OF OBSTETRIC ULTRASOUND EXAM AMONG PREGNANT WOMEN: DESIGN-THINKING APPROACH

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Under the Supervision of Professor Jake Luo

Design thinking approach is an approach used widely to solve problems by providing innovative solutions. In this dissertation I focused on the user experience research field where I designed a new obstetric ultrasound reports by adopting the design thinking approach to reach the main goal of the dissertation which is mitigating pregnant women information needs about obstetric ultrasound exam and improve their understanding and knowledge about the obstetric ultrasound report and the exam. I developed two versions of new designed report called SPOUR (Smart Patient-Oriented Obstetric Ultrasound Report). We have conducted five studies to reach the dissertation goal and designed two novel obstetric ultrasound reports that help to make the medical reports more readable for the patient. The evaluation of the designed reports showed that it's useful and easy to use for the expectant parents who had an obstetric ultrasound exam, and it has shown an improvement in understanding the report content.

***Study one: Information needs and knowledge of obstetric ultrasound exam to achieve patient-centered care: Literature Review***

The aim of this study is to explore women information needs about obstetric ultrasound exam in the body of literature. PubMed, Science direct and google scholar databases was searched for

English language, peer-reviewed articles from 2000 to 2021. The keywords used are “pregnant women” “ultrasound exam” “obstetric ultrasound” “information need” “knowledge”. The bibliographies of key texts were then used to source further articles. We found that women lack knowledge about the meaning, purpose, capabilities, technical limitation, and safety of the scan, and there is a need for improvement of information provision to the patients. Also they need information especially when abnormality detected or information about down syndrome screening exam. We discussed how the internet become a source of information for women which may increase the uncertainties and anxiety for pregnant women and how it could be mitigated.

***Study two: Patients’ unmet information needs and gaps of obstetric ultrasound exam: A qualitative content analysis of social media platforms***

The aim of this study is to find the exact information the women are seeking before or after the ultrasound exam. This was a qualitative content analysis study. We systematically gathered pregnancy-related consumer health questions from three public forums (Yahoo! Answers, BabyCenter, PregnancyForum) and one ultrasound internet forum (Reddit/ultrasound). We used a purposive sampling strategy. We only included questions about ultrasound exams, and we excluded any questions related the cost or training of the ultrasound exam. We also coded the emotion expressed by the women in the questions we included. After coding each question, we categorized the data into thematic topics and subtopics. In this social media study, we discovered major information gaps that should be filled to better support health consumers’ understanding of obstetric ultrasound exam and obstetric ultrasound medical reports. The information gaps could become barriers to healthy decision-making and create stress among pregnant women. More

work needs to be done to mitigate the information gaps, such as providing more consumer-friendly and personalized information during pregnancy.

***Study three: What Makes a Patient Oriented Obstetric Ultrasound Report: Design-Thinking Approach***

The aim of this study is to discuss and recommended several methods to provide a patient friendly obstetric ultrasound report based on our pervious study. We discussed the design thinking approach we adopted to design a consumer friendly medical report that aim to mitigate patients' information need. With design thinking approach, we analyzed user's needs and built a novel prototype of a patient-oriented obstetric ultrasound report. Our recommendations include adopting ideas related to artificial intellegence and UX/UI design principals for designing a patient friendly medical report. We recommended adding features in the results and summary sections to make it readable by a lay person. We also recommended adding new sections (e.g., About ultrasound exam, and what's next) to increase women's knowledge about obstetric ultrasounds and pregnancy health. We demonstrated a prototype of our new obstetric ultrasound design for a routine second trimester report which we built based on our findings of a previous study we conducted to explore unmet information needs and gaps of obstetric ultrasound exams.

***Study four: Evaluating first version of a smart patient-oriented obstetric ultrasound report (SPOUR)***

The aim of the study is to evaluate the first version of the design by conducting interventional study where we compare our new design with a traditional design. In this design version, we adopted the infographic design where the report designed by providing several sections to the design and separating the result section into two sections, one for the result and the other section

for the explanation and terminology definition. This report can be provided to the patient as a responsive PDF and contain all the sections and methods recommended in the previous study except that the report won't be interactive and does not require any clicking from the patient side. Extra information can be found using barcode which direct patient to reliable websites for further information. To evaluate the design we used five constructs which are: Report understanding, perceived ease of use, perceived usefulness, perceived esthetics, and intention to use the report. The result showed that women understanding of the report is significantly different than their understanding of the traditional report. They found that report easy to use, useful, aesthetic, and they have the intention to use it.

***Study Five: Evaluating second version of patient-oriented obstetric ultrasound report (POUR)***

The aim of this study is to evaluate the second version by conducting interventional study where we compare our new design with a traditional design. This version have been discussed widely in the third study where we provided a user interface with several buttons to organize the information for the women when they access their obstetric ultrasound report through patient portal. We found that understanding the report is significantly different in comparison with the old design. Perceived ease of use, perceived usefulness, intention to use, and perceived esthetics were also significantly different than the traditional design. We Also measured the new components we added where we found that these new components were perceived as easy to use and useful by the majority of respondents.

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## LIST OF ABBREVIATIONS

OB	Obstetric
LMP	Last Menstrual Period
POUR	Patient-Oriented Obstetric Ultrasound Report
SNOMED CT	Systemized Nomenclature of Medicine – Clinical Terms
UMLS	Unified Medical Language System
PORTER	Patient-Oriented Radiology Reporter
MRI	Magnetic Resonance Imaging
AMA	American Medical Association

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## **Chapter I: Introduction & Background**

Research shown that the online searching for information significantly increase during the pregnancy periods (Asplin et al, 2012). However, the reliability of most of the internet sources is questionable. Different researchers have evaluated a patient-oriented medical information and different website on the internet, and they found it notably incomplete, inaccurate, and biased ( Al-Bahrani & Plusa, 2004, Bernstam et al, 2005). Until now, it is unknown what type of information the patients seek when they planning to do or did an obstetric ultrasound exam. Ultrasonography was first used by Ian Donald and has gained acceptance in the process of prenatal care. Prenatal ultrasound not only offers test but also improves the psychological analysis of the mother. It offers a sense of assurance reducing factors such as stress. Over the years it has caused negative effects and raised the point whether it is important to carry out the process in a case of uncertainty. Great improvements have been made over the years improving on the ultrasound observation. According to Ijeruh et al (2019) routine obstetric sonography (ultrasound examination) has been mentioned to be a procedure through which the rate of maternal mortality can be reduced by locating the problems earlier.

Information quality and timing after the ultrasound examination is an important factor of patients' satisfaction of maternal care during the scan. The professional is expected to give full information including the gender of the child after the scan, but it was not the case in some of the instances (Tsoi et al 1987). It was also noticed that the patients have a lot of anxiety after the scan hence majority preferred to hear the results from the sonographer immediately after the scan (Whynes, 2002). Good communication between healthcare workers and the maternal patient during the scan has proved to be a good factor to promote satisfaction. Effective communication creates a good relationship for the process of acquiring medical information from the maternal

patients to be easier. Patient complains increase with communication being one of the reasons. According to Easen & Harrison 2017, this has been caused by the increased emphasis on the patient satisfaction. Around 11% of the complains presented in the 2010-2011 analysis was about poor communication. Ultrasound practitioners are expected to convey the message, both positive and negative without preparation (Alkazaleh 2003). The statistics showed that 85% of respondents agreed that they need to be trained for a short period to convey both bad and good news. 65% percent insisted that it should be made to become mandatory to the practitioners (Easen & Harrison 2017). Good communication must include proper and well-organized content. Some of the Maternal patient cannot understand the information presented to them hence has to be explained and not assumed. Our research aim is to find the unmet information needs and gaps of obstetric ultrasound exam and provide a feasible solution. The research questions was what information needs and gaps of obstetric ultrasound exam? and what solutions can be made to mitigate the information needs?

We conducted a qualitative online forum study to understand pregnant women's information need and gap of obstetric ultrasound exam. The data set for this analysis consists of a set of 435 questions posted in four pregnancy forums and ultrasound subforum of a very large web forum from 2018-2020. We performed a qualitative thematic analysis to assess the information needs of pregnant women undergo or about to undergo an obstetric ultrasound examination. The analysis revealed six themes and nine subthemes where the pregnant women need an OB ultrasound information. These themes are: general information about ultrasound exam, report interpretation, image interpretation, result explanation, lack of communication, and emotion. We found that women express different emotion such as sad, anxious, confused, when discussing their ultrasound exam with their peers. The anxiety from lack of information

accompanied with emotional stress due to ultrasound exam has been proven. To make the obstetric ultrasound more comfortable for women, reducing anxiety, and improving pregnant women's knowledge before and after ultrasound; there is a need to improve the obstetric ultrasound report to contain lay language and more explanation to the patient about their pregnancy status and the obstetric ultrasound exam in general. To understand the nature of a diagnostic process, a medical condition, or a disease, it is important for the patient to understand the medical terminology in their report. This will allow patients to be well informed about their medical status and be able to make their own decision. Understanding medical terminology in a medical report may also decrease anxiety, and improve patients-communication relationship. According to O'Connell et al, misunderstanding of a medical terminology may lead to patients anxiety and distress (O'Connell, 2013). Moreover, several countries have required by law a patient access to a patient centered clinical report which means it should be in a simple text, easy to read and understand. For example, there are regulation by united stated and European Union which indicate that the patient should permit access to their medica information upon request (Tavakoli, 2013). United kingdom illustrated a best practice for patient access to their healthcare records(Royal College of General Practitioners, 2010).

Obstetric ultrasound report is a type of detailed communication provided to the patient. However, in our qualitative content analysis study (Alanazi EM, 2021), we found that women posted their report to ask questions about different things such as a certain medical terminology, different measurements, or the ultrasound images. Most of the hospital provide a patient portal for their patient where they can access their medical reports electronically. various researchers have attempted to understand the patients views on the use of online platforms. Patients want an easily readable material. A study by Martin-Carreras, Cook, and Kahn, Jr (2019) highlighted the

readability issues of radiology reports. The authors accessed 108,228 radiology reports from the United States health system database while excluding duplicates and missing data. They computed a reading grade level index and measured the number of words and sentences that could be read by an eighth-grade literacy level. Only 4.2 percent (4094) of the reports were readable for the 8th-grade reading level, which is the average literacy level for American adults. The researcher concluded that even though radiology reports are primarily intended for healthcare givers, they should be written in a simpler form to enhance patients' understanding.

User Interface and user experience design or UI/UX design is the process by which a designer can create a design to improve user experience. Hence, we provide a new design to the obstetric ultrasound report that will maximize the usability and improve user experience with the design. We took into consideration the presence of other technologies such as Natural Language processing and image processing module, and we assumed that the report is integrated to these modules to provide definitions of medical terminologies and organization annotations of the obstetric ultrasound images. The new design of obstetric ultrasound report is a patient-centric design in which we developed the report based on patients concern from our preliminary study (Alanazi et al, 2021). Patient centered approach and design thinking approach is used interchangeably to describe an approach that meant to solve a certain problem by providing an innovative solutions based on patients needs. According to Altman et al “ design thinking approach is to prioritizes developing empathy for users, working in collaborative multidisciplinary teams, and using “action-oriented rapid prototyping” of solutions”. What we did in our design is we looked at the patients information need and based on that we developed a novel obstetric ultrasound report. We called the new report a Smart Patient-Oriented Obstetric Ultrasound Report (SPOUR).

We developed two designs, one is information rich design, and the other is interactive design. We conducted an interventional study to evaluate these designs. In this study we compared a traditional report with our new designed reports to examine assess differences among the reports using different constructs. These constructs are: Perceived ease of use, perceived usefulness, intention to use, understanding, and perceived esthetics. We also examined usefulness and the ease of use of the new features we added in the report. Our aim from these two designs is to mitigate information needs, improve women understanding of obstetric ultrasound report, and enhance the women experience when reading the report.

## **Chapter II: Literature review of unmet information needs of obstetric ultrasound exam**

### **Introduction**

The concept of Health information-seeking behavior (HISB) has been studied since the 80's (Lambert, & Loiselle, 2007). However, there is an increase in the amount of information available as well as an increase in focus on self-care and self-monitoring (Lambert, & Loiselle, 2007). And because we are in the age of information, researchers become interested to understand why a consumer searches for information and what type of information they are looking for. It is indicated that it is a public health goal to enhance the individual's health information and the ability to use it effectively (Graffigna et al, 2017). A patient with high health information level is a patient with high information seeking behavior and tends to engage more with their care management (Graffigna et al, 2017). During pregnancy women become more inquisitive and tend to seek information online (Alanazi EM, 2021, Asplin et al, 2012). Part of the prenatal screening test that women go through is obstetric ultrasound exam. Before conducting the exam and after the exam women might have a lot of questions and could seek clarifications from their peers or be searching the internet if they could not have complete information during the care (Alanazi EM, 2021).

Obstetric ultrasound is a type of prenatal screening exam used for the imaging of fetus and women with adnexia. The mechanism involves the use of sound waves which are transferred into the specific region being examined (Campbell, 1980). Up to 4 million pregnant women undergo the process of ultrasound each year in the United States (Silvestri et al, 2016). There are a clinical and economic impact of pregnancy ultrasound (Bricker et al. 2000). An early pregnancy ultrasound provides; better gestational age assessment, earlier detection of, multiple pregnancies and detection of fetal malformation at a time when abortion is possible (Bricker et al. 2000). The process of

ultrasound and its impact on women's psychological behavior and feelings like anxiety has been extensively studied since 1980s (Robinson, Hibbard, & Laurence, 1984). It has generally been assumed that level of anxiety in the women reduce after ultrasound because it reassures them that their fetal is safe and it further promotes bonding (Gross et al, 2020). However, results of a number of research claims that ultrasound have been associated with increased anxiety (Kaasen et al., 2017). In addition, it has also been found that anxiety disorder is the most common psychological issue in the pregnant women and may affect 6.6 to 21.7% pregnant women (Somerville et al., 2014). This might be related to insufficient information provided to women. In a qualitative content analysis research we have found that different women expressed their worries when they asked questions in social media about obstetric ultrasound exam (Alanazi EM, 2021)

The role of ultrasound with respect to pregnant women is important but it can also be said that it has both positive and negative aspects. As research also shows that ultrasounds have both positive and negative impacts on pregnant females (Bricker et al., 2000). A factor that play a role in effecting psychology of a women is lack of information provided by the healthcare providers (Kaasen et al, 2017). Research shows that lack of information and awareness of the females is also one of the most prevalent factors that cause development of anxiety symptoms among them. A systematic review was done which included multiple study designs of multiple research. Author concluded one key finding as: "One key finding for clinicians was the need for all staff, women, and partners to be well informed about the specific purposes of ultrasound scans and what they can and cannot achieve" (Garcia et al, 2002, p. 1). Additionally, lack of communication by health care providers also increase anxiety among females and cause insecurities regarding fetus (Whynes, 2004). On the other hand, females have "fear of unknown", they are worried about the health of the fetus and about safety and body parts of their baby. In this study, we aim to explore

women information needs about obstetric ultrasound exam to understand the women information needs and gaps of obstetric ultrasound exam.

### **Methodology:**

PubMed, Science direct and google scholar databases was searched for English language, peer-reviewed articles from 2000 to 2021. The keywords used are “parents” or “women” and “obstetric ultrasound” and “information need” and “knowledge”. The bibliographies of key texts were then used to source further articles. Article titles and abstracts were screened by the principal researcher. Included articles are: 1) articles discussing empirical evidence of information need of obstetric ultrasound exam among women, and 2) Studies about women knowledge of ultrasound exam. We excluded articles discussing the clinical aspect of ultrasound exam such as diagnosis and treatment using ultrasound, and articles discuss the education and knowledge of healthcare practitioners, and articles about information needs of down syndrome screening (DSS).

The literature review analyzed to answer the following question:

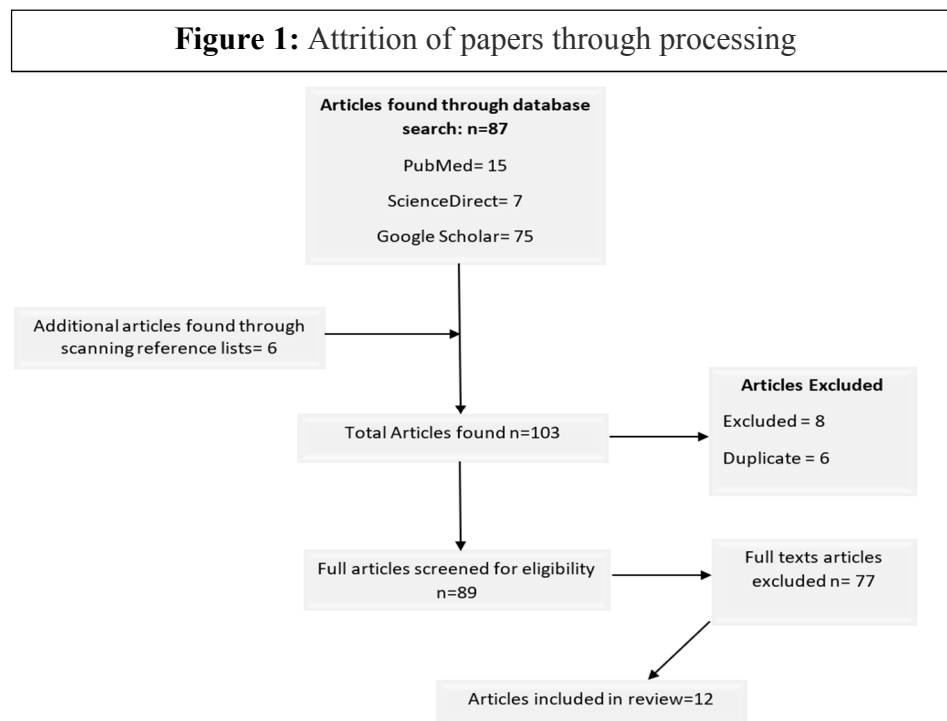
What is the information the women needs about ultrasound exam?

- Unmet information needs
- Information needs when abnormalities detected

### **Results:**

We have found 103 articles that discussed the lack and need of information about ultrasound exam and only included 12 articles for the review as shown in figure 1. The extensive

literature review provides us with two themes related to women information need of obstetric ultrasound exam which answer the research questions. These themes are: Unmet information needs, and information needs when detecting abnormalities. The research published in different countries, however most of the findings are common among different countries. Researchers explored women experience about ultrasound exam and have mentioned the need of information either during first trimester exam (Nykänen et al, 2017) or second trimester exam(Lalore et al, 2007, Larsson et al, 2009). And have mentioned the women opinion about written information provided to them (Lalore et al, 2007. Carlsson et al, 2021)



### **Unmet Information Needs:**

Different studies have explored, investigate, describe, and examine the women view about the provision of information provided to them either by the physician, midwife, or the

sonographer. Although the studies conducted in different countries as shown in Table 1, There are common findings. Different studies have indicated that women provided poor verbal and written information about the exam (Carlsson et al, 2021. Lalor, 2007. Mensah et al 2014). Also, it has been indicated that women are not informed about the purpose, benefits, limitations, and consequences of ultrasound testing (Carlsson et al, 2021. Kohut et al 2002. Mensah et al 2014). They have poor knowledge about the antenatal screening methods with partner and less educated parents are more likely to have less knowledge about it (Nykänen et al, 2017), and they are uncertain about the risks associated with ultrasound technology and whether the risk would increase with several examinations (Øyen,& Aune , 2016) In a study carried out in Ghana to evaluate how Ghanaian women perceive the use, and their assessment of the experience, of antenatal ultrasound scanning, they found that not inly the reason of the exam was not explained but also result was not explained to patient. (Mensah, 2014). This is echoing our previous findings (Alanazi et al, 2021) Where we found that women need to knowledge and more information about the purpose of the exam, what to expect, and how to prepare for the exam. We have also found that women need interpretation of their report and images, and would like more explanation of the result they received.

The women reported that they need information about exam procedure (Carlsson et al 2014, Skirton), and more information at the time point of the examination with explaining what is possible to see during the exam (Carlsoon et al, 2014). Also, they wanted information about the risks associate with prenatal testing including harm to the fetus, miscarriage and potential harm to mother. (Skirton et al, 2008). There are two studies mentioned the written information provided to the patient. Carlsson et all have mentioned that Participants provided their opinion about the written information given to them which vary between the participants with some of

them said that they did not read it and others mentioned that it was too basic and others felt that they appreciate more written information. Lalore et al discussed the availability of leaflets to provide information for the patients and it has been read by majority of the patient when it is available .

### **Need of information when fetus abnormality has been detected:**

The women indicated that they need information need explicit information the same day a fetal malformation is detected ( Larsson et al, 2010). Two studies have pin point women experience when a specific anomaly detected such as Choroid plexus cyst (Larsson et al, 2009), or Holoprosencephaly ( Redlinger-Gross et al, 2002). In both studies the women expressed their needs for more information. The more information provided the more anxiety would be eased and it the more control the parents can gained which will also help them in making their decision about wither to continue or terminate the pregnancy. Also, Redlinger-Gross et al, 2002 , indicated that many parents searched the internet and the library to learn more bout the disease, and were looking for information that could offer them the hope they were looking for. Asplin et al mentioned that the time between releasing the results and meet the physician were so long which give the women the opportunity to seek information through the internet. Lalore et al 2007 have mentioned that women who experienced diagnosis of fetal anomaly would like a supplementary written information to assist them to understand and recall the information provided to them, and help them to explaining the problem to significant others.

## **Discussion:**

### **Provider-patient communication and lack of information:**

Patient has the right to have effective communication with the physician in which the patient is informed about the received care, and listened to by the healthcare provider. This has been supported by the patients' rights declarations and different regulatory guidelines (Patak et al, 2009). However, a poor communication may occur between the patients and the provider leaving the patients uninformed and uncertain about either the service provided to them or a condition they encountered. For the ultrasound exam, we have found that patients ask for more information regarding the exam or the report with some of the women complaining about the communication with healthcare providers (Alanazi EM et al, 2021). In this literature review we have found that women want to know more about the ultrasound exam in general such as the purpose, benefits, limitations, and the safety of ultrasound testing, or they want more information when abnormality is detected. Having effective communication with patient will allow them to be more informed about their case and become more educated about the services provided. Leaving women with uncertainties may lead to increased anxiety during pregnancy period (Kaasen et al., 2017). It has been shown that women who had enough level of effective communication with their health care providers had a comparatively reduced level of anxiety and stress as compared to those who didn't have that communication. Tadmor (1995) demonstrated that women who had continuous sessions of conversation with their gynecologist were satisfied as they were getting information about their fetus whereas, women who lacked communication with their health care provider, didn't have information about what their ultrasound scan suggested. They were anxious about the wellbeing of their fetus.

When conducting the obstetric ultrasound exam, either a sonographer or a physician will do the obstetric ultrasound exam for the patient. It is important to train a sonographer about how to effectively communicate with the patient especially because sonographers are not allowed to give the patient any result before the physician approval. Facial expression during the scan, being responsive and allow patient to see the monitor is part of the communication skills the radiographer should acquire (Baillie et al. 2000). Therefore, it is crucial for sonographer to maintain a positive facial expression when conducting the scan and be responsive in the way limited to his authority of providing information. In a research study, 85% of sonographers agreed that they need to be trained for a short period to convey information to the patients. 65% percent insisted that it should be made to become mandatory to the practitioners (Nykänen et al, 2017).

#### **Lack of information about ultrasound & Need for awareness regarding reasons for a scan**

The result showed that women lack certain information regarding ultrasound exam. When women during the start of their pregnancy are asked to have their ultrasound done, they usually prefer the option declining the ultrasound test and the reason is usually their fear regarding the health of their fetus or are afraid of the results of ultrasound (Watson et al., 2002). Providing enough information is important for patient to be comfortable with the procedure and have an educated decision about their care. In addition, good communication and providing enough information result in better patient satisfaction and reduce patient complains (Easen and Harrison, 2017). Therefore, enhancing the patient care and improving the quality of care such improving the sonographers skills would improve the ultrasound service and enhance the patients' perspective about the obstetric ultrasound (Ugwu et al, 2009).

Roshanai, Ingvoldstad and Lindgren (2014) in their study referred that pregnant women should be provided with necessary information. Women who don't have knowledge about the ultrasound become anxious as they take it as a threat. Therefore, the women should be provided with significant information regarding ultrasound scan to ensure that they are well informed about the exam and the result. Also, research showed that women need to be aware of important information regarding ultrasound scan, educate women about the importance of monitoring the pregnancy through the ultrasound exam which may reduce their uncertainties as well as anxiety level (Larsen et al. 2000; Salmoukas et al., 2015).

### **Conclusion:**

Pregnant women's access to information is paramount and should be provided with relevant and useful information to manage this specific period of their lives. During the pregnancy, there is a lot of anxiety and uncertainty about the nature of the pregnancy and the health condition of the pregnancy, factors that are very critical for a healthy birth. This uncertainty results in women becoming more inquisitive, driving them to seek out pregnancy-related information. This has included seeking out information about ultrasound exams on the internet; and has included posting on social media platforms asking for help in interpreting ultrasound images, in a bid to better gain more information about their pregnancies. Pregnant women's access to information is paramount and should be provided with relevant and useful information to manage this specific period of their lives. Along with training healthcare providers to efficiently communicate with the patient, interventional e-health solution can be developed to provide the women with clear and sufficient information to help them understand the exam procedure, and their results.

Table1: Studies included and main findings of the review

Author title	Purpose of the work	Study design	Country	Category	Targeted Findings
Asplin et al (2012)	Explore pregnant women's experiences of received information in relation to fetal malformation detected on ultrasound	Qualitative content analysis	Sweden	Need of information when abnormalities detected	Women found the information provided confusing and have insufficient verbal information, and time between the release of the result and meeting the physician allowed women to seek information from the internet. All women valued the opportunity for a sufficient time and dialog with a physician to receive sufficient information.
Nykänen et al (2017)	describe the expectations to and knowledge of antenatal screening of expecting parents, and their	Quantitative study (Survey)		Unmet information need	Over 10% of the participants reported to have poor knowledge of the antenatal screening

	experiences concerning the first-trimester screening scan				methods. Partners and low educated parents were even more likely to have a poor knowledge of screening methods. Highly educated participants and nulliparous participants reported needing more information on antenatal screening
Carlsson et al (2021)	Examine the pregnant women's and their partner's experience of the information given at the antenatal clinic regarding screening methods	Qualitative content analysis	Sweden	Unmet information need	In this study, some participants stated that they received little information and was not aware of the purpose of the second trimester ultrasound scan (the second-trimester ultrasound scan is a form of foetal diagnostics). They would like to

					<p>know how the examination was carried out and more information at the time point of the examination with explaining what is possible to see during the exam.</p> <p>Regarding the combined test and invasive testing, the parents had varying information about the choices and consequences that can come with taking the test and would like more information about it.</p> <p>Participants provided their opinion about the written information given to them which vary between the particiapnts with</p>
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					<p>some of them said that they did not read it and others mentioned that it was to basic and others felt that they appreciate more written information. Some of the participants wants more information about screening methods available besides the second-trimester ultrasound scan and the time points and purposes of these tests. Some parents said they had trouble remembering what kind of information they had received or had trouble remembering if the information they had comprehended had</p>
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					<p>been obtained from the midwife or someone else. In general, participants believe that the midwife attitude and information was clear and have positive opinion about the midwife provision of information.</p>
Lalor et al (2007)	<p>to examine the current provision of pre-ultrasound information to women; to determine if the information provided was related to women's knowledge of the routine second trimester ultrasound; and to describe women's expectations of the scan</p>		Republic of Ireland	Unmet information need	<p>health professionals provide little information to women on which they can make informed decisions about their pregnancy. This study discussed the availability of leaflets to provide information for the patients and different factors that affect its</p>

					impact as a source of information.
Larsson et al (2009)	to gain a theoretical understanding of parents' experiences and handling of the situation, when their foetus was diagnosed as having choroid plexus cysts, at a routine second trimester ultrasound examination	Qualitative study (Interview)	Sweden	Need of information when detecting abnormalities	The major category in this study is the need for knowledge. As parents would like more information to reach a knowledge about the case. This considered by the authors as a solution to overcome the anxiety. Because going through amniocentesis was the parents decision, they were very confused and worried and would like more information especially from the physicians and would like not only enough information but

					counseling to guide them to make the appropriate decision. The parents mentioned that they lost control but they regain it after getting enough information and creating strategies.
Øyen,& Aune (2016)	to gain knowledge and a deeper understanding of pregnant women's expectations, attitudes and experiences regarding ultrasound examination during pregnancy	Qualitative study	Norway	Unmet information need	In this study, they indicate the women need all the information available to assure the health of their pregnancy. They mentioned how providing the images to the parents increase emotional attachments. Also, in the study women were uncertain about the risks associated with

					ultrasound technology and whether the risk would increase with several examinations.
(Kohut et al) 2002	evaluated women's understanding of prenatal ultrasound in terms of meeting the requirements for informed choice	Quantitative	Alberta	Unmet information need	many of the respondents did not recall having been fully informed about the purpose, benefits, limitations, and consequences of ultrasound testing 1 in 10 women stated that they had received no information from any health care source regarding prenatal ultrasound prior to their scan.
Skirton et al (2008)				Unmet information need	In this study, they indicated that the most wanted information about prenatal testing was about the possibility of harm

					to the fetus, including miscarriage and potential harm to mother. Other topics for information included information about the procedure, the condition for which the test was performed, options for action after the test, and the chance of a reliable result.
Mensah et al (2014)	To evaluate how Ghanaian women perceive the use, and their assessment of the experience, of antenatal ultrasound scanning.	Quantitative study	Ghana	Unmet information need	Most of the participants did not told about the reasons for the exam and did not have the results explained to them. The participants claimed that the sonographer did not explain the procedure before the examination. Some of the

					<p>participants could not ask questions or see their fetuses on the monitor.</p> <p>In general, this study showed that there is <b>lack of information provision</b> from health care providers about indications for the ultrasound, the processes involved and the results of the procedure.</p>
Redlinger-Gross et al (2002)	Explore the Experiences and Needs of Parents Who Receive a Prenatal Diagnosis of Holoprosencephaly (HPE)	Qualitative study	USA	Need of information when detecting abnormalities	<p>Parents need more information about HPE and mentioned that this information would have been helpful in making their decision about either keeping or terminating the pregnancy.</p> <p>Also, the study indicated that many parents</p>

					searched the internet and the library to learn more about the disease, and were looking for information that could offer them the hope they were looking for
Larsson et al (2010)	Generate a theoretical understanding of parents' experiences of the situation when their fetus is found to have an abnormality at a routine ultrasound examination	Qualitative study	Sweden	Need of information when detecting abnormalities	The women indicated that they need information need explicit information the same day a fetal malformation is detected. They needed more information about the ultrasound finding as it made it possible for them to prepare and to understand the diagnosis and how it would affect their child.

Lalore et al (2007)	explore women's experiences of encounters with caregivers after the diagnosis of fetal anomaly at the routine second trimester ultrasound scan	Qualitative study	Ireland	Need of information when detecting abnormalities	In this study, it has indicated that women could not comprehend what the physician said as they were using medical terminologies, and mentioned that the use of visual images enhanced their understanding of the case. All women described the need for supplementary written information either after the initial scan or after the appointment with the fetal medicine specialist. They described the usefulness of such information in several ways, from protecting parents through referral to appropriate
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					Internet sites, enhancing recall and understanding, to assisting in explaining the problem to significant others
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## **Chapter III: Patients' Unmet Information Needs and Gaps of Obstetric Ultrasound Exam: A Qualitative Content Analysis of Social Media Platforms**

### **Introduction:**

An obstetric ultrasound is a medical procedure that uses an ultrasound machine to perform an examination and observe a fetus in the womb. It is used to monitor fetus development and detect possible congenital anomalies, fetal growth disorders, multiple gestation pregnancies, and other placental abnormalities.<sup>1</sup> Although an obstetric ultrasound is important for detecting any gestational abnormalities, it may also lead to positive or negative psychological effects for the patient. Several studies have discussed the psychological effects of ultrasound exams during pregnancy (Ewigman et al, 1993. Ekelin et al, 2009. Harpel, 2008. Asplin et al, 2012). Ekelin et al discussed how the ultrasound can offer a sense of assurance and reduce anxiety among parents. This is not always the case, and some women become anxious during the ultrasound exam either because of the sonographer's behavior during the exam or their inability to see the monitor<sup>3</sup>. Also, ultrasound exam may detect a minor fetal anomaly or "Soft marker" such as choroid plexus cysts or echogenic bowel. These minor anomalies might rise a concern to the sonographer and the Obstetrician but most of the time it could be false alarm and disappear in the follow up exam (Thirup et al, 2021), In a study conducted about the importance of information and support following a suspected second-trimester anomaly that is later discarded, they found that discussing "soft markers" with parents even if it is minor increase parents worries and may continue to linger even after the medical concern was discarded (Thirup et al, 2021). They also found that women needed more knowledge than what they received at the hospital and many of the women turned to the internet for information about the condition (Thirup et al, 2021). Providing comprehensive information for the women about the ultrasound exam and results and

providing them access to the images can reduce their level of anxiety (Harpel, 2008. Asplin et al, 2012). Therefore, it is important to provide women with enough information in order to improve their satisfaction and psychological well-being, which in turns affects maternal–fetal bonding<sup>3</sup> and pregnancy health (Shahhosseini et al, 2015).

According to Forster et al, maternity patients are inquisitive, and often there is insufficient time to answer all the patients' questions in a clinical visit. In this study, we aim to identify the unmet information needs among pregnant women before and after ultrasound exams. To the best of our knowledge, there are no studies that investigate the exact information women are seeking before or after an ultrasound exam. Most existing studies mention that the women lack knowledge and their need of information; this has been observed when women complain about the need of knowledge when they were expecting a baby with abnormalities (Thirup et al, 2021). when they were unaware of the purpose of an ultrasound exam and its technical limitations (Lalor & Devane, 2007), or when the procedure of the exam and the result had not been explained to them (Mensah et al, 2014)

The purpose of this study was to leverage social media question and answer (Q&A) platforms to discover unmet information needs and knowledge gaps among pregnant women who are seeking to mitigate anxiety about ultrasound exams. Use of social media and internet or web forums for gathering information can be helpful because of the wide adoption of internet use across the world. Web forums have been discussed and analyzed in different studies (Iosifidis, Petros, and Nicholas Nicoli, 2020. Oh, 2012. Wellde & Miller, 2016. Munawar & Prabhu, 2021. Zhang et al, 2020. Alasmari et al, 2021) The social Q&A websites allow users to ask questions and contribute to discussions about a topic of interest and receive answers and advice from other users. Health is one of the most popular topic categories in these platforms. Health consumers

write posts to interact with one another and share thoughts and concerns. This makes social media forums an ideal resource for exploring the relationship between concepts and gathering direct and detailed information about personal health interests. Many users with different levels of skills and knowledge use these platforms.

## **1. Methodology**

### ***1.1. Data source and collection***

Our goal was to collect consumer health questions from social media forums to identify pregnant women's information needs. In this study, our source of data was 3 forums (Yahoo! Answers, BabyCenter, PregnancyForum) and a subreddit forum (Reddit/ultrasound). Yahoo answer was one of the largest QA platforms before it was closed with 21 million users from the US and 90 million users worldwide (Zhang et al, 2020). Because the rich amount of data and large user base, researchers are still using the yahoo!answers data to understand the patients' information needs and also use the data for their studies (Zhang et al, 2020. Alasmari et al, 2021). The other 3 forums were selected because of their popularity in obstetrics (Wellde & Miller, 2016) and ultrasound domains (Alasmari et al, 2021) , and to ensure that the themes and subthemes cross validate each other from the data of all the four forums we selected.

We performed a qualitative inductive content analysis of posts submitted between February 2018 to November 9, 2020, to assess the unmet information need of pregnant women undergoing or about to undergo an obstetric ultrasound exam. The contents of these topics were coded using the inductive content analysis process (Elo & Kyngäs, 2008) Content analysis processes have been used by several researchers who adopted social media as their data source (Iosifidis, Petros, and Nicholas Nicoli, 2020. Oh, 2012. Wellde & Miller, 2016. Munawar &

Prabhu, 2021. Zhang et al, 2020. Alasmari et al, 2021). The inductive approach is particularly useful if there is no adequate previous knowledge about the phenomenon or if this knowledge is fragmented (Elo & Kyngäs, 2008). We used open code and grouped, categorized, and abstracted the data (Elo & Kyngäs, 2008). The sampling process was intended to retrieve threads that contain questions about ultrasound exams. We used a purposive sampling strategy to find users who posted questions about obstetric ultrasound exams, and we determined the sample size using theoretical saturation.

In this study, we systematically reviewed 985 threads in the 4 forums and selected threads that contained questions or comments about ultrasound exams to assess the information needs of pregnant women. This strategy was used to determine what information a woman needs before or after an ultrasound. EMA organized the data, generated initial codes, and systematically identified and coded users' intents when requesting information. JL did a secondary revision and refinement of the codes. Then, we analyzed and created thematic maps of the main topics and subtopics. Finally, TA and MW refined the topics and subtopics, and we finalized the analysis.

## ***2.2. Thematic analysis***

We included posts related to patients' health information needs regarding an ultrasound exam. We also coded the negative emotions the women expressed in their comments and questions. We excluded any questions related to the exam costs or questions from students or practitioners about the ultrasound exam,

We then synthesized the collected information into themes. Each theme represents a key group of information gaps patients have frequently asked about or discussed. After categorizing the collected data, subthemes were included within each of the major theme groups. For each

themes, we counted the frequency of the questions and calculated the percentage of posts that contain the theme.

## 2. Results:

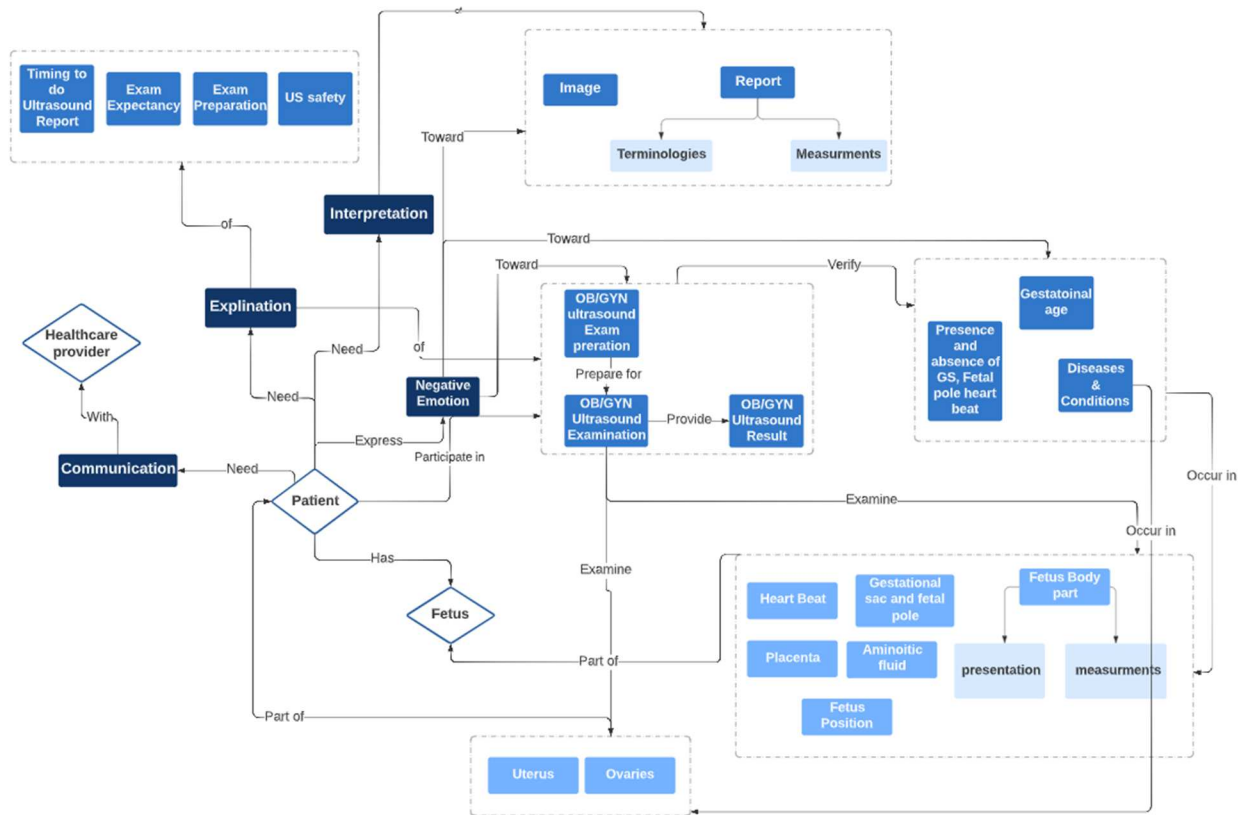
The analysis revealed eight themes related to obstetric ultrasound information needs, as shown in Table 1. These themes include: 1) Safety, 2) Questions before ultrasound exams, 3) Report interpretation, 4) Image interpretation, 5) Result explanation, 6) expressions of negative emotion, 7) Food intake, 8) Lack of communication. Figure 1 show the ultrasound exam workflow and illustrate the women questions and concerns of different topics related to the exam.

Table 1: Percentage of Thematic Topics and Subtopics

Main themes	Subthemes	Percentage per theme	Percentage of total	Number of questions or expressions
Safety (n=80) (18.39%)	Doppler	21.25%	3.90%	17
	Vaginal ultrasound	17.5%	3.21%	14
	Ultrasound beam	61.25%	11.26%	49
Questions before ultrasound exam (n=83) (19.08%)	Exam preparation	28.91%	5.52%	24
	Exam expectancy	40.96%	7.81%	34
	Timing to do obstetric ultrasound	30.12%	5.74%	25
Report interpretation (n=72) (16.55%)	Measurements	27.77%	4.59%	20
	Terms	34.72%	5.74%	25
	Acronym	37.5%	6.21%	27
Results explanation (n=113) (20.91%)	Gestational age	39.82%	10.34%	45
	Diseases and conditions	31.85	8.27%	36
	Presence and/or absence of GS, fetal pole, and heart rate	28.31%	7.35%	32
Image interpretation (n=87) (20%)	Gender reveal	69%	13.8%	60
	Location and shape	31%	6.2%	27

Negative emotion (n=114) (26.20%)	Negative emotion		26.20%	114
Healthy lifestyle (n=6) (1.37%)	Healthy lifestyle		1.37%	6
Lack of communication (n=15) (3.44%)	Lack of communication		3.44%	15

Figure 1: workflow of ultrasound exam and semantic relationships of a key data elements in social media questions



### **3.1. Report Interpretation**

We defined the report interpretation theme as a need to interpret and understand a medical concept, term, or measurement in the report content. This theme contains three subthemes: 1) questions about measurements, 2) questions about terminologies, and 3) questions about acronyms. Many pregnant women have difficulty understanding different measurements (4.59%), medical terminologies (5.74%), and acronyms (6.21%) that appear in the obstetric ultrasound report. For example, women in the second trimester often ask what “AFI” means. They also ask about medical terminology such as “lateral ventricle” and measurements such as cervix length and heart rate. They often wonder whether what they are seeing is normal. We noticed women’s struggles to comprehend these types of information in a medical report were associated with negative emotions.

*“..... The report says that the fetus is about 35-36 weeks. The other readings are*

*BPD 8.7 cms*

*HC 30.3 cms*

*TCD 46.0 mms*

*AC 31.7 cms*

*FL 6.7 cms*

*TL 6.0 cms*

*HL 5.8 cms*

*It says 'all long bones correspond to about 33-34 weeks'*

*That comment makes me worried. Your replies are most welcome”*

*“..... i went for my 16 weeks u/s and the report says echogenic bowel. has anyone else also got this in their u/s report????????? i have no idea what is this.....”*

### **3.2. Image interpretation**

A high percentage of women (20%) posted an image they received from their ultrasound exam to ask questions about the image, such as the baby's gender (69%), an explanation of a vague shape they see in the image, or a location of a certain fetal body part(31%). Some of the questions expressed anxiety about the fetus's development status.

*"..... I will be seeing an OB/GYN for the first time next month, so in the meantime I'm left to worry about my baby. One thing I know from the research I've done is that black areas on the 2D ultrasound indicate fluid, and fluid at the back of the neck/spinal cord can mean issues. To me it looks like there's fluid in my baby's neck, but I'm unsure. I'm also worried it doesn't have enough room in there. To me there also seems to be something strange about his mouth/chin relationship? ..... Can someone let me know what they can gather from my photos?"*

### **3.3. Result explanation**

We defined result explanation as an explanation of a condition or disease that a health care provider detected after the ultrasound exam. a lot of women want the result they received to be explained by their peers (20.91%). There subthemes emerged from this theme. First, subtheme is the gestational age (39.82%) where we found a lot of women are confused about the difference of gestational age between last menstrual period and ultrasound exam, and some of them are even concerned about the differences even if it is one week. Second subtheme is the disease and conditions with women asking questions about conditions or diseases their ultrasound detected in the fetus or the mother(31.85%). These results were often communicated with a health care provider. Third subtheme is questions about Presence and/or absence of gestation sac, fetal pole, and heart beat (28.31%)

*“Has anyone had an ultrasound and they told you the due date was off by 8 or more days?*

*I had one last week (20 wks preg.) and they told me that i would be due 8 days after my original due date. ....Just curious if an ultrasound can be trusted this late in pregnancy or if it's possible for the baby to just be light in weight....has anyone experienced this?”*

*“.....I had my 20 week ultrasound last week and was detected with this condition. Ever since I have been reading horribly scary stuff on internet about VCI. I would really like to speak with someone who had this condition and delivered a perfectly normal healthy baby.....*

*Please do share your experience if you had similar condition”*

#### **3.4. Safety of ultrasound exam and questions before the exam**

Women asked for general information about ultrasounds, such as whether ultrasounds are safe for the baby (18.39%). They might refrain from doing the exam to avoid any harm it may cause to the baby. Their questions about safety of the exam range from the safety of ultrasound beam(16.25%), the safety of doppler exam(21.25%), and the safety of vaginal ultrasound (17.5%). They also ask general questions such as when to do an ultrasound exam (5.74%), how to prepare for the exam (5.52%), what to expect from the exam (7.81), and a healthy lifestyle during pregnancy (1.37%).

*“.....I want to minimize ultrasound exposure especially early on- unless there's an emergency I'll only be getting the 20-week anatomy scan. I want to limit Doppler use too.....”*

*“....how many ultrasounds did you have during pregnancy and at which weeks??”*

### **3.5. Negative emotions**

In the majority of threads, women expressed negative emotions, such as being worried, confused, anxious, depressed, sad, or tense about different aspects of the ultrasound (26.20%). We coded a high percentage of negative emotions distributed among subtopics as shown in Figure 3. For example, a woman was anxious about a certain measurement she could not understand in her report, and another woman was confused about an image she could not comprehend.

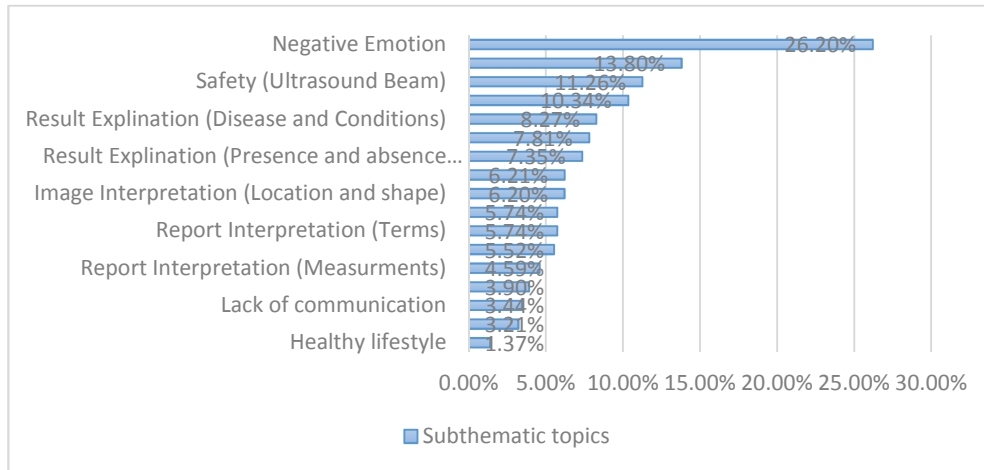
### **3.6. Lack of communication**

In the analysis, we found complaints about poor communication with health care providers, which causes the mothers or family members to be anxious or worried and seek others opinions (3.44%). The example below shows how a pregnant woman went to the emergency room after not getting enough information from her doctor about having a low fluid level.

*“.....fluids were low I’m not sure but he freaked me out and told me i need to have another ultrasound in 2 weeks. I left the doctors officer and took matters in to my own hands and went in to the E.R after 7 hours of getting nowhere with them they told me they wouldn’t be checking my fluids all they had down was hearing the baby’s heart and a mini ultrasound but it didn’t show how low fluids were ..my baby’s heart rate has always been really good and he is always moving on the ultrasound.....”*

*“..... My doctor has received the results yet hasn't bothered to call me. I had a look online and I just need a second opinion atm. What can you tell from these images?”*

Figure 2: Percentage of Subthematics topics



Out of 435 threads, 96 mentioned which trimester the woman was in. The majority of women who disclosed this information were in the second trimester of their pregnancy (9.42%), followed by the first trimester (7.81%) and the third trimester (5.05%). This could be because most of the women in their second trimester were undergoing a detailed ultrasound exam called the anomaly scan. Further, the second trimester is when the baby’s gender can be identified. Hence, women might encounter a lot of information that they struggle to understand, and they may turn to social media to find answers. Most of the women in their first trimester asked questions about the absence or presence of a detectable heart rate, fetal pole, or gestational sac or expressed confusion about gestational age.

### 3. Discussion

An obstetric ultrasound is the first-line imaging modality used in pregnancy. In this study, we understand information needs and gaps of obstetric ultrasound exam. We collected the data from Yahoo!answer before the announcement of shutting down the website by May 2021, We used other websites to collect data as well, from which we observed that they cross validated

each other. The results showed that it is critical to provide adequate information to patients regarding the ultrasound exam. Many factors lead women to seek explanations of their ultrasound exams on social media.

### ***3.1. Inadequate information and report release time***

In different studies, women expressed their needs for more detailed information from their health care providers (Asplin et al, 2012, Thirup et al, 2021. Nykänen et al, 2017. Quinlan-Jones, 2017) A balance between detailed and necessary information is important to avoid ambiguities and unnecessary anxiety. In addition, it maybe difficult for women to remember and comprehend all the information provided in a visit (Carlsson et al, 2021. Quinlan-Jones, 2017). This could be one of the reasons women seek further information online. In a study conducted to explore Parental experiences of prenatal whole exome sequencing (WES) in cases of ultrasound diagnosed fetal structural anomaly, the parents preferred to have as many information as possible in different format and “appreciated receiving clinical details in written format relating to the specific anomalies identified” (Quinlan-Jones, 2017). Therefore, it is important for clinicians to provide written and verbal information to patients during the consultation, and access to a patient-friendly ultrasound report as soon as possible after the appointment, to help reduce patient uncertainty in the period immediately following the consultation.

Additionally, the time between the clinical visit and the release of the patient’s report may lead women to seek outside opinions. In a study conducted to explore pregnant women’s experiences of received information in relation to fetal malformation detected on an ultrasound, most women thought the time between the first examination and second verifying ultrasound examination was too long, giving them ample opportunity to seek information online. The

information they found online gave a sense of security or insecurity, depending on what they learned (Munawar & Prabhu, 2021).

### ***3.2. Difficulty understanding obstetric ultrasound notes and images***

The growth of e-health, including the development of electronic medical records and the easy access of information by both health care providers and patients, has become an integral part of today's health care (Forster et al, 2015). Multiple health care facilities provides a web portal with different functionalities and features, and most patient portals allow patients to email their health care providers and make appointments and allow providers to provide electronic fillings of medication and make clinical reports accessible. However, making medical reports available to patients through the patient portal may lead to misinterpretation of the information provided due to the complexity of medical terminology and knowledge gaps (Gunn et al, 2017) Health care providers have not fully addressed the issues of readability and comprehension of medical reports for health consumers when accessing patient portals. In a study conducted to measure the readability of radiology reports, researchers found that almost all radiology modalities do not meet the recommended patient readability guidelines indicating that he the radiology reports are difficult for patients to understand.<sup>23</sup>

In this study, we found that patients asked about different medical terminologies they could not understand in their obstetric ultrasound report. It is recommended that materials written to patients be at or below the 4<sup>th</sup> to 6<sup>th</sup> grade reading level (Trofimova, 2018). The content of an obstetric ultrasound report exceeds the average reading level, which may lead patients to seek other opinions about their report. Technological advancements such as Natural Language Processong Allow providing patient-friendly definitions of medical terminologies which will enhance patients' understanding and readability of a medical report.

In addition, Interpretive numeracy is defined as “the ability to understand the strengths and limitations of numbers to represent health or disease states, the efficacy of an intervention, or other expected health outcomes.” (Schapira et al, 2008). Patients may misinterpret the numeric data available in their report. In this study, we found that parents often struggled to comprehend measurements that appear in obstetric ultrasound reports. This issue was reflected in 4.59% of the posts we examined. Common numeral results in the obstetric ultrasound report include fetal parameters, heart rate, cervix length, amniotic fluid index, and estimated fetal weight. We found these measurements are often asked about on social media. We recommend that the obstetric ultrasound exam provide an intuitive indicator to show whether the measurements are normal. This will eliminate some confusion and make the report easier for patients to comprehend.

Furthermore, medical images in the obstetric ultrasound exam are important to many pregnant women. In some studies, obstetric ultrasound images were correlated with a strong psychological effect in pregnant women because seeing the fetuses in the images helped them form stronger emotional bonds with their babies (Van der Zalm & Byrne, 2006). Despite this, little work has been done to help patients understand their radiology imaging information (Arnold et al, 2016). In this study, we found many parents posted their obstetric ultrasound images online to ask for further interpretations of the image. With technological advancement, an image processing module could be developed within the patient portal system to enhance the representation of imaging information. For example, in a research study for brain MRI reports including notes and images, a portal used an image processing module and natural language processing module to explain MRI images and reports information (Arnold et al, 2016).

### ***3.3. Need for information before conducting the obstetric ultrasound exam***

A systematic review of women's views of pregnancy and ultrasounds conducted in 2008 mentioned, "Women's early concerns about the safety of ultrasound [exams] were rarely reported in more recent research." (Garcia et al, 2002). However, in this study, we found that women are still asking about the safety of ultrasound exams or refrain from having an ultrasound exam to protect their babies from any harm the procedure might cause. These women's poor knowledge about the safety and purpose of an ultrasound aligns with findings in other research studies (Mensah et al, 2018. Garcia et al, 2002). Therefore, providing a more thorough explanation about the safety and purpose of the exam and how to prepare for the exam is needed to prevent misunderstanding and to ensure they do not miss out on an important diagnostic procedure.

Alongside questions about obstetric ultrasounds, some women (1.37%) asked about how to maintain a healthy lifestyle during their pregnancies. Expanding this research to examine all questions women ask during their pregnancy may reveal more questions women ask about how to maintain a healthy lifestyle, but this is outside the scope of this study. However, it is important to provide pregnant women with health management resources to help them adhere to a healthy lifestyle and avoid unfavorable birth outcomes. The AMA and the U.S. Department of Health and Human Services recommend writing patient education materials at or below the seventh-grade reading level (Martin-Carreras & Kahn, 2018). We recommend adding information to the medical report that will increase women's knowledge about how to maintain a healthy lifestyle and a healthy pregnancy.

## **4. Conclusion**

In this study, we found that many women seeking information about ultrasound exam online because of poor provision of the information, difficulty remembering what was said

during the office visit, or difficulty understanding the radiology report. It is crucial to provide pregnant women with enough clear information because they are prone to high anxiety levels if they are uncertain about their pregnancy, which may negatively affect the pregnancy outcome. We noticed that the obstetric ultrasound report needs substantial improvement. We recommend using technological advancements to provide a patient-friendly report that contains easy-to-understand information. Filling this gap by improving obstetric ultrasound reports will allow pregnant women to easily find credible information. This may improve the quality of care and increase women's satisfaction with the exam.

## **Chapter IV: What Makes a Patient Friendly Obstetric Ultrasound Report: Design Thinking Approach**

### **Introduction:**

One of the important aspects in improving the quality of care is to provide a service that meets the needs of both health care providers and patients (Lee et al 2018). Studies have discussed patients' needs and their health information-seeking behaviours (Luker, 1995. Cawley & Cappello, 1990. Gravis et al, 2011. Clarke, 2016. Alanazi EM et al, 2021). As medical records have become more readily available through patient portals, patients have sought health information more actively. The OpenNote study (Walker, 2014), which aimed to explore the effects of providing access to these medical notes, found that more than one-fifth of patients who participated in the study were sharing their medical records with others who could help them understand the reports and offer clinical advice. With respect to the radiology reports, different studies have discussed the importance of providing easy access to reports with clear and detailed information (Lee, 2016. Bruno et al, 2014). There have been several attempts to provide a patient-centered report that can be easily understand by patients (Oh SC et al 2016. Cook et al, 2017). The obstetric ultrasound is one of the radiology modalities that provides information about fetus viability and healthy pregnancies. According to Forster et al., patients during pregnancy are inquisitive, and there is rarely enough time to ask or answer all of their questions during hospital visits (Forster et al, 2015). Research has shown that online searches for information significantly increase during pregnancy periods, and online communities are helpful because of accessibility and availability of information (Lagan et al, 2011)

Some studies have discussed what makes a good and complete ultrasound report (Cargill & Morin, 2017. Edwards et al, 2018), however, to the best of our knowledge, there are no recommendations for an obstetric ultrasound report that targets patients. In this paper, we provide design

recommendations for creating a patient-friendly report for an obstetric exam based on a previous study we conducted to look at patients' information needs relating to the exam (Alanazi EM et al, 2021). Our recommendation is based on the design thinking approach (Altman, 2018). The design thinking approach was widely adopted in the industry and academics to provide innovative solutions for their customers. In a study conducted by researchers at the University of Virginia's Darden Business School and the Design Management Institute to look at how widely a design thinking approach could be applied among different organizations, they found that this approach is not only an innovative process but also a problem-solving process( Liedtka, 2014).

We follow the design-thinking principles (Figure1) to create patient-friendly design recommendations for ultrasound reports. In addition, we also demonstrate the design recommendations by creating a novel smart patient-oriented obstetric ultrasound report (SPOUR) for a routine second trimester exam. First, we conducted a qualitative content analysis study (Alanazi EM et al, 2021) where we systematically gathered pregnancy-related consumer health questions from four public forums (Yahoo! Answers, BabyCenter, PregnancyForum, and a subreddit forum(Reddit/ultrasound)). Our qualitative content analysis showed that the women cannot understand their obstetric ultrasound report and may become anxious if they encountered uncertainties (Alanazi EM et al, 2021). We provided recommendations on how the ultrasound report can be enhanced to meet the patients' information needs.

Figure 1: Design Thinking process, stages of design thinking and method in each stage

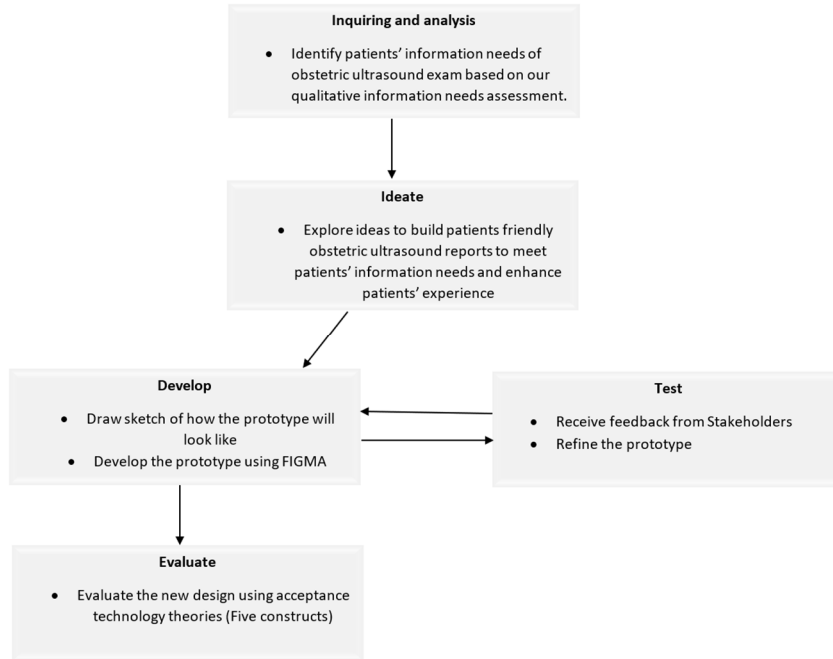


Table 1 show our recommendations of each section in the report. The recommendations relay on technology advancements such as artificial intelligence applications. In the recommendation we provided and the report we designed, we have not only focused on how to address the women information needs but also we focused on user experience and usability context to ensure that the users perceived the report as: useful, easy to use, esthetics, and have intention to use it.

Table1: Recommendation for patient oriented obstetric ultrasound report

	<b>Recommendation</b>
<b>Esthetic perception</b>	1) Provide sections and subsections to ensure easy navigation of the report 2) Use colors that makes the navigation mechanism easy, with avoiding any colors that might affect the users emotions
<b>Result section design</b>	1) Info Icons to display more information about the report content, 2) Underlined terminology to define a medical terminology, 3) Definition of a medical condition, if possible.

<b>Impression section design</b>	Provide an infobutton for an explanation of a disease or condition in a lay language, if possible.
<b>Image section design</b>	<ol style="list-style-type: none"> <li>1) Indicators to show wither the image is normal or abnormal,</li> <li>2) A general information about what the sonographer looked at in this section,</li> <li>3) Image taken with no annotation,</li> <li>4) Colored annotation of the image to show the body parts,</li> </ol>
<b>Educational section design</b>	Provide educational sections to briefly <ol style="list-style-type: none"> <li>1) Indicate the safety of ultrasound exam, what to expect from them, when to do the exam, and how prepare for the exam</li> <li>2) Provide suggestions from reliable sources such as WHO and The American College of Obstetrician and Gynecologists website to maintain a healthy pregnancy</li> <li>3) Provided in a link to a website that contained detailed recommendation and education during pregnancy.</li> </ol>

**Esthetic perception:**

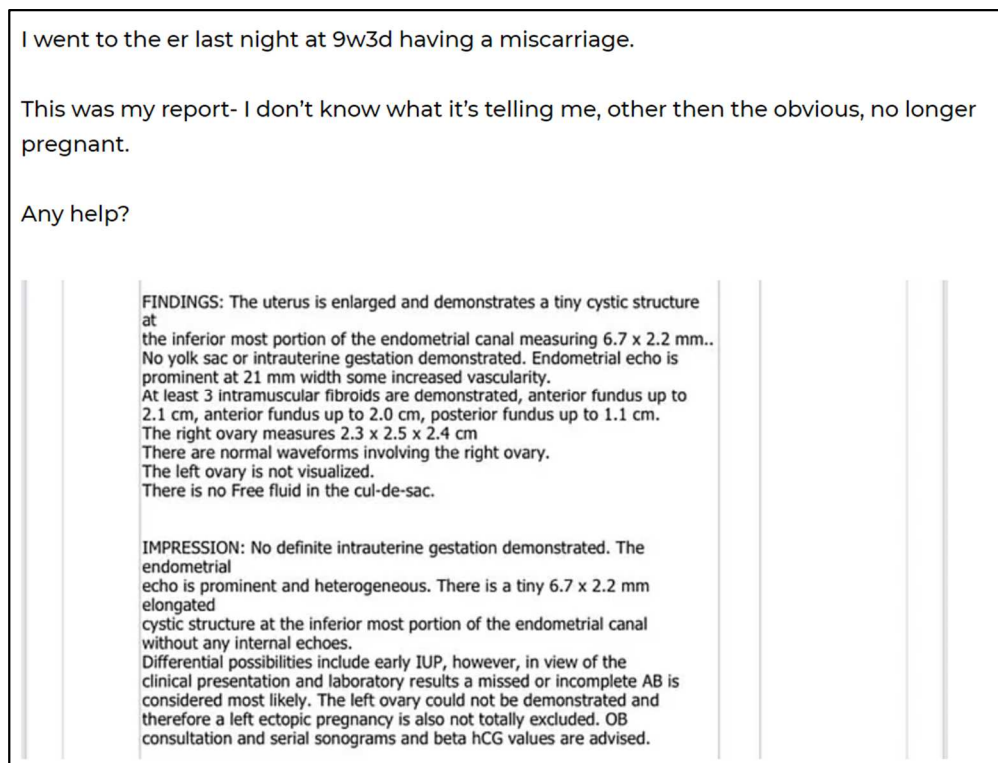
With visual design we are focusing on the esthetics of the product or a website. Esthetic perception, especially in the context of user experience design, is an important aspect to increase user satisfaction (Seckler et al, 2015).Also, It has been proven that visual design increases a product’s usability (R.N. Schenkman &U. Jonsson, 2000). Proper structuring of a medical reports and use of suitable colors is fundamental for the user experience design to make reading the report easy and more enjoyable for a lay person.

**A. Report structure design**

In the visual design of an e-commerce websites, developers must be concerned with how the information displays can be navigated and not only not only with how visual displays of this information are constructed (D. Zhao and N. Zhou, 2008). Similarly, we believe that navigational mechanisms of a medical report is important aspect when designing the report. It is indicated that “Developers of effective information visualization are confronted with a fundamental problem: Design a visualization of a particular information space that displays what the user wants to see,

and allows the user to focus quickly on areas of interest” (D. Zhao and N. Zhou, 2008). To enhance patients’ experience when reading the obstetric ultrasound report, the report should not only have complete and accurate information but also different sections that facilitate the navigation of the report. In the previous study we noticed that women posted their ultrasound reports to ask for more explanation about the reports and about the results they received( Alanazi EM et al, 2021) Most of the reports posted on social media were poorly organized and could not be easily understood by a layperson. Such condensed information normally only produced or used by a health care provider (Figure 2). Women in social media also posted images they received after the ultrasound exam to ensure that their fetuses were healthy and did not have any issues. To provide a patient-friendly report, our primary goal is to provide a report that is easy to read as well as making the report contents organized, easy to navigate, attractive, and able to meet the patients’ information needs.

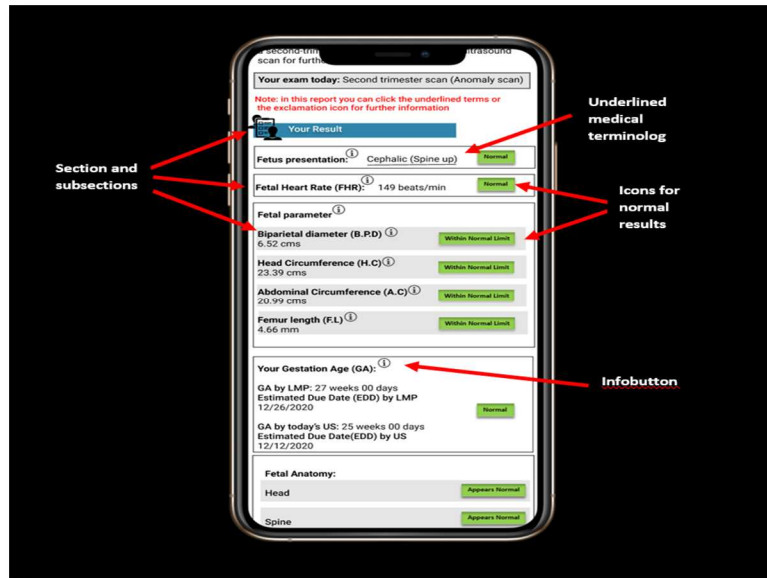
Figure 2: Example of a report posted in social media



Structuring ultrasound reports in general has been discussed widely in the literature. According to Necas, an ultrasound report should contain the following sections: (1) title; (2) patient identification, demographics, date, recipients, provider details; (3) indications: history and clinical information; (4) technique and procedural description (when required); (5) findings; (5a) itemized findings; (5b) normal and abnormal observations; (5c) diagnostic comments; (6) impression/conclusion; (7) the names of the individuals involved in the examination; (8) Inclusion of reference standards in the footnotes (when required). Our recommended structure is similar to what has been suggested in the body of literature. However, there is more that can be done to the medical report released to the patient via the patient portal. Efficient content organization is crucial for improving the readability of reports, such as explanation of key contents, interpretation of the medical terminologies, and links to reliable resources.

To develop a patient-friendly obstetric ultrasound report, we recommend not only sectioning the report header, such as the results and impressions, but also sectioning the details in the ultrasound report for easy navigation through the information provided. In addition, a subsection should be provided, if necessary, using a suitable color to distinguish a section and a subsection within the report. Figure 2 shows how we organized the results in the designed SPOUR and the colors we used to distinguish each section and subsection. The color-coding will make the report easy to navigate and possibly more attractive to read.

Figure 3: Organization of the result section in the Patient Oriented Obstetric Ultrasound Report (SPOUR)- Interactive Design

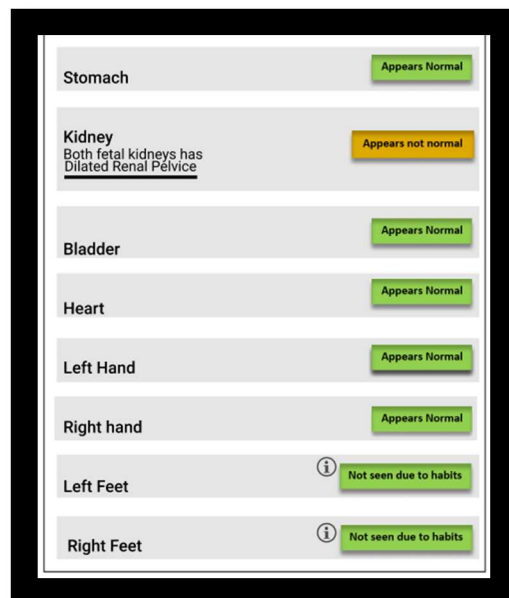


### B. Color of Psychology:

For user-experience design, we think beyond the usability. There is a psychological aspect that is fundamental when designing software products (Kompaniets et al, 2019). Researchers have studied colors in terms of their impact on human behavior, cognition, and affects (Elliot & Maier, 2014). In a study conducted to link different design factors with subjective aesthetics (Seckler et al, 2015), researchers found that color is one of the factors that plays an important role in aesthetic perception. We found that Blue hues were favored most often, in keeping with other studies findings (Luker et al, 1995. L.C. Ou et al, 2017). In addition, we recommend designing a report in a way that is not only more pleasant and attractive for patients but also avoids colors that make them anxious. Hence, careful attention is needed not only to the type of colors used in the report. According to Elliot and Maier, “Red and yellow were posited to be stimulating, to prompt an outward focus, and to produce forceful action, whereas green and blue were posited to be relaxing, to encourage an inward focus, and to produce calm and stable

action.” (Elliot, A. J., & Maier, 2014). For our new report POUR, we used blue for the main sections, such as the results and the impressions, as shown in Figure 2. We used gray if we needed to subsection some of the content for easy navigation. We have provided green icons to indicate that the result is normal. We avoided using red and yellow for abnormal findings; both are commonly used to indicate caution in signage and brake lights (Elliot, A. J., & Maier, 2014). Hence, we used light brown to indicate abnormal findings (Figure4).

Figure 4: Normal and abnormal observations - SPOUR



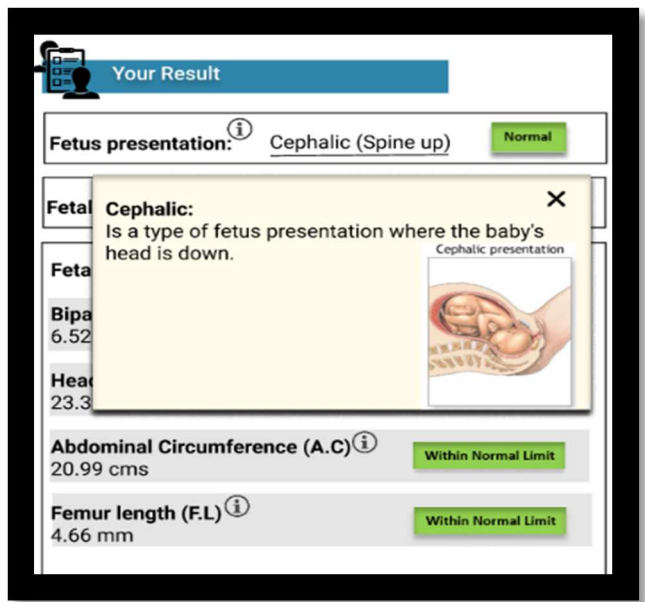
## Result section design

### A. Terminology definition design:

Transforming professional medical terminologies to a patient-friendly version has been an important topic in many studies (Oh SC et al, 2015. Trofimova, 2018. Cook TS, 2017). There are different standardized lexicons available, such as Radlex, SNOMED CT, and UMLS, which can be used as a sources to define a medical terminology. Radlex is a lexicon used to meet the needs of clinical practice, research, and education in radiology (Rubin, 2008). It was developed to

overcome some of the limitations found in other lexicons such as SNOMED CT and UMLS (Martin-Carreras T & Kahn, 2018). However, Martin-Carreras and Kahn discussed the limitations of Radlex as a patient information source. They compared the readability of the lexicons developed by professional organizations such as Radlex and MedlinePlus and a domain-specific lexicon called PORTER which builds the domain of an MRI of the knee to be incorporated into a patient portal and provides lay language definitions of medical terminology for patients. They found that “at the eighth-grade reading level, 8.8% of MedlinePlus summaries, 10.7% of RadLex definitions, and 89.7% of PORTER definitions are readable.” This indicates that building a domain-specific patient friendly glossary is the best method when providing a translation of medical terminology. Therefore, building a glossary specific to obstetric ultrasound medical terminology would provide more information and definitions related to obstetric ultrasound reports. Figure 5 shows an example of a definition to a medical terminology in Obstetric Ultrasound Report..

Figure 5: Medical terminology in interactive POUR

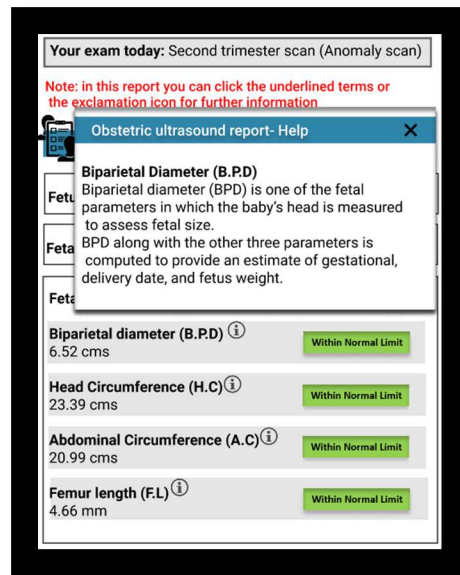


## **B. Further explanation of the result design:**

Internet become a source of information for pregnant women. That could be due to several reasons such as insufficient provision of information or releasing the report before the office visit and difficulty to read the report and interpret the image (Alanazi EM et al, 2021). Different e-commerce websites provide their customers with “Information Icons” to provide detailed information to answer any questions the users might ask and avoid any confusion they might encounter. Similarly, we can provide patients with an “Info Icons” to help them understand their ultrasound reports and be more knowledgeable about the content of their report, if needed. For example, we found that majority of women asking about why there is a difference in the gestational age between Last Menstrual Period and Ultrasound Exam. In this case, Information Icon could provide detailed information about why such difference could exist. This will enhance women knowledge and meet their information need about this aspect of the exam. In our newly designed sample (Figure 3), the exclamation icon is an “Info icons” to assist patients to understand different terms in their obstetric ultrasound report; if the patient clicks it, they will find user-friendly explanations of these different medical concepts in the field of obstetric ultrasound exams. To assist women to understand their report, we could provide Icons that exhibit further information about the report.

Figure 4 shows an example of a window that pops up if a woman clicks an “info icon” about a biparietal diameter in her report. A simple and easy explanation in the report could help eliminate this confusion. Hence, we recommend developing a database that contains patient friendly explanations of the report content. It is crucial to test the readability of this information provided using both Flesch Reading Ease and the Flesch–Kincaid grade level to ensure that it meet the average reading level, if possible (Alanazi EM et al, 2021).

Figure 6: Information Icon in SPOUR



### C. Normal and abnormal observations:

Most of the reports we have seen posted by the women in social media has normal and abnormal observation for only the fetal anatomy. Other parts in the report does not contain any observation. For example, Measurements of the fetala parameters, Amniotic Fluid index, and heart rate, are only provided without mentioning wither it is within the normal limit or normal for gestational age. In our social media analysis study (Alanazi EM et al, 2021). We have noticed women asking about their Amniotic fluid index (AFI), others asking about fetal heart rate, cervix length, fetal weight, fetal parameters, and gestational age difference between LMP and US. We suggest providing indicator to show wither these different measurements are normal or abnormal. In ultrasound exam, we can express the normal and abnormal observation in different ways. For example, using the indicator “Within normal limit” for fetal parameters, and using “normal for gestational age” for amniotic fluid index since both measurements may change depend in the patient’s case and the gestational age. In addition, we noticed that some of the women in social media are panicking when they have been informed that their fetus feet or hands

can not be seen. Therefore, we recommend to provide an icons for any body part that could not be seen due to habitus, and provide the icon “suboptimal” in the image section. Provide explanation of what this icons means as shown in figure. In our proposed design, we provided the following icons: normal, appears normal, normal for gestational age, suboptimal, not seen due to habitus, and within normal limits. We used the color green for normal observation and brown for abnormal observation. Figure shown the icons we used in different part in the report and the infobutton in front of certain icons that might be difficult for patient to understand.

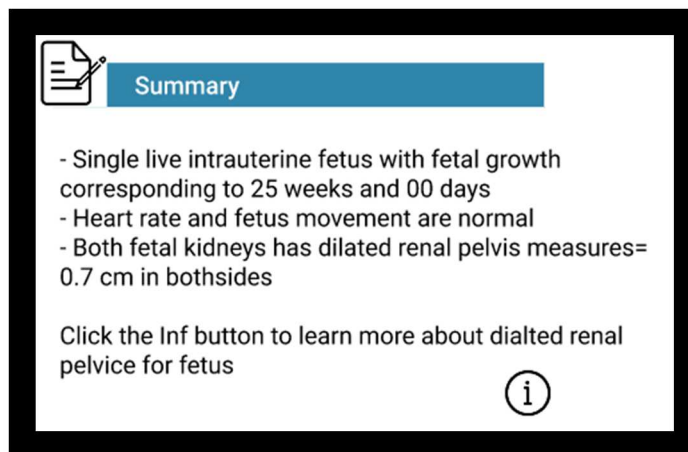
### **Impression (Summary) section design:**

Ultrasound exam may detect a minor fetal anomaly or “Soft marker” such as choroid plexus or echogenic bowel. These minor anomalies might rise a concern to the sonographer and the Obstetrician but most of the time it could be false alarm and disappear in the follow up exam.<sup>34</sup> In a study conducted about the importance of information and support following a suspected second-trimester anomaly, they found that discussing “soft markers” with parents, even if it is minor, increase parents worries and may continue to linger even after the medical concern was discarded (Thirup et al, 2021). They also found that women needed more knowledge than what they received at the hospital and many of the women turned to the internet for information about the condition (Thirup et al, 2021). Providing comprehensive information for the women about the ultrasound exam and results and providing them access to the images can reduce their level of anxiety (Thirup et al, 2021). We found that a lot of pregnant women ask their peers in social media to explain results for them and some of these are soft markers such as “echogenic bowl” (Alanazi EM et al, 2021).

Although explaining the results in detail is the physician’s role, It has been indicated that patients may not comprehend all the information given to them in a single visit (Carlsson et al, 2021). In addition, women tend to seek the internet as a source of information and could be their number one choice when seeking information about their pregnancy (Ugwu et al, 2007). Since

searching the internet may provide endless information that is not tailored to the patients' cases and may increase the patients' uncertainty and anxiety, we could add in the summary section an Infobutton Manager (IM) that could direct the patient to a reliable source that provides credible information tailored to the patient's case (Figure 7). An infobutton Manager is commonly used in electronic health records to retrieve sensitive context knowledge to address clinicians information needs (Cimino, 2007). This technology will meet the patients' information needs, and it may reduce the panic caused by blindly searching for online health information.

Figure 7: Summary and What's Next section- Interactive SPOUR

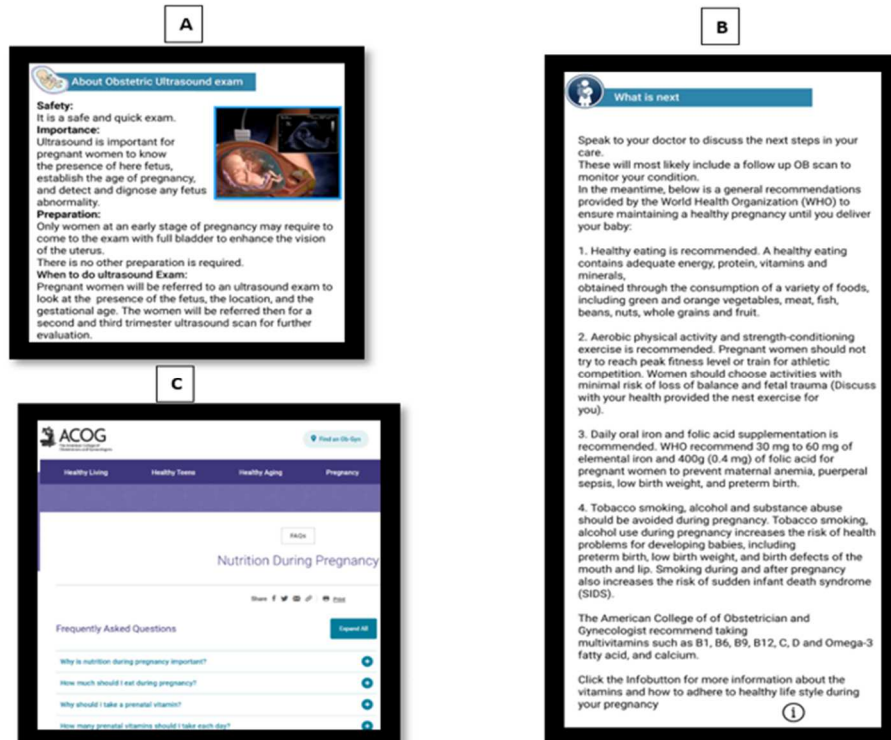


### **Educational knowledge expansion design:**

Pregnant women tend to ask on social media when to do their ultrasound exam, what to expect, the safety of the ultrasound exam, and ways of maintaining a healthy lifestyle (Alanazi EM, 2021). Although these questions and concerns should be addressed before the exam, we believe that providing sections in an ultrasound report answer them will help women be more knowledgeable about the exam. Given that it is recommended to provide educational material at

or below the seventh-grade reading level (Martin-Carreras, Kahn, 2018), we suggest adding two different sections. The first section is “About the Ultrasound Report,” which discusses briefly ensuring the safety of the ultrasound exam, when to do the exam, and what to expect from it (Figure 8-A). The second section is “What’s Next”; in this section we can provide a brief recommendation about maintaining a healthy lifestyle from a reliable resource such as the World Health Organization (WHO) or the American College of Obstetricians and Gynecologists (Figure 8-B). We could also add a link that directs the patient to a detailed and patient-friendly source showing the most frequently asked questions to maintain a healthy pregnancy from a reliable website such as the American College of Obstetricians and Gynecologists website. Figure 8-C shows the frequently asked questions provided by the American College of Obstetricians and Gynecologists website, which can provide as an infobutton to provide women with detailed nutritional advice on maintaining a healthy pregnancy.

Figure8: Educational Sections and link to website for detailed information



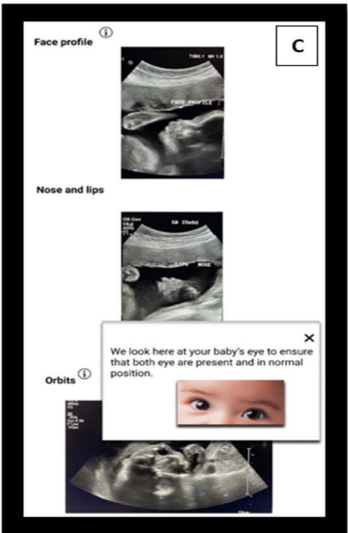
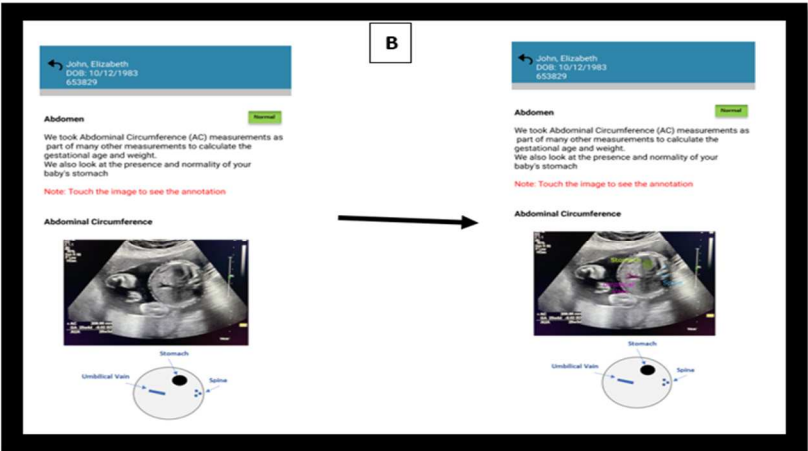
### **Image section design:**

Obstetric ultrasound images can make a strong psychological impact on pregnant women, given that a pregnant woman could have a strong emotional bond with her baby once she sees the fetus in the images (Van der Zalm & Byrne, 2006). In different studies, women have indicated that the sonographers or physicians fail to communicate effectively about the Obstetric ultrasound images and what has been seen in the monitor during the exam (Van der Zalm & Byrne, 2006. Øyen & Aune, 2016). We identified many parents post images in social media to seek for interpretation. Little work, to date, has been done to facilitate image interpretation for patients when accessing their images through patient portals. There are studies that have discussed experimental systems; one is to view an image with a report, and the other is an advanced system that integrates image processing modules to create a timeline that describes the disease's progression (Greco et al, 2016. Arnold et al, 2012). With technological advancement, it becomes possible to organize the images in a way that makes it easy for patients to navigate. For the obstetric ultrasound images, especially during the second trimester scan, a sonographer will take many images, especially if the exam is comprehensive and not limited to specific parts. Women in this stage of pregnancy become excited to see these babies' images. Most of the women ask for images in a CD or on paper to keep them as memories. Organizing the images in a way that makes it easy for women to navigate through the number of images she gets after the exam is an important factor for increasing the women's satisfaction with the quality of care provided to her, which will increase the Obstetric and Gynecology facility economically in a competitive market (Wheatley, 1997). During the second trimester scan, the sonographer takes images of different body parts of the fetus. Figure 9-A shows our proposed idea on the first page displayed when pregnant women access their images for a routine second trimester exam. We organized the images based on each body part. If the patient accesses the body part, she will see a brief

explanation of what has been photographed, and the images of each body part will be further sectioned based on what has been taken for each specific part (Figure 9-C). Illustrative images can be added, if possible, to further explain the images for the patient, as shown in Figure 9-B. An infobutton can also be added to provide more information or more visual representation of some of the images as shown in Figure 9-C. We believe that providing these features might increase the mother–fetus bonding and make the ultrasound experience more pleasant and informative.

Women might panic if they looked at an image and cannot understand what the shapes might be conveying, and most of these women seek image interpretation in social media to calm their fears and worries (Alanazi EM et al, 2021). To the best of our knowledge, there is no experimental system to date that annotates images for patients to help them further understand their images. Most of the background work has discussed annotating the medical terminologies using natural language processing to provide a translation in a lay language (Oh SC et al, 2016. Martin-Carreras & Kahn, 2018). Ultrasound modules built by different companies such as HP and Siemens may provide colorful annotations. An obstetrics and gynecology department may ask the sonographer to annotate the image before sending it to the PACS system. This will allow women to see not only the images but also annotations of the images for further understanding. Figure 9-C shows an example of how the image will look like if annotated. Further work might be done to use deep learning algorithms to automatically annotate the obstetric ultrasound images during the scan.

Figure 9: Image section- Interactive



**Conclusion**

Radiology reports is considered physician-physician communication and contain medical jargon that can only be comprehended by radiologists and other physicians (Bruno et al, 2014). Numerous papers have discussed difficulties in reading radiology reports in general and the importance of providing easy access to radiology reports with detailed information. When women undergo thorough obstetric ultrasound exams, their experiences can be trying if uncertainties are involved. The recommendations we have provided to health care organizations will assist in the development of a user-friendly report for pregnant women. This might increase the competitive advantage of a facility by providing a high quality of care and improving

patients' satisfaction. We also hope that our new designed report will help women better understand the content provided in their reports to mitigate their information needs and allow them to become more knowledgeable about the exam, their cases, and how to have a healthy pregnancy. Future studies will be conducted to evaluate the understanding and acceptance of our new designs.

## **Chapter V: Evaluating Information Rich design of of Patient Oriented Obstetric Ultrasound Report (SPOUR): Interventional Study.**

### **Introduction:**

One of the pillars to improve the quality of care is to provide patients access to their healthcare records to meet their needs and preferences (Institute of Medicine, 2001) . Most healthcare sectors are moving toward using patient portals. Until now, radiology reports occurred between radiologists and physicians and were written in a medical jargon understood only by medical professionals (Bruno et al, 2014). Since one of the patients' portal purposes is to promote the patient's involvement in healthcare delivery, the current state of radiology reports needs improvement.

Obstetric ultrasound is a radiology modality where a pregnant patient has a regular examination using ultrasound for different purposes such as estimating gestational age, detecting fetus viability, or detecting any abnormalities. Women become inquisitive during pregnancy and increasingly seek pregnancy-related health information online (Forster et al, 2015). Previous work to understand patient's information needs and gaps found that women ask questions about ultrasound exams such as the safety of the exam, when they should have one, what to expect during the exam, and report and image interpretation and explanation (Alanazi EM et al, 2021). A study conducted in Nottingham, UK to audit 384 women receipts of information during routine antenatal ultrasound investigated women's perceptions of and attitude towards routine screening(Whynes' 2002). They found that "sixty-five women (6.6%) cited information flow as the area for improvement, with 40 wanting more details on the interpretation of the screen image and 20 wanting fuller inclusion in discussions". A medical report is one way of communicating the results with patients. Physicians might have limited office time with patients to communicate

details from the report (Forster et al, 2015). This poor communication may lead to reduce patient satisfaction and lead to patient complaints. In addition, obstetrics is one of the most sued subspecialties in the U.S (Cheng, 2012). Identifying best practices to improve communication between pregnant women and health care providers will enhance the quality of care and improve patients' satisfaction. Since radiology reports are a medium to communicate with patients, and given the time constrains physicians have to discuss the result and answer questions, it becomes important to enhance the report in ways that a lay person can read and comprehend.

The objective of the study was to evaluate an a new designed report which contains all the information a patient might need. We built the report using a design thinking approach where we looked at what women frequently ask about when they receive their obstetric ultrasound results<sup>4</sup>.

### **Smart Patient Oriented Obstetric Ultrasound Report (SPOUR)**

We relied on a design thinking approach, also called a user- centered approach or user-centered design (32). In a design thinking approach, we look for the user's needs; in our case we looked at the information needs among pregnant women when seeking an ultrasound exam. Once we identify the user needs, we define the problem and ideate a consumer-oriented health care tool to address the needs. Finally, we develop a prototype and test it. In this study we found a high percentage of pregnant women asking about their ultrasound results (Alanazi EM et al, 2021), hence, we developed a new report around this information need. Appendix A shows our previous findings and our proposal to address it in our new designed report.

Our new designed report was based on a traditional report from a pregnant woman who gave it to us voluntarily. This was the clearest report out of 20 traditional reports we gathered from the

internet (posted by women in social media). We are assuming reports will be available in a patient portal, and it integrated into two modules (Natural Language processing module and image processing module). In this design, we started with patients' demographic information and healthcare providers information as shown in Figure (2). We followed this with a proposed section "About ultrasound Exam". The result section was split into two subsections, a result section and a section on terms and explanation that will be retrieved based on the patient case. However, some of the information is static such as the explanation of the different fetal parameters. Some of the definitions, explanations, and illustrative images are retrieved from websites like MedlinePlus and Radiopedia, which is an educational web and a wiki-based international web resource that contains a radiology encyclopedia and imaging case repository. Any definitions rewritten to meet our readability criteria was evaluated by JL, MU, and TA to ensure its accuracy and comprehensibility. The summary section summarizes the results and in case of any abnormality found, there will be a link that directs the patient to a reliable website that contains more information.

We developed two different designs, both called Patient-Oriented Obstetric Ultrasound Report (POUR), and both has the same content but different displaying features. In this paper we are evaluating our information rich design. Fig 1-a and Figure 1-b show the first page and the last page of the note section, and Figure 1-C, show the first page of the image section.

#### **Information rich design of Routine second trimester report:**

In this design we only provided the information to the patient in the report. Patient will only have to scan to a barcode if they want detailed information about the case. When patient accessing the report through patient portal, it will be displayed as a responsive pdf file.

Below is the features of information rich design (SPOUR):

## 1) General information about ultrasound report

### Note section

## 2) Result:

- Dividing the results into two columns: The first column is for the actual result, the second column is for the terms and explanation of the result.
  - Result Column
    - Providing icon which indicate wither the result is normal or abnormal
    - Coloring of results sections for easy navigation
    - Underlined terms for the medical terms that need easy definition
  - Terms and explanation column
    - Define medical terminologies in a patient friendly language.
    - Explain some of the medical terms in a patient friendly language.
    - Measurement normal range, if possible.
      - Heart Rate
      - Cervix
      - Amniotic Fluid Index
      - Fetal weight

## 3) Summary:

Provide barcode for detailed information about any abnormal condition, if possible.

## 4) What's next section

- This part is new which we included what is expected that the patient will do. We provided in this section recommendation of what food and multivitamin should be taken and what type of exercise a pregnant women should do. A barcode will be provided to

direct patient for more information about their case. These suggestions and detailed information is based on WHO and the American College of Obstetrician and Gynecologist recommendations (Figure 1-b).

## Image section

- 1) **Classifying the images** into different part: (e,g head, hand, leg, face...etc) for easy navigation
- 2) **Two images provided.** First is image without annotation and the second image is an annotated image. we annotated and label the images to show which part a sonographer was looking for in the image
- 3) **Descriptive images**, if possible, to facilitate the understanding of the image content in ultrasound
- 4) **Icons** which indicate wither the image is normal or abnormal

Fig1-a: First page of the SPOUR- Information rich Design- Note section

**OBSTETRIC ULTRASOUND REPORT**

Patient's name: Elizabeth Johns  
DOB: 10/12/1983  
Scan date: 10/10/2020  
Medical Record Number (MRN): 567264E

Consultant name: Dr Pamela Benjamin  
Sonographer name: Nichole Atkinson

**About obstetric Ultrasound scan :**

- Safety:** It is a safe and quick exam.
- Importance:** It is essential for pregnant women to establish the presence of a living embryo/fetus, estimate the age of the pregnancy, diagnose congenital abnormalities of the fetus.
- Preparation:** Only women at her early stage of pregnancy may require to come to the exam with full bladder to enhance the vision of uterus. If vaginal ultrasound is requested, then she has to empty her bladder. No other preparation is required.
- When to do ultrasound exam:** Pregnant women should be referred to an ultrasound exam at her early stage of pregnancy to look at the presence, size, location, and number of gestational age. Then, she will be referred for a second-trimester scan, NT screening scan and third-trimester ultrasound scan for further evaluation per her physician request.

Your exam's today: Second-trimester scan (Anomaly scan)

**Your results :**

Fetus Presentation: Cephalic **Normal**

Fetal Heart Rate (FHR): 149 beats/min **Normal**

**Fetal Parameter**

Estimation of the gestational age and fetal weight is done by sonographic measurements of fetal parameters. These parameters are mean sac diameter (MSD), Crown-rump length (CRL), biparietal diameter (BPD), head circumference (HC), Occipitofrontal diameter (OFD), femoral length (FL), humerus length, and abdominal circumference (AC) depending on the trimester of pregnancy. Mean Sac Diameter (MSD), Crown-rump length (CRL) are a parameters used in first trimester. While other parameters are used in second and third trimester.

BPD, OFD, HC is measurements of fetus head. Abdominal circumference is measuring the abdomen. Femur length (FL) is measuring the length of a bone in your baby's thigh, humerus length (HL) is measuring the length of a bone in your baby's upper arm. Each parameter will give a measurements correspond to the baby's gestational age. We take the average of all parameters to estimate the gestational age.

Fig1-b: Result and summary page of the SPOUR- Information rich Design- Note

**Summary**

- Single live intrauterine fetus with fetal growth corresponding to 25 weeks and 06 days
- Heart rate and fetus movement are normal
- Both fetal kidneys have dilated renal pelvis measures= 0.7 cm on both sides

To learn more about Dilated renal pelvis scan the barcode

**What's next ?**

Speak to your doctor to discuss the next steps in your care. These will most likely include a follow-up OB scan to monitor your condition.

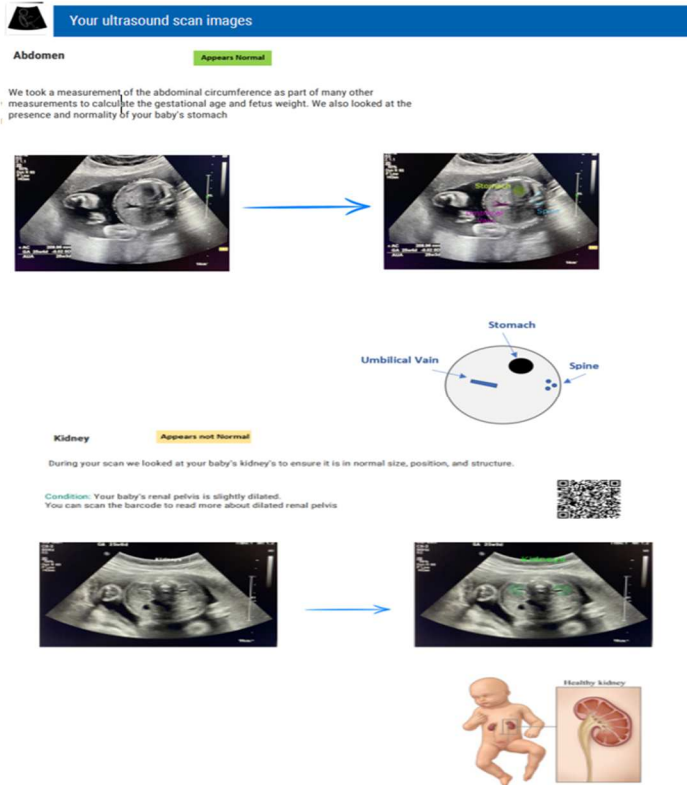
In the meantime, below is general recommendations provided by the World Health Organization (WHO) to ensure maintaining a healthy pregnancy until you deliver your baby:

1. Healthy eating is recommended. Healthy eating contains adequate energy, protein, vitamins, and minerals, obtained through the consumption of a variety of foods, including green and orange vegetables, meat, fish, beans, nuts, whole grains, and fruit.
2. Aerobic physical activity and strength-conditioning exercise are recommended. Pregnant women should not try to reach peak fitness level or train for athletic competition. Women should choose activities with minimal risk of loss of balance and fetal trauma (Discuss with your health provided the best exercise for you).
3. Daily oral iron and folic acid supplementation are recommended. WHO recommends 30 mg to 60 mg of elemental iron and 400g (0.4 mg) of folic acid for pregnant women to prevent maternal anemia, puerperal sepsis, low birth weight, and preterm birth.
4. Tobacco smoking, alcohol, and substance abuse should be avoided during pregnancy. Tobacco smoking, alcohol use during pregnancy increases the risk of health problems for developing babies, including preterm birth, low birth weight, and birth defects of the mouth and lip. Smoking during and after pregnancy also increases the risk of sudden infant death syndrome (SIDS).

The American College of Obstetrician and Gynecologist recommend taking multivitamins such as B1, B6, B9, B12, C, D and Omega-3 fatty acid, and calcium.

Scan the barcode for more information about the vitamins and how to adhere to a healthy lifestyle during your pregnancy please

## Fig1-C: Image of Abdominal Circumference and Kidney- Image section



## Figure 2-a: Traditional report- Note section

REG.N [REDACTED] REF.DATE: [REDACTED]  
 Patient Name [REDACTED]  
 AGE/SEX [REDACTED]  
 REF. BY [REDACTED]

### USG FOR FETAL WELL BEING

GA(LMP): 27 wks 00days

Single live intrauterine pregnancy with normal and regular cardiac activity is imaged

Presentation : Cephalic  
 Fetal movement : Present  
 Liquor : Adequate (AFI= 18.52 cm)  
 Placenta : Posterior, not low lying, 3.5 cm away from internal Os,

B.P.D. : 6.52 cms (26 wks 03 days)  
 H.C. : 23.39.5 cms (25 wks 04 days)  
 A.C. : 20.99 cms(25 wks 04 days)  
 F.L. : 4.66 cms (25 wks 05 days)  
 Composite : 25 wks 00 days  
 Fetal weight : 135 gms + 20 gms  
 H.R. : 149 bpm  
 Cervix. : 3.4 cms  
 USEDD : 05/02/2021

Skull/brain appears normal, heart appears normal, spine appears normal, abdomen appears normal, stomach visible, hands both visible, legs both visible, feet not seen, kidneys both visible (Both kidneys are slightly dilated =0.7 cm)

#### IMPRESSION:

- Single live intrauterine fetus with fetal growth corresponding to 25 wks 00 days
- Both kidneys with dilated renal pelvis measures= 0.7 cm

Figure2-b: Example of two images in traditional report



### Research hypothesis:

- *H1*: There is a significant difference of understanding score between the two designed report with understanding score is higher in new designed report .
- *H2*: There is a significant difference of perceived ease of use (PEU) between the two designed report with PEU higher in the new designed report .
- *H3*: There is a significant difference of perceive usefulness (PU) between the two designed report with PU higher in the new designed report .
- *H4*: There is a significant difference of intention to use(ItoU) the two designed report with ItoU higher in the new designed report .
- *H5*: There is a significant difference of Perceived Esthetics (PE) the two designed report with PE higher in the new designed report .
- *H6*: the new components added in the new designed is perceived to be easy to use
- *H7*: the new components added in the new designed is perceived to be useful

### Methodology:

This is an interventional study conducted between 9<sup>th</sup> September and 14<sup>th</sup> November, 2021 in which we evaluated our new design by comparing it with a traditional design (Figures 2-a and 2-b). There were two groups, the control group had access to a traditional design and the interventional group had access to the information rich design.

### **Survey development:**

The survey questions were developed after careful review of existing literature. The survey contained demographic questions adopted from NHANES (National Center for Health Statistics, 2002) and the Health literacy scale. Health literacy questions were based on S-TOFHLA (Short Test of Functional Health Literacy in Adults) (Chew LD, 2004). This project will compare the five constructs (Understanding, perceived ease of use, perceived usefulness, intention to use, and perceived aesthetics) between the two reports.

All the survey questions are closed-ended questions which range between nominal, Likert scale, and Yes or No questions. All participants answered questions in the first three blocks, then each group was randomly assigned to one of the reports (Traditional report or information rich report). ALL survey questions, except health literacy questions, were self-developed questions with some of the demographic questions adopted from NHANES questionnaire.

### **Understanding:**

Understanding consisted of five items based on questions women had about their ultrasound reports on social media (Alanazi EM et al, 2021). For example, a lot of women asked about gestational age<sup>4</sup>, hence we asked about their comprehension of gestational age in the report, whether they saw the differences in gestational age between the last menstrual period and ultrasound exam and whether they were normal or abnormal (Seckler et al, 2015). For each correct answer, one point was allotted, and incorrect answers were scored as zero.

### **Perceived ease of use, Perceived usefulness, and Intention to use:**

The three concepts were adopted from the Technology Accepted Model proposed by Davis and his colleagues (Davis et al, 1989). According to Davis et al., perceived ease of use is

defined as “the degree to which a person believes that using a particular system would be free of effort” (22), whereas perceived usefulness defined as “the degree to which a person believes that using a particular system would enhance his or her job performance” (Davis, 1989). We developed questions to compare the perceived ease of use and perceived usefulness between the two reports. In addition, we isolated the new components we added in new design and measured the perceived ease of use and perceived usefulness of each component.

In addition, intention to use a product or a software is one of the TAM constructs to measure the users intention to use a technology. Intention captures motivational factors that can lead someone to perform a task. The stronger the intentions, the greater the likelihood someone will engage in a behavior. Both credibility and PU can influence the adoption of a service or technology (Pai, & Huang, K.-I. 2011).

#### **Perceived aesthetics:**

Esthetics is especially important in user experience design to increase user satisfaction (Seckler et al, 2015). Visual design can increase a product’s usability (Schenkman , 2002). In our new designed, we utilized images and colors that makes the report more attractive and easier to navigate.

#### **Statistical analysis:**

The software package SPSS (version ) was used for statistical analysis. A power analysis following Cohen’s (1992) strategy (Cohen, 1992) was used to determine the required sample size and ensure that the analysis would be significant when using the minimal sample size, as well as minimizing the risk of committing a Type II error. The level of significance (alpha) was set at 0.05, which means we were prepared to accept a 5% risk of falsely rejecting the null hypothesis.

A statistical power analysis with a power of .8, with a medium effect size of .25. The minimum sample size for each group is 64.

**Target population and eligibility criteria:**

Our target population was women of childbearing age (Colugnati, 2007). Our age range is 18- 49 who are or were pregnant whether they had an ultrasound exam before or not. We included only English speaking participants.

**Recruitment plan:**

This survey was disseminated in Amazon Mechanical Turk (MTurk) and collected through Qualtrics. This is a crowdsourcing website which consider a low-cost website to recruit participants and provide almost an immediate access to large number of participants (Swan, 2012). To motivate users to participate, each participant who participates received:

- 0.50\$ for each participant who completed the screening questions and was not eligible to participate. Women who are eligible
- 3.60\$ for participants who are eligible to participate and has completed the survey questions.

**Verify eligibility criteria:**

Amazon Mechanical Turk (Mturk) requires workers to identify their identities by providing full legal name, address, and social security number to the company. Any workers who cannot verify their identities are not able to create an account with Mturk. For our research, we adopted several methods recommended by researchers to ensure high quality data and reduce misinterpretation (Kim & Hodgins, 2020. Mellis & Bickel, 2020. Cara et al, 2020). To verify that

participants meet the eligibility criteria, Mturk provides a premium qualification to select workers. Participant's gender is one of the qualifications we will choose from. However, not all our eligibility criteria was included in Mturk qualification premium. We created a screening question to exclude any participant who did not meet the eligibility criteria. Hence, we did not explicitly mention the eligibility criteria in the consent form; instead, we recruited participants and excluded any participants who did not meet our eligibility criteria after answering the screening questions.

### **Ethical considerations:**

Ethical approval was granted by the research ethical committee at the University of Wisconsin-Milwaukee. A consent form provided to women with a full description of the potential risks, benefits, and data collection purposes.

### **Result:**

In duration of two months, 470 women participated in the screening questions survey and 216 (46%) were eligible to participate in the main survey. Only 138 (63.88%) completed the main survey. We included 128 only for the final analysis so each group had 64 participants. One hundred and ten (85.53%) participants were from the United States with 78.12% married, and 89.84% have had an obstetric ultrasound exam before. 49.21% are not a healthcare provider, 89% have at least college degree, and almost all participants (98.43%) are white. Table 1 shows the participants' demographic characteristics. We measured if there is any significant difference between the demographics of two groups using Chi squared. We found no significant differences between the demographics of each group except with the age with p value= .013.

Table 1: Demographics

Characteristics	Control group	Interventional group	P-value (Chi <sup>2</sup> )
	Total n(%)	Total n(%)	
<b>Age</b>			.013
<ul style="list-style-type: none"> <li>&lt; 20 years</li> <li>20-29 years</li> <li>30-39 years</li> <li>40-49 years</li> </ul>	0(0) 16(25) 33(51.6) 15(23.4)	1(1.6) 30(46.9) 27(42.2) 6(9.4)	
<b>Occupation</b>			.060
<ul style="list-style-type: none"> <li>Obstetrician</li> <li>Sonographer</li> <li>Radiologist</li> <li>Other healthcare provider</li> <li>Not a healthcare provider</li> </ul>	6(9.4) 5(7.8) 6(9.4) 11(17.2) 36(56.3)	16(25) 10(15.6) 4(6.3) 10(15.6) 24(37.5)	
<b>Education</b>			.057
<ul style="list-style-type: none"> <li>Some school</li> <li>High school</li> <li>Some college</li> <li>College degree and above</li> </ul>	0(0) 6(9.4) 19(29.7) 39(60.9)	1(1.6) 1(1.6) 12(18.8) 50(78.1)	
<b>Race</b>			.430
<ul style="list-style-type: none"> <li>White</li> <li>Black or African American</li> <li>American Indian or Alaska Native</li> <li>Asian</li> <li>Native Hawaiian or Pacific Islander</li> <li>Unknown</li> <li>Other</li> </ul>	42(65.6) 5(7.8) 0(0) 17(26.6) 0(0) 0(0) 0(0)	48(75) 3(4.7) 0(0) 12(18.8) 0(0) 0(0) 1(1.6)	
<b>Country of born</b>			.490
<ul style="list-style-type: none"> <li>Born in the United States of America</li> <li>Others</li> </ul>	51(79.7) 13(20.3)	54(84.4) 10(15.6)	
<b>USA Citizenship</b>			.611
<ul style="list-style-type: none"> <li>Citizen by birth or naturalization</li> <li>Not a citizen of the US</li> </ul>	54(84.4) 10(15.6)	56(87.5) 10(15.6)	
<b>Marital Status</b>			.321
<ul style="list-style-type: none"> <li>Married</li> <li>Widowed</li> <li>Divorced</li> <li>Separated</li> <li>Never Married</li> <li>Living with partner</li> </ul>	47(73.4) 0(0) 4(6.3) 1(1.6) 6(9.4) 6(9.4)	53(82.8) 1(1.6) 0(0) 1(1.6) 4(6.3) 5(7.8)	

<b>Employment Status</b>			.257
<ul style="list-style-type: none"> <li>Competitive and integrated employment</li> <li>Other employment</li> <li>Non-paid work position (volunteer)</li> <li>Unemployed and looking for work</li> <li>Not in labor force: unemployed but not looking for work</li> <li>Unknown</li> </ul>	41(64.1) 17(26.6) 1(1.6) 1(1.6) 4(6.3) 0(0)	50(78.1) 11(17.2) 0(0) 2(3.1) 1(1.6) 0(0)	
<b>Total Income</b>			.559
<ul style="list-style-type: none"> <li>0 to \$ 4,999</li> <li>\$ 5,000 to \$ 9,999</li> <li>\$10,000 to \$14,999</li> <li>\$20,000 to \$24,999</li> <li>\$25,000 to \$34,999</li> <li>\$35,000 or above</li> </ul>	7(10.9) 8(12.2) 7(10.9) 7(10.9) 9(14.1) 26(40.6)	3(4.7) 5(7.8) 6(9.4) 9(14.1) 7(10.9) 34(53.1)	
<b>Have you done an obstetric ultrasound exam (Sonogram)?</b>			.604
<ul style="list-style-type: none"> <li>Yes</li> <li>No</li> <li>I do not know what the Obstetric Ultrasound Exam is</li> </ul>	58(90.6) 6(9.4) 0(0)	57(89.1) 6(9.4) 1(1.6)	

### Health literacy:

We used the Short Test of Functional Health Literacy scale (STOFHLA) to measure the health literacy score among both groups. This variable is used as a control variable to ensure that each group has the same health literacy score, and level of health literacy will not affect their understanding of the report. We found that there is no significant difference of health literacy between two groups ( $p = 0.144$ ; Table 2).

Table 2: Health literacy level based on STOFHLA (Short Test of Functional Health Literacy in Adults) score:

<b>Health literacy</b>
<p>1. How often are appointment slips written in a way that is easy to read and understand? (1) Always (2) Often (3) Sometimes (4) Occasionally (5) Never</p>
<p>2. How often are medical forms difficult to understand and fill out? (1) Always (2) Often (3) Sometimes (4) Occasionally (5) Never</p>
<p>3. How often do you have difficulty understanding written information your health care provider gives you? (1) Always (2) Often (3) Sometimes (4) Occasionally (5) Never</p>

4. How often do you have problems learning about your medical condition because of difficulty understanding written information?  
(1) Always (2) Often (3) Sometimes (4) Occasionally (5) Never
5. How confident are you filling out medical forms by yourself?  
(1) Always (2) Often (3) Sometimes (4) Occasionally (5) Never
6. How confident do you feel you are able to follow the instructions on the label of a medication bottle?  
(1) Always (2) Often (3) Sometimes (4) Occasionally (5) Never
7. How often do you have someone help you read hospital materials?  
(1) Always (2) Often (3) Sometimes (4) Occasionally (5) Never

Item	Control			Intervention			P value (Chi-squared)
	Inadequate	Marginal	adequate	inadequate	Marginal	adequate	
Health literacy	79.7% 51	20.3% 20	0% 0	89% 57	10.9% 7	0% 0	.144

Note: inadequate health literacy (0–16), marginal health literacy (17–22), and adequate health literacy (23–36)

### Reports evaluation:

We have used five constructs to evaluate our new designed report (Figure 1) by comparing it with a traditional report (Figure 2). The five constructs are: understanding, perceived ease of use, perceived usefulness, intention to use, and perceived aesthetics. We used Mann Whitney U to compare between the two designs because the data is not normally distributed.

As shown in Table 3, our new designed report improved women’s understanding of the report content with a mean difference of -1.03 ( $p < 0.001$ ). Our new designed report is perceived to be easy to use compared to the traditional report with a mean difference of -320 ( $p < 0.001$ ). Additionally, the new designed report was more useful compared to the traditional design with a mean difference of -2.76 ( $p < 0.001$ ). In addition, there is a significant difference of the intention to use the reports, with participants intending to use the new designed report more than the

traditional report with a mean difference of -1.31 ( $p < 0.001$ ). Finally, participants find our new designed report is more pleasant to use, compared with the traditional report with mean difference of -2.20 ( $p < 0.001$ ).

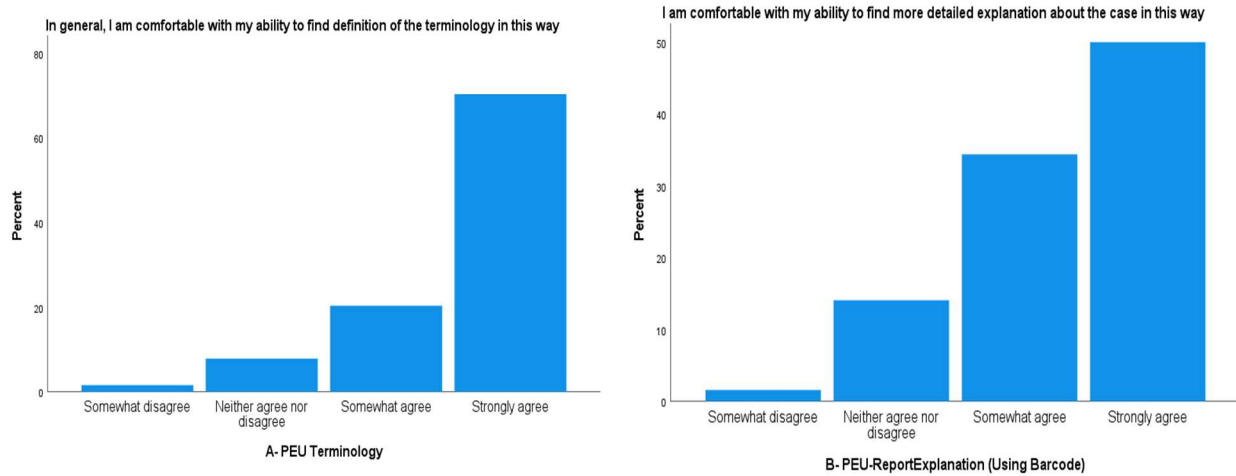
Table 3: Five constructs to compare between traditional and new designed obstetric ultrasound report

Group		Understanding score	Perceived Ease of Use	Perceived Usefulness	Intention to use	Perceived Esthetics
1	Mean	2.84	10.0156	9.9063	7.6406	11.1719
	N	64	64	64	64	64
2	Mean	3.88	13.2187	12.6719	8.9531	13.3750
	N	64	64	64	64	64
Mean difference		-1.03	-3.20	-2.76	-1.31	-2.20
Mann Whitney U (P value)		<.001	<.001	<.001	<.001	<.001

### Components of our new designed report:

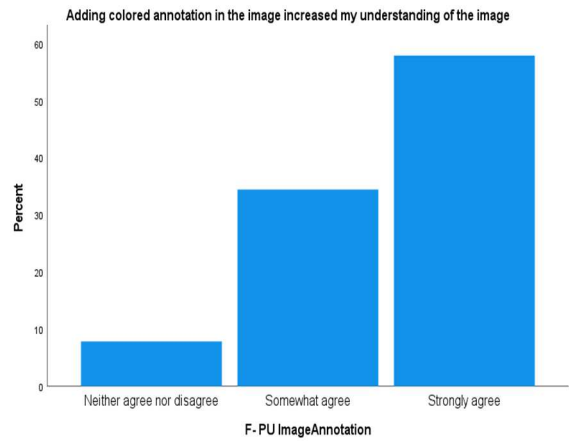
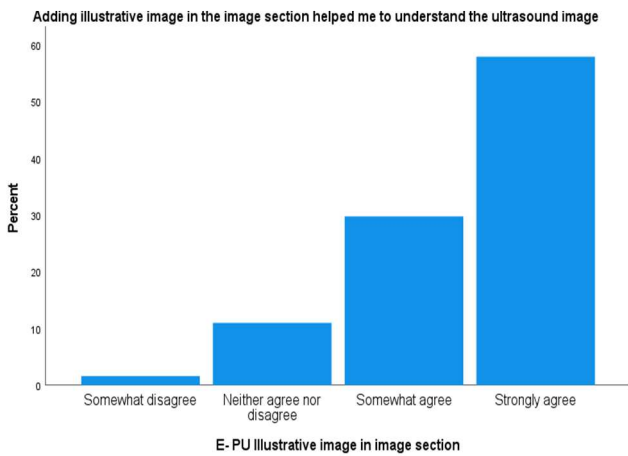
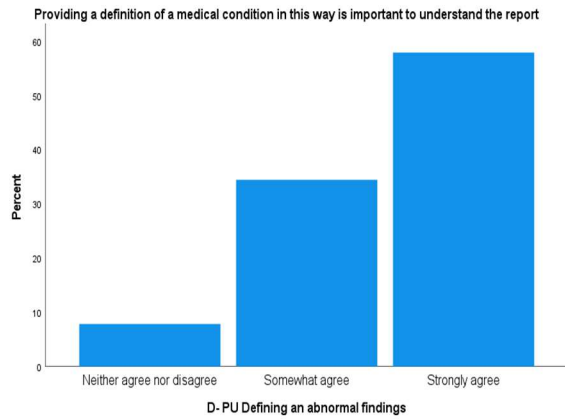
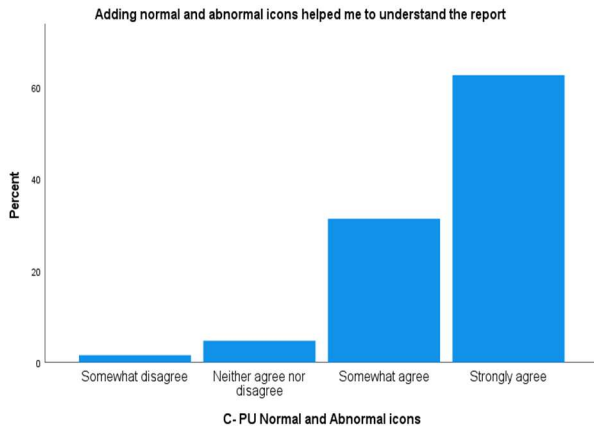
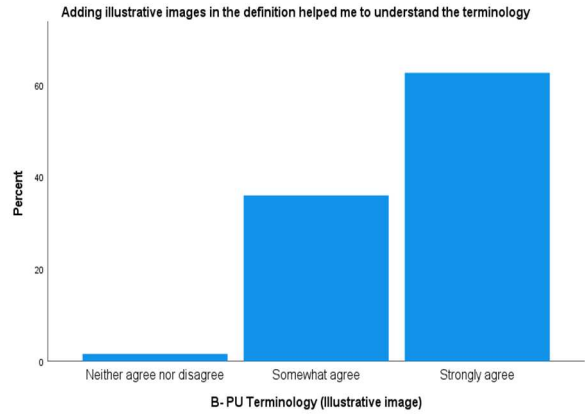
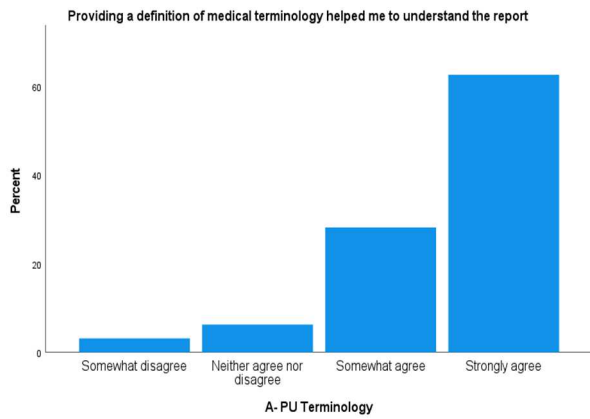
We isolated the new components we developed in SPOUR, and asked our interventional group about the perceived ease of use and perceived usefulness of these components. For perceived ease of We measured only two components, finding medical terminology in the explanation section, and using the barcode appears in the summary and what's next section. We found that most of the participants find themselves comfortable with either locating the definition in the explanation section or using the barcode for more information as show in figure3-A & figure3-B.

Figure3: Perceived ease of use of two new components of Obstetric Ultrasound Report

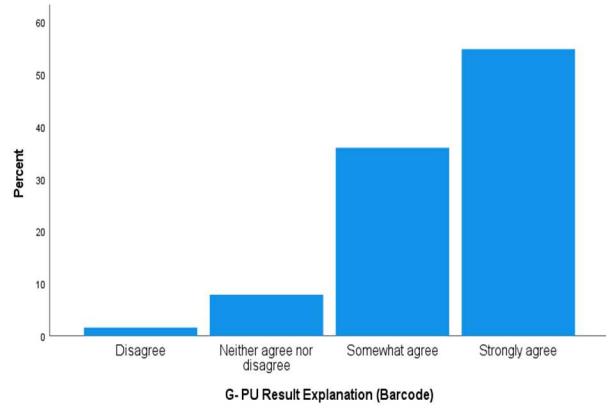


For perceived usefulness, we asked participants and the usefulness of the features we added in our new designed reports, these features are: 1) Definition of the medical terminologies, 2) illustrative image of the medical terminologies, 3) normal and abnormal icons, 4) illustrative images for the fetus image, and 5) image annotation. Participants found all these features were useful as shown in figure 4. None of the participants (0%) disagreed or somewhat disagreed of adding illustrative images to understand the medical terminology, providing an easy definition of abnormal findings, adding colored annotation to annotate the image information, providing a section to give more information about ultrasound exams, or adding a section (What's Next) to have recommendations about how to maintain a healthy lifestyle during pregnancy. Therefore, it is highly recommended to add at least some of these features to the report to increase ease of navigation and understanding.

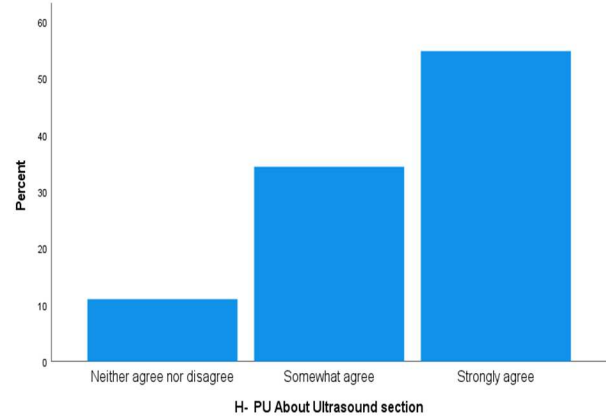
**Figure4: Perceived usefulness of two new components of Obstetric Ultrasound**



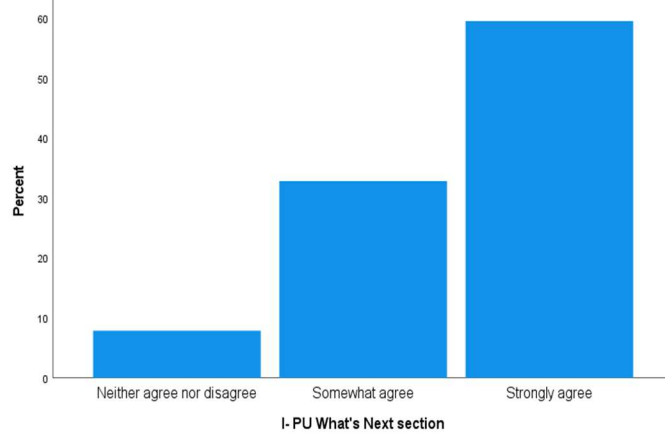
Providing more information about the case from other sources is useful for a pregnant women to learn more about her case



I found it useful to have information about the safety, preparation, and other information about the obstetric ultrasound exam.



I found it useful to provide healthy lifestyle recommendations for pregnant women



## Discussion:

### Design thinking approach to develop innovative solutions:

Design thinking approach is a human-centered and problem-solving approach that is anchored on the concept of trying to understand customer needs while developing new products, and services. Design thinking reverses the traditional thinking strategy of creating what the innovators think people want, and focuses on healthcare stakeholders' needs, analyzing their problems, coming up with human-centered ideas, and prototyping the best ideas based on people inputs. The process of design thinking is also collaborative, creative and employs a human-centered approach when producing products and services to achieve better results. By using a design thinking approach in developing solutions for the healthcare sector, decisions are made

based on what customers need instead of relying on historical data that may be outdated during the time a product is being developed. It also reduces the chances of making bad decisions based on instincts instead of evidence.

Several studies on the application of design thinking in the healthcare sector show that inventions developed using the approach had greater user satisfaction, high usability, and are more effective. One such study is a systematic review titled Design Thinking in Health Care (Myra et al, 2018) determine how design thinking is enhancing innovation, efficiency, and effectiveness by increasing focus on patient and health care providers' needs. The objective of the study was to determine if design thinking was effective in the healthcare sector and how it was being used in the industry. This indicate that our approach is Innovative and solution-based problem-solving approaches that will meet patients' information needs and may reduce patients' anxiety, improve patients satisfaction, and may reduce physicians workload.

#### **Patients' Views on online access, Readability, and Understanding of Radiology Report.**

With the advancement in technology, patients also want effective methods of delivering radiology information, and various scholars have attempted to understand their views on the use of online platforms. A study is by Short et al. (2017), who attempted to establish whether posting patient-centered mammography reports on a web-based portal is effective. Using an online crowdsourcing platform, the researchers developed a survey that involved 193 women who were either 18 years or older. The participants were chosen randomly and then subjected to one of three types of reports: a standard one, another report drafted according to the Mammography Standards Act, and an online interactive report. The subjects were then asked to state their understanding and experience with the reports given to them. The score for comprehension was highest among the individuals who viewed the web-based results.

Furthermore, the patients revealed that they were most satisfied with the radiologist who delivered the online reports. Therefore, the format chosen for a radiology report will influence the patient's understanding and satisfaction when viewing the report.

The above arguments are also presented by Gefen, Bruno, and Abujudoh (2017), who posit that online portals have improved communication between radiologists, physicians, and their patients. With the increasing use of web-based platforms to avail patients, there has been increasing satisfaction about transparency in the radiology sector. Furthermore, better access to reports can help patients understand and take an active role in their health matters. It also provides an opportunity for better communication between patients and radiologists. Therefore, all medical practitioners, including radiologists and referring physicians, should develop ways to ensure the timely release of information to patients according to the latter's preferences.

Other than access to radiology reports online, patients want an easily readable material. A study by Martin-Carreras, Cook, and Kahn, Jr (2019) highlighted the above issue. The authors accessed 108,228 radiology reports from the United States health system database while excluding duplicates and missing data. They computed a reading grade level index and measured the number of words and sentences that could be read by an eighth-grade literacy level. Only 4.2 percent (4094) of the reports were readable for the 8th-grade reading level, which is the average literacy level for American adults. The researcher concluded that even though radiology reports are primarily intended for healthcare givers, they should be written in a simpler form to enhance patients' understanding.

## **Web Portal and Radiology Report: Technical Features for Patients Centric Reporting**

There are several technical features that can be used to enhance Radiology report and increase its readability. In our new report we used several technical features such as infobutton and automatic translation. There are previous studies that conduct experimental systems to make the radiology report easy to understand using different technological feature. For example, PORTER (Patient-Oriented Radiology Reporter) is a system used natural language processing module to translate medical terms to help patients understand radiology reports by translating medical terms into simple language (Martin-Carreras, Cook, and Khan Jr, 2019). A similar system was used to increase user understanding of image-guided biopsy reports. Park et al. (2020) improved upon the PORTER system to identify and explain the meanings of radiology terms used in biopsy procedures. Seven patients who were supposed to undergo thyroid biopsy were selected and asked to participate in the trial level. Before the procedure was done, the participants were asked about their previous diagnostic report to establish whether they read it and understand. After that, the patients received versions of reports using PORTER and given 10 minutes to peruse through the system. The patients were then analyzed to determine whether the protocol had improved their understanding of the reports. The subjects managed to understand 26.3 percent of the annotated report. A feedback chart was drawn to determine the participants' experience while using the PORTER system on a scale of 1-5. A mean of 4.82 was achieved, meaning that the system greatly improved patient understanding of results when using the protocol.

Cook, Oh, and Khan Jr (2017) argue that a system that gives illustrations and meanings of medical terms in radiology reports can improve patients' understanding of results and their conditions. The researchers sought to examine a web-based portal with reports of knee MRI

evaluations that provided meaning and illustration of the radiology terminology on the reports. They selected a seven-month period during which they invited patients who had undergone knee MRI examination to access their reports online. A three-part checklist was used for the survey: The participants who checked the results, the terminologies they hovered over to see their meanings, and the time spent on the terms. During the trial period, 1138 MRI examinations were done. 16.3 percent (185) of the patients accessed the reports on the portal. 65% of the views hovered over an average of 27.5 terms on each report and used at least 3 minutes to view the terms. Afterward, 22 of the participants agreed to complete a survey. The result indicated that 77% of them noted that including the definitions was crucial in understanding the reports.

### **Conclusion:**

Radiology reports are known to be a doctor to doctor communication. However, with patient portals, patients can access radiology reports but enhancements are needed for reports to be patient friendly. Women become inquisitive during their pregnancy and tend to search information online when they encounter uncertainty. Providing detailed yet understandable OB ultrasound report could meet women's information needs, decrease women's anxiety when facing uncertainties, increase maternal fetal attachments, and provide a competitive advantage to the healthcare facilities. Our new designed report increased the understanding of a second trimester ultrasound report. The intention to use this design is higher than the intention to use a traditional report. We built this design with assumption that the report is integrated with NLP and image processing modules. For our prototype report to be used in a real system, more work is needed to build accurate NLP and image processing modules for the OB ultrasound reports.

## **Chapter VI: Evaluating interactive design of Smart Oriented Obstetric Ultrasound Report (SPOUR): Interventional Study**

### **Introduction:**

Hospitals pay billions of dollars to implement the patient portal. One of the patient portal purposes is to allow patients to have access to their health records and be part of the decision-making process. However, the adoption of patient portal or Personal Health Record (PHR) is still slow with less than 1% of individuals in the US have adopted the PHRs (Lafky & Horan, 2011). Medical Reports become available to the patients via patient portal after the clinical exam. Patients may find most of the medical terminologies difficult to read. Several studies show a relationship between health literacy and usage of PHRs where low health literacy results in low utilization of PHRs (Czaja, 2015). Patients are dissatisfied with medical reports in general and radiology reports in specific with delays and a lack of details of radiology reports were some of the reasons of dissatisfaction among patients (Johnson et al, 2009). In addition, more than one-fifth of patients sharing their medical records with others who could help clarify meaning, offer clinical insights, and give second opinions (Walker et al, 2014).

In a previous study, we conducted a qualitative content analysis of four social media platforms to explore the women information needs and gaps of obstetric ultrasound exam. We found that many pregnant women ask their peers to interpret the obstetric ultrasound report and images. Also, we found that most of the women questions are accompanied with negative emotions such as being worried, confused, or anxious. We used the findings of our preliminary study to design a new obstetric ultrasound report that is more friendly and can be read by a lay person. With technological advancements such as natural language processing module and Image processing module, we can improve medical reports to meet patients' information needs in obstetric ultrasound exam (Alanazi & Luo, 2022). This will help meet the intended purpose of

patients' portals by empowering the patients to understand their medical report and have more knowledge about the exam.

We have designed a new obstetric ultrasound report using a design thinking approach (Alanazi & Luo, 2022). Our report contains features that are built based on the findings of our preliminary study (Alanazi EM, 2021). For example, out of 435 questions gathered, 16.5% ask about the content of the report such as measurements and medical terminologies, Hence, we added information, explanation, and definitions of medical terminologies to the ultrasound report (Alanazi EM et al, 2021). Also, 18% of these questions were about the safety of ultrasound procedure, therefore, we included a section in the report about ultrasound procedure to provide brief description about the obstetric ultrasound exam (Alanazi EM et al. 2021). The report also organized in a way that makes it easy for patients to navigate (Figure2). It contains medical information to encourage pregnant patients to adhere to a healthy lifestyle. All these features have an impact not only on pregnant patients but may have an impact to the hospitals by providing a competitive advantage to a physician practice since the report will improve patient satisfaction and well-being and allow them to take more active role in their care.

### **Research hypothesis:**

- *H1*: There is a significant difference of understanding the two reports.
- *H2*: There is a significant difference of perceived ease of use (PEU) between the two designed report.
- *H3*: There is a significant difference of perceive usefulness (PU) between the two designed report.
- *H4*: There is a significant difference of intention to use(ItoU) the two designed report.

- *H5*: There is a significant difference of Perceived Esthetics (PE) of the two designed report.
- *H6*: the new components added in the new designed is perceived to be easy to use.
- *H7*: the new components added in the new designed is perceived to be useful.

### **Methodology:**

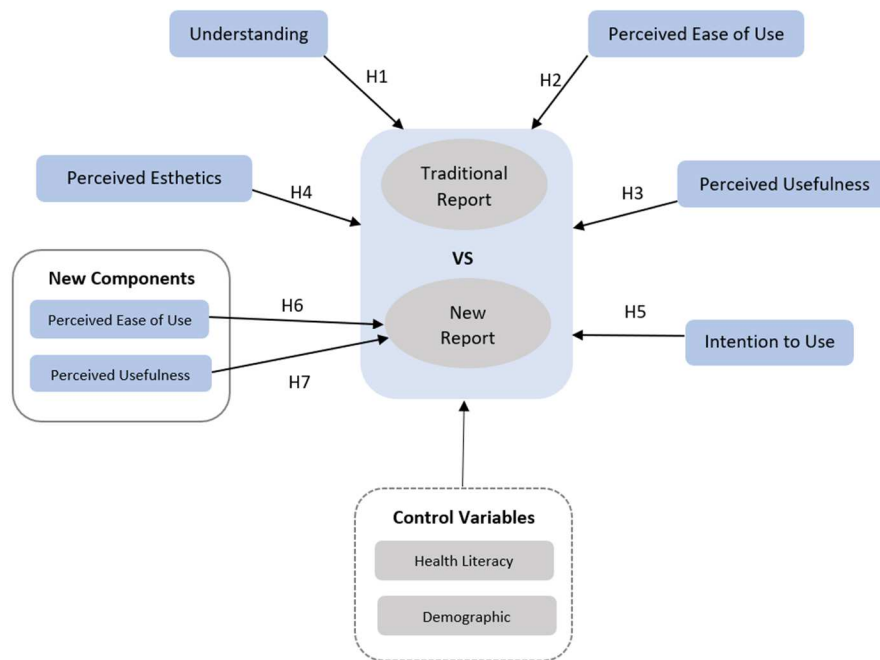
This is an interventional study conducted between September 9<sup>th</sup> and November 14<sup>th</sup>, 2021 in which we evaluated our new design (Figure 2) by comparing it with a traditional design (Figure3). There were two groups, first group is the control group who have access to a traditional design and the second group is an interventional group who have access to the information rich design. We adopted technology acceptance theories to evaluate the new design. According to momani & Jamous, Technology acceptance theories “designed to measure the degree of acceptance and satisfaction to the individuals against any technology or information system but from different points of view depending on the constructs or determinants which represent their structure”. The construct we used to evaluate our new design reports are : Report Understanding, Perceived Ease of Use, Perceived Usefulness, Perceived esthetics, Intention to Use (Figure1).

We disseminated the survey using Amazon Mechanical Turk (MTurk), and placed amount of money for each participant to motivate users. First, we used screening questions to include only women who are or were pregnant and at childbearing age (18-49). We provided 0.50\$ for all participants who completed the screening questions. Women who are eligible were invited to the main survey and provided 3.60\$ upon completing the survey.

### **Ethical considerations:**

Ethical approval was granted by the research ethical committee at the University of Wisconsin-Milwaukee 22.004. A consent form provided to women with a full description of the potential risks, benefits, and data collection purposes.

Figure1: Research Hypothesis and conceptual elements used for the evaluation



**Result:**

In duration of two months, 470 women participated in the screening questions survey and 216 (46%) were eligible to participate in the main survey. Only 143 (66.20%) completed the main survey. We included 128 only for the final analysis so each group had 64 participants. One hundred and four (81.25%) participants were from the United States with 80.46% married, and 85.15% have had an obstetric ultrasound exam before. 48.43% are not a healthcare provider, 67.18% have at least college degree. Table 1 shows the participants’ demographic characteristics. We measured if there is any significant difference between the demographics of

two groups using Chi squared. We found no significant differences between the demographics of each group except with the marital status with p value= .017.

Table 1: Demographics

Characteristics	Control group Total n(%)	Interventional group Total n(%)	P-value (Chi squared)
<b>Age</b>			.290
• < 20 years	0(0)	1(1.6)	
• 20-29 years	16(25)	24(37.5)	
• 30-39 years	33(51.6)	29(45.3)	
• 40-49 years	15(23.4)	11(17.2)	
<b>Occupation</b>			.230
• Obstetrician	6(9.4)	13(20.3)	
• Sonographer	5(7.8)	3(4.7)	
• Radiologist	6(9.4)	6(9.4)	
• Other healthcare provider	11(17.2)	16(25.0)	
• Not a healthcare provider	36(56.3)	26(40.6)	
<b>Education</b>			.293
• Some school	0(0)	1(1.6)	
• High school	6(9.4)	4(6.3)	
• Some college	19(29.7)	12(18.8)	
• College degree and above	39(60.9)	47(73.4)	
<b>Race</b>			.328
• White	42(65.6)	42(56.6)	
• Black or African American	5(7.8)	3(4.7)	
• American Indian or Alaska Native	0(0)	2(3.1)	
• Asian	17(26.6)	15(23.4)	
• Native Hawaiian or Pacific Islander	0(0)	0(0)	
• Unknown	0(0)	0(0)	
• Other	0(0)	2(3.1)	
<b>Country of born</b>			.651
• Born in the United States of America	51(79.7)	53(82.8)	
• Others	13(20.3)	11(17.2)	
<b>USA Citizenship</b>			.811
• Citizen by birth or naturalization	54(84.4)	53(82.8)	
• Not a citizen of the US	10(15.6)	11(17.2)	

<b>Marital Status</b> <ul style="list-style-type: none"> <li>Married</li> <li>Widowed</li> <li>Divorced</li> <li>Separated</li> <li>Never Married</li> <li>Living with partner</li> </ul>	47(73.4) 0(0) 4(6.3) 1(1.6) 6(9.4) 6(9.4)	56(87.5) 0(0) 0(0) 0(0) 0(0) 8(12.5)	.017
<b>Employment Status</b> <ul style="list-style-type: none"> <li>Competitive and integrated employment</li> <li>Other employment</li> <li>Non-paid work position (volunteer)</li> <li>Unemployed and looking for work</li> <li>Not in labor force: unemployed but not looking for work</li> <li>Unknown</li> </ul>	41(64.1) 17(26.6) 1(1.6) 1(1.6) 4(6.3) 0(0)	43(67.2) 15(23.4) 1(1.6) 4(6.3) 1(1.6) 0(0)	.438
<b>Total Income</b> <ul style="list-style-type: none"> <li>0 to \$ 4,999</li> <li>\$ 5,000 to \$ 9,999</li> <li>\$10,000 to \$14,999</li> <li>\$20,000 to \$24,999</li> <li>\$25,000 to \$34,999</li> <li>\$35,000 or above</li> </ul>	7(10.9) 8(12.2) 7(10.9) 7(10.9) 9(14.1) 26(40.6)	5(7.8) 4(6.3) 14(21.9) 8(12.5) 8(12.5) 25(39.1)	.529
<b>Have you done an obstetric ultrasound exam (Sonogram)?</b> <ul style="list-style-type: none"> <li>Yes</li> <li>No</li> <li>I do not know what the Obstetric Ultrasound Exam is</li> </ul>	58(90.6) 6(9.4) 0(0)	51(79.7) 10(15.6) 3(4.7)	.108

### Health Literacy:

Health literacy is defined as the “degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions”.<sup>8</sup> There are several studies that show the relationship between health literacy and usage of patient’s portal, and it is evident that low health literacy negatively impacts the usage of PHR because it requires reasoning and ability to understand the information.<sup>2</sup> We used Short Test of Functional Health Literacy scale (STOFHLA) to measure the health literacy among both groups (Ratzan & Parker, 2000). This variable is used as a control variable that health literacy will not affect the understanding and acceptance of the report.

We used the Short Test of Functional Health Literacy scale (STOFHLA) to measure the health literacy score among both groups. This variable is used as a control variable to ensure that each group has the same health literacy score, and level of health literacy will not affect their understanding of the report. We found that there is no significant difference of health literacy between the two groups ( $p = 0.090$ ; Table 2).

Table 2: Health literacy level based on STOFHLA (Short Test of Functional Health Literacy in Adults) score

Health literacy-Interactive design							
1. How often are appointment slips written in a way that is easy to read and understand? (2) Always (2) Often (3) Sometimes (4) Occasionally (5) Never							
2. How often are medical forms difficult to understand and fill out? (1) Always (2) Often (3) Sometimes (4) Occasionally (5) Never							
3. How often do you have difficulty understanding written information your health care provider gives you? (2) Always (2) Often (3) Sometimes (4) Occasionally (5) Never							
4. How often do you have problems learning about your medical condition because of difficulty understanding written information? (2) Always (2) Often (3) Sometimes (4) Occasionally (5) Never							
5. How confident are you filling out medical forms by yourself? (1) Always (2) Often (3) Sometimes (4) Occasionally (5) Never							
6. How confident do you feel you are able to follow the instructions on the label of a medication bottle? (2) Always (2) Often (3) Sometimes (4) Occasionally (5) Never							
7. How often do you have someone help you read hospital materials? (1) Always (2) Often (3) Sometimes (4) Occasionally (5) Never							
Item	Control			Intervention			P value (Chi Square)
	Inadequate	Marginal	adequate	inadequate	Marginal	adequate	
Health literacy	79.7% 51	20.3% 20	0% 0	87.5% 56	9.4% 6	3.1% 2	.090

**Reports evaluation:**

We have used five constructs to evaluate our new designed report (Alanazi EM & Luo J 2022) by comparing it with a traditional report (Alanazi EM et al, 2022). The five constructs are: understanding, perceived ease of use, perceived usefulness, intention to use, and perceived aesthetics. We used Mann Whitney U to compare between the two designs because the data is not normally distributed (Leard statistics, nd)).

As shown in Table 3, our new designed report improved women’s understanding of the report content with a mean difference of -0.562 ( $p < 0.003$ ). Our new designed report is perceived to be easy to use compared to the traditional report with a mean difference of -2.43 ( $p < 0.001$ ). Additionally, the new designed report was more useful compared to the traditional design with a mean difference of -1.96 ( $p < 0.001$ ). In addition, there is a significant difference of the intention to use the reports, with participants intending to use the new designed report more than the traditional report with a mean difference of -1 ( $p < 0.004$ ). Finally, participants find our new designed report is more pleasant to use, compared with the traditional report with mean difference of -1.43 ( $p < 0.001$ ).

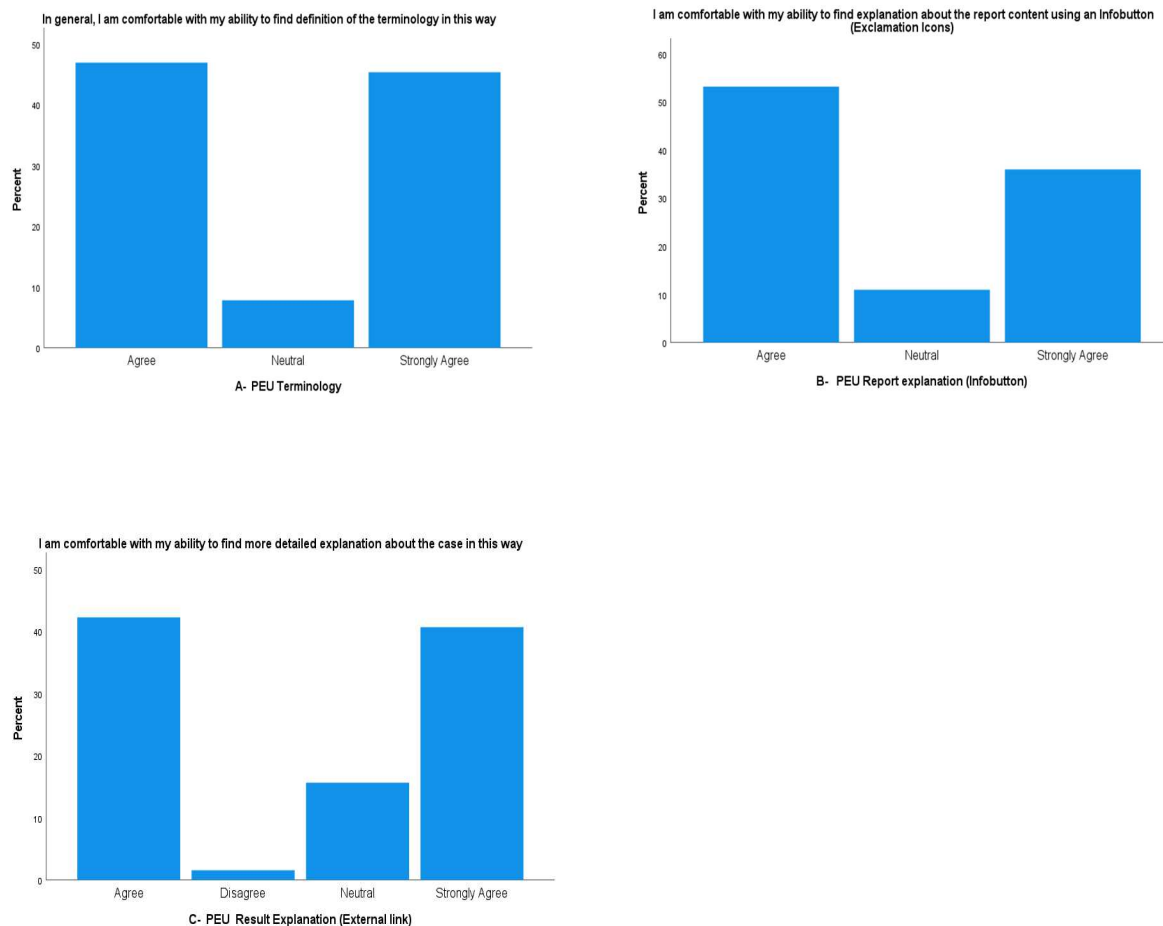
Table 3:Five constructs to compare between traditional and new designed obstetric ultrasound report (Interactive design)

Group		Understanding score	Perceived Ease of Use	Perceived Usefulness	Intention to use	Perceived Esthetics
1	Mean	2.84	10.01	9.90	7.64	11.17
	N	64	64	64	64	64
2	Mean	3.40	12.45	11.87	8.64	12.60
	N	64	64	64	64	64
Mean difference		-0.562	-2.43	-1.96	-1	-1.43
Mann Whitney U (P value)		.003	<.001	<.001	.004	.001

## Components of our new designed report:

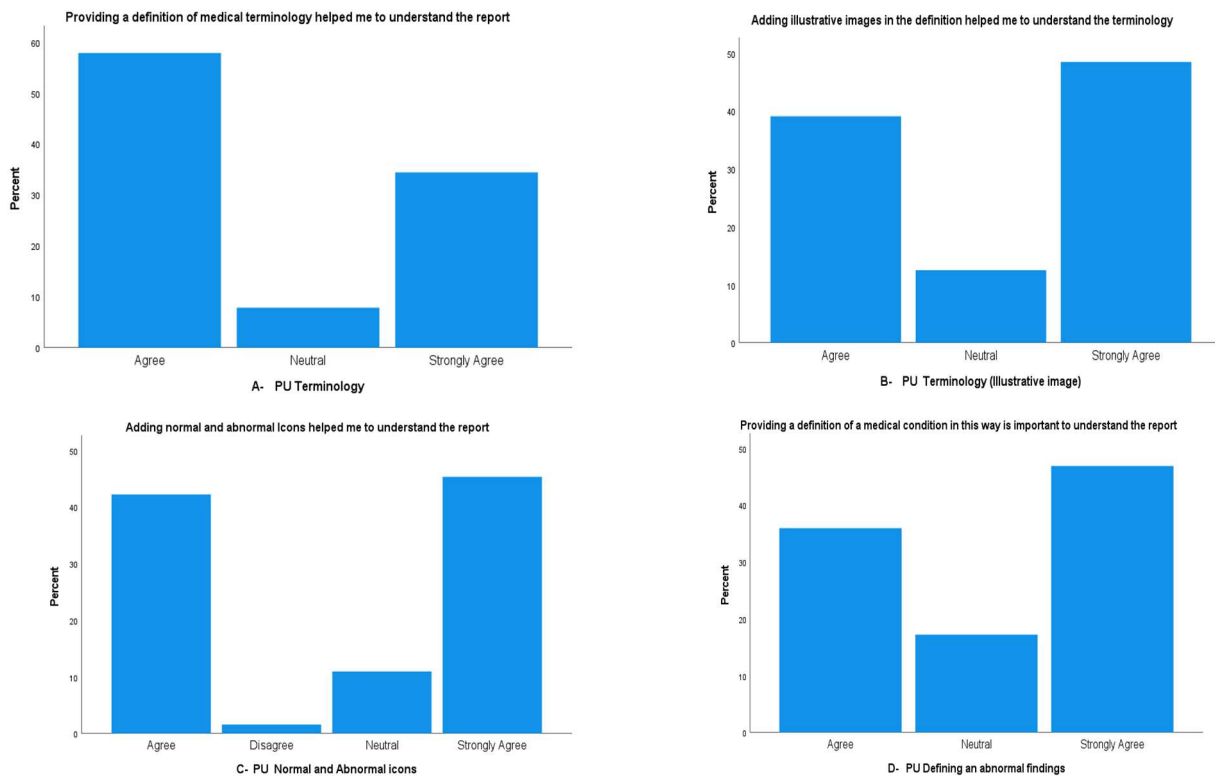
We isolated the new components we developed in POUR, and asked our interventional group about the perceived ease of use and perceived usefulness of these components. For perceived ease of use we measured only two components, finding medical terminology in the explanation section, and using the barcode appears in the summary and what's next section. We found that most of the participants find themselves comfortable with either locating the definition in the explanation section or using the barcode for more information as shown in figure2-A, figure2-B, & figure2-C.

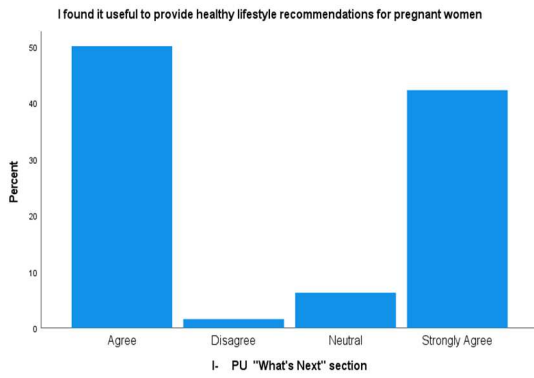
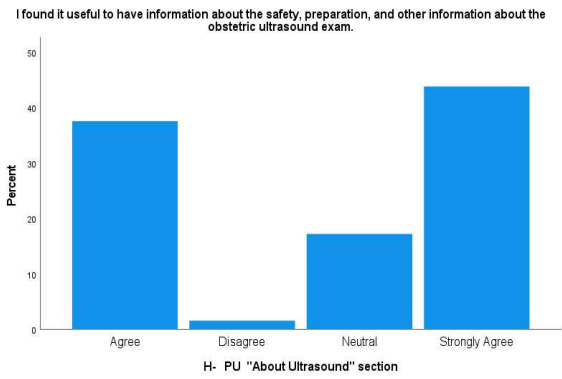
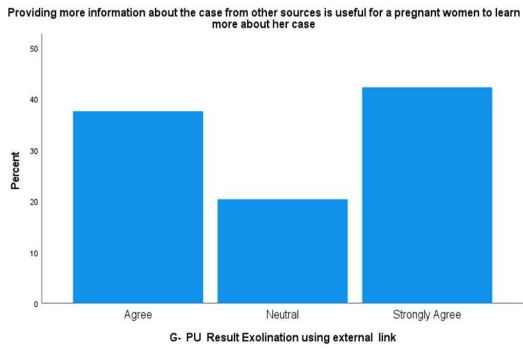
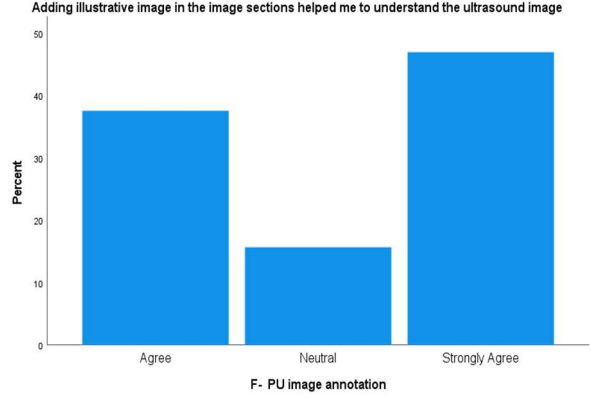
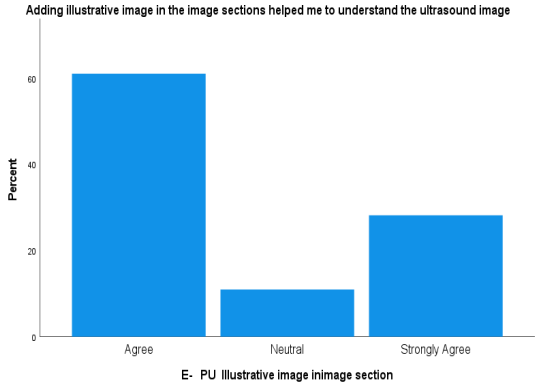
Figure2: Perceived ease of use of two new components of Obstetric Ultrasound Report



For perceived usefulness, we asked participants and the usefulness of the features we added in our new designed reports, these features are: 1) Definition of the medical terminologies, 2) illustrative image of the medical terminologies, 3) normal and abnormal icons, 4) illustrative images for the fetus image, and 5) image annotation. Participants found all these features were useful as shown in figure 4. None of the participants (0%) disagreed or somewhat disagreed of adding illustrative images to understand the medical terminology, providing an easy definition of abnormal findings, adding colored annotation to annotate the image information, providing a section to give more information about ultrasound exams, or adding a section (What's Next) to have recommendations about how to maintain a healthy lifestyle during pregnancy. Therefore, it is highly recommended to add at least some of these features to the report to increase ease of navigation and understanding.

Figure3: Perceived usefulness of two new components of Obstetric Ultrasound





## **Discussion:**

Females often lack information and knowledge regarding obstetric ultrasound exams (Alanazi EM et al, 2021) Often, women don't have effective communication with their health care provider and are not provided with enough information about their ultrasound scan results (Lalor & Devane, 2007. Asplin et al, 2012) Providing enough information to women increases fetal-maternal attachment (Boukydis et al, 2006), and participation in the examination leading to greater satisfaction (Ekelin et al, 2004). Hence, developing an informative and patient friendly ultrasound report may satisfy the information needs around ultrasound exams. This study designed a new pregnancy ultrasound that improved patients' understanding of the obstetric ultrasound report. There was a significant difference of the intention to use the new report in comparison with the traditional report. Participants found the new report easy to use, useful, and more esthetic in comparison to the traditional report. All the new components added to the report were found to be easy to use and useful.

## **UX design in healthcare:**

UX design in healthcare should help provide an enjoyable and engaging experience to healthcare consumers. Great user experiences are useful, usable, and desirable (Gualtieri, 2009). Usefulness ensures that the user can achieve their goal when interacting with the product. In this study, we measured the perceived usefulness of our new designed ultrasound report in comparison with the traditional report. We found significant differences in perceived usefulness in comparison with the traditional report ( $p = < 0.001$ ). We incorporated several components that we believed to be useful to women and mitigate information needs. These components, such as medical definitions and illustrative images, were useful to a majority of the participants. According to Gualtieri, desirability is "influenced by factors such as imagery, language,

aesthetics, fun, and sophisticated production values that come from attention to detail. These all add up to emotional engagement that sets brands apart from competitors”. Aesthetics play an important role in product usability,<sup>16</sup> hence, we designed our new reports to be attractive and engaging. We paid attention to the color of psychology where we chose colors that is not desirable but suitable for the patient perception.<sup>6</sup> We found a significant difference of perceived esthetics of our new designed report in comparison to the traditional report ( $p < 0.001$ ).

### **Mitigate health information needs with Artificial intelligence:**

Machine learning, deep learning, and natural language processing (NLP) are subfields of artificial intelligence which can be utilized to make medical reports patient friendly. Few studies have developed experimental systems to make the reports easier to read using different subfields of artificial intelligence such as NLP (Oh SC et al, 2016. Arnold et al, 2013). To the best of our knowledge, there is no experimental system to mitigate the information needs of obstetric ultrasound reports. In our new designed report, we assumed that the report was integrated with NLP and image processing modules to enhance the radiology reports, provide a user-friendly definition of different medical terminologies, and to organize the images for ease of navigation. We believe that taking advantage of these technologies will enhance the readability of medical reports, as well as increasing transparency and consumer controls which lead to improve healthcare quality and to reduce healthcare costs (Lafky & Horan, 2011).

### **Conclusion:**

In conclusion, radiology report is known to be a doctor - doctor communication, but with the age of patient portal, patients are able to access radiology report. Different studies showed number of benefits associated with accessing radiology report online. However, the quality of

radiology report is poor and needs improvement in order to avoid miscommunication with the patient. Our new designed report provides features that makes the report easy to read and enhanced users experience. The technology advancement such as Natural Language processing (NLP) and image processing can be utilized to solve the readability issues with radiology report. Medical terms can be translated to a patient friendly definitions and images can be annotated to facilitate image reading for patients.

### **Limitations:**

There are few limitations that must be considered for this research. First, the report is for the second trimester scan. There are other type of reports in obstetric ultrasound exam such as reports issued for the first trimester scan or reports for NT screening which considered different in content and might need to be evaluated in separate. In addition, we evaluated the design with a traditional design; the organization of the content and displaying the information in the traditional design is different in each facility. We do not know how changing the type of the traditional design will affect the evaluation of the new design. Before adopting the new designed report, more research in this area is required. Testing different report types and using different traditional designs is needed to ensure that the design is effective and will meet the patients need.

### **Recommendations for Further Research:**

In this study we evaluated the new designed reports based on five concepts. These concepts are: understanding the report, perceived ease of use, perceived usefulness, perceived aesthetics, and the intention to use the report. The new reports is a prototype designed using a case that will be presented to all the participants. if the new designed report used in real case, we do not know how would feeding that much of information would affect the mother

psychologically or how much it would affect the physicians' workload either by increasing the workload (women might ask more questions), or decreasing it. We also need to learn about how the new design will improve the women satisfaction about the healthcare services and how much the new design will improve the competitive advantage of a certain facility.

Further research is recommended to measure the women perception of a detailed information and women preference of the information they want to receive. Another recommended research is research that focus on developing the technical aspect of the design. For example, more research about the ontology in radiology and how to provide easy definitions to the patients through patients portal. In addition, further research in natural language processing for a friendly medical report is needed as well as research in deep learning and computer vision in radiology to automatically annotate radiology images for the patients.

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## APPENDICES

### Appendix A: Consent Form

**Study title:** Patient-Centric Solution to Mitigate Information Need of Obstetric Ultrasound Exam Among Pregnant Women: Design-Thinking Approach

**Researchers:**

Jake Luo

Associate professor

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We are inviting you to take a survey for research. This survey is completely voluntary. There are no negative consequences if you choose not to participate. If you start the survey, you can always change your mind and stop at any time.

To ensure that you are eligible to participate in the survey, we will ask you a few screening questions.

If you are eligible, you will be able to complete the survey.

You can still receive a compensation even if you are not eligible.

- 0.50\$ for each participant who completed the screening questions and was not eligible to participate.
- 3.60\$ for each participant who are eligible to participate and has completed the survey.

**What is the purpose of this study?**

Medical reports can often be confusing or seem intimidating to patients. In this study, we want to evaluate a new obstetric ultrasound report, which aims to provide clear and useful information for pregnant women and to help them better understand the information they are being provided on the

report. By participating in this study, you can help improve the obstetric ultrasound provided to expectant mothers.

**What will I do?**

The survey will ask questions about the level of understanding, acceptance, ease of use, usefulness, and aesthetics of an obstetric ultrasound report. The survey will take about 30 minutes.

**Risks:**

The possible risks of the study are minimal. Amazon could link your worker ID (and associated personal information) with your survey responses. Make sure you have read Amazon's MTurk participant and privacy agreements to understand how your personal information may be used or disclosed.

Breach of confidentiality: There is a chance your data could be seen by someone who should not have access to it. We are minimizing this risk in the following ways: Data is anonymous, we will not be collecting information that can be used to identify you personally. We store all electronic data on a password-protected, encrypted computer.

**How long will it take?**

The survey will take about 30 minutes.

**Costs:** None

**Compensation:**

- 0.50\$ for each participant who completed the screening questions and was not eligible to participate.
- 3.60\$ for participants who are eligible to participate and has completed the survey questions.

**Future research:**

Your data won't be used or shared for any future research studies.

**Where will data be stored?**

Data will be stored on the servers for the online survey software (Qualtrics) and on a password-protected, encrypted computer

**How long will it be kept?**

The data will be kept until it analyzed and the study is published, no longer than: September 22, 2022

## Who can see my data?

- We (the researchers) will have access to anonymous data. This is so we can analyze the data and conduct the study.
- Agencies that enforce legal and ethical guidelines, such as o The Institutional Review Board (IRB) at UWM o The Office for Human Research Protections (OHRP)
- We may share our findings in publications or presentations. If we do, the results will be aggregated or grouped data which shows no individual results.
- Amazon: Because they own the MTurk internal software, and to issue payment, Amazon will have access to your MTurk worker ID. There is a possibility Amazon could link your worker ID (and associated personal information) with your survey responses.

## Agreement to Participate

Your participation is completely voluntary, and you can withdraw at any time.

To ensure that you are eligible to participate in the survey, we will ask you a few screening questions. If you are eligible, you will be directed to the survey.

You can still receive a compensation even if you are not eligible.

- 0.50\$ for each participant who completed the screening questions and was not eligible to participate.
- 3.60\$ for each participant who are eligible to participate and has completed the survey questions.

Total number of participants= 192

Yes I consent (1)

No I do not consent (2)

*Skip To: End of Survey If Study title: Patient-Centric Solution to Mitigate Information Need of Obstetric Ultrasound Exam... = No I do not consent*

End of Block: Default Question Block

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Start of Block: Screening Questions

## Appendix B: Screening questions

SD1 What is your age?

- (1)
  - 20–29 years (2)
  - 30–39 years (3)
  - 40–49 years (4)
  - 50–59 years (5)
- 

SD2 Have you ever been pregnant?

- Yes (1)
  - No (2)
  - I am currently in my first pregnancy (3)
- 

SD3 Is English the language you most commonly speak at home?

- Yes (1)
- No (2)

End of Block: Screening Questions

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Start of Block: Sociodemographic status

## Appendix C: Main Survey

SD4 What is your Occupation?

- Obstetrician (1)
  - Sonographer (2)
  - Radiologist (3)
  - Other healthcare provider (4)
  - Not a healthcare provider (5)
- 

SD5 What is your highest level of education?

- Some school (1)
  - High school (2)
  - Some college (3)
  - College degree and above (4)
-

SD6 What is your race?

- White (1)
  - Black or African American (2)
  - American Indian or Alaska Native (3)
  - Asian (4)
  - Native Hawaiian or Pacific Islander (5)
  - Unknown (6)
  - Other (7)
- 

SD7 In what country where you born?

- Born in the United states of America (1)
  - Others (2)
- 

SD8 Are you a citizen of the United States?

- Citizen by birth or naturalization (1)
  - Not a citizen of the US (2)
-

SD9 What is your marital status?

- Married (1)
  - Widowed (2)
  - Divorced (3)
  - Separated (4)
  - Never Married (5)
  - Living with partner (6)
- 

SD10 What is your employment status?

- Competitive and integrated employment (1)
  - Other employment (2)
  - Non-paid work position (volunteer) (3)
  - Unemployed and looking for work (4)
  - Not in labor force: unemployed but not looking for work (5)
  - Unknown (6)
-

SD11 What is your total income?

- 0 to \$ 4,999 (1)
  - \$ 5,000 to \$ 9,999 (2)
  - \$10,000 to \$14,999 (3)
  - \$20,000 to \$24,999 (4)
  - \$25,000 to \$34,999 (5)
  - \$35,000 or above (6)
- 

SD12 Have you done an obstetric ultrasound exam (Sonogram)?

- Yes (1)
- No (2)
- I do not know what is the Obstetric Ultrasound Exam is (3)

**End of Block: Sociodemographic status**

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**Start of Block: Health Literacy**

HL1 How often are appointment slips written in a way that is easy to read and understand?

- Always (1)
  - Most of the time (2)
  - About half the time (3)
  - Sometimes (4)
  - Never (5)
- 

HL2 How often are medical forms difficult to understand and fill out?

- Always (1)
  - Most of the time (2)
  - About half the time (3)
  - Sometimes (4)
  - Never (5)
-

HL3 How often do you have difficulty understanding written information your health care provider gives you?

- Always (1)
  - Most of the time (2)
  - About half the time (3)
  - Sometimes (4)
  - Never (5)
- 

HL4 How often do you have problems learning about your medical condition because of difficulty understanding written information?

- Always (1)
  - Most of the time (2)
  - About half the time (3)
  - Sometimes (4)
  - Never (5)
-

HL5 How confident are you filling out medical forms by yourself?

- Always (1)
  - Most of the time (2)
  - About half the time (3)
  - Sometimes (4)
  - Never (5)
- 

HL6 How confident do you feel you are able to follow the instructions on the label of a medication bottle?

- Always (1)
  - Most of the time (2)
  - About half the time (3)
  - Sometimes (4)
  - Never (5)
-

HL7 How often do you have someone help you read hospital materials?

- Always (1)
- Most of the time (2)
- About half the time (3)
- Sometimes (4)
- Never (5)

End of Block: Health Literacy

---

Start of Block: Control Group

First group A link below will direct you to an obstetric ultrasound report. You will have two sections, image, and notes. Based on these two sections you will have a short quiz about the report content followed by questions about your acceptance level of the report.

please click the link below "Traditional report", then take a look at the report and come back to complete the survey

[Traditional report](#)

---

Understanding1 According to the report, what is the position of the fetus?

- Baby's head is up (1)
  - Baby's head is down (2)
  - I do not know (3)
-

Understanding2 According to the report, cervix length is.....

- Normal (1)
  - Abnormal (2)
  - I do not know (3)
- 

Understanding3 According to the report, the placenta position is posterior which means.....

- The placenta is in the front wall of the uterus (1)
  - The placenta is in the back wall of the uterus (2)
  - I do not know (3)
- 

Understanding4 According to the report, gestational age(GA) by ultrasound (US) is 25 weeks and Gestational age by last monasterial period (LMP) is 27 weeks. Does two weeks difference indicate any problem with the baby growth?

- Yes (1)
  - No (2)
-

Understanding5 According to the report, Amniotic Fluid Index (AFI) is.....

- Normal (1)
  - Abnormal (2)
  - I do not know (3)
- 

PEU1 I am comfortable with my ability to find information in notes and the images

- Strongly agree (1)
  - Somewhat agree (2)
  - Neither agree nor disagree (3)
  - Somewhat disagree (4)
  - Strongly disagree (5)
- 

PEU2 I am comfortable with my ability to figure out the location of issues in the image

- Strongly agree (1)
- Somewhat agree (2)
- Neither agree nor disagree (3)
- Somewhat disagree (4)
- Strongly disagree (5)

---

PEU3 In general, I am comfortable with my ability to understand this report and the severity of the case

- Strongly agree (1)
  - Somewhat agree (2)
  - Neither agree nor disagree (3)
  - Somewhat disagree (4)
  - Strongly disagree (5)
- 

PU1 Using this report, I may not need to seek further information and more explanation from the internet

- Strongly agree (1)
  - Somewhat agree (2)
  - Neither agree nor disagree (3)
  - Somewhat disagree (4)
  - Strongly disagree (5)
-

PU2 I may not need to communicate with healthcare provider for more explanation of the report

- Strongly agree (1)
  - Somewhat agree (2)
  - Neither agree nor disagree (3)
  - Somewhat disagree (4)
  - Strongly disagree (5)
- 

PU3 If I have this report, I'll be more aware of my pregnancy status

- Strongly agree (1)
  - Somewhat agree (2)
  - Neither agree nor disagree (3)
  - Somewhat disagree (4)
  - Strongly disagree (5)
-

ItoU Assuming I have access to the report, I intend to use it

- Strongly agree (1)
  - Somewhat agree (2)
  - Neither agree nor disagree (3)
  - Somewhat disagree (4)
  - Strongly disagree (5)
- 

ItoU I would like to receive my obstetric ultrasound report in this design

- Strongly agree (1)
  - Somewhat agree (2)
  - Neither agree nor disagree (3)
  - Somewhat disagree (4)
  - Strongly disagree (5)
-

PE1 I feel the design of this report is pleasant

- Strongly agree (1)
  - Somewhat agree (2)
  - Neither agree nor disagree (3)
  - Somewhat disagree (4)
  - Strongly disagree (5)
- 

PE2 I feel the design of this report is clean.

- Strongly agree (1)
  - Somewhat agree (2)
  - Neither agree nor disagree (3)
  - Somewhat disagree (4)
  - Strongly disagree (5)
-

PE3 I feel the design of this report is fascinating.

- Strongly agree (1)
- Somewhat agree (2)
- Neither agree nor disagree (3)
- Somewhat disagree (4)
- Strongly disagree (5)

End of Block: Control Group

---

Start of Block: 1st interventional group

Q48 A link bellow will direct you to an obstetric ultrasound report. You will have two sections, image, and notes. Based on these two sections you will have a short quiz about the report content followed by questions about your acceptance level of the report.

please click the link below, look at the report and come back to complete the survey

[Information rich report](#)

Note: The name of the patient and healthcare providers that appeared in the report are Fictional.

---

Q49 According to the report, what is the position of the fetus?

- Baby's head is up (1)
  - Baby's head is down (2)
  - I do not know (3)
-

Q50 According to the report, cervix length is.....

- Normal (1)
  - Abnormal (2)
  - I do not know (3)
- 

Q51 According to the report, the placenta position is posterior which means.....

- The placenta is in the front wall of the uterus (1)
  - The placenta is in the back wall of the uterus (2)
  - I do not know (3)
- 

Q52 According to the report, gestational age(GA) by ultrasound (US) is 25 weeks and Gestational age by last menstrual period (LMP) is 27 weeks. Does two weeks difference indicate any problem with the baby growth?

- Yes (1)
  - No (2)
-

Q53 According to the report, Amniotic Fluid Index (AFI) is.....

- Normal (1)
  - Abnormal (2)
  - I do not know (3)
- 

Q54 I am comfortable with my ability to find information in notes and the images

- Strongly agree (1)
  - Somewhat agree (2)
  - Neither agree nor disagree (3)
  - Somewhat disagree (4)
  - Strongly disagree (5)
- 

Q55 I am comfortable with my ability to figure out the location of issues in the image

- Strongly agree (1)
- Somewhat agree (2)
- Neither agree nor disagree (3)
- Somewhat disagree (4)
- Strongly disagree (5)

---

Q56 In general, I am comfortable with my ability to understand this report and the severity of the case

- Strongly agree (1)
  - Somewhat agree (2)
  - Neither agree nor disagree (3)
  - Somewhat disagree (4)
  - Strongly disagree (5)
- 

Q57 Using this report, I may not need to seek further information and more explanation from the internet

- Strongly agree (1)
  - Somewhat agree (2)
  - Neither agree nor disagree (3)
  - Somewhat disagree (4)
  - Strongly disagree (5)
-

Q58 I may not need to communicate with healthcare provider for more explanation of the report

- Strongly agree (1)
  - Somewhat agree (2)
  - Neither agree nor disagree (3)
  - Somewhat disagree (4)
  - Strongly disagree (5)
- 

Q59 If I have this report, I'll be more aware of my pregnancy status

- Strongly agree (1)
  - Somewhat agree (2)
  - Neither agree nor disagree (3)
  - Somewhat disagree (4)
  - Strongly disagree (5)
-

Q60 Assuming I have access to the report, I intend to use it

- Strongly agree (1)
  - Somewhat agree (2)
  - Neither agree nor disagree (3)
  - Somewhat disagree (4)
  - Strongly disagree (5)
- 

Q61 I would like to receive my obstetric ultrasound report in this design

- Strongly agree (1)
  - Somewhat agree (2)
  - Neither agree nor disagree (3)
  - Somewhat disagree (4)
  - Strongly disagree (5)
-

Q62 I feel the design of this report is pleasant

- Strongly agree (1)
  - Somewhat agree (2)
  - Neither agree nor disagree (3)
  - Somewhat disagree (4)
  - Strongly disagree (5)
- 

Q63 I feel the design of this report is clean.

- Strongly agree (1)
  - Somewhat agree (2)
  - Neither agree nor disagree (3)
  - Somewhat disagree (4)
  - Strongly disagree (5)
-

Q64 I feel the design of this report is fascinating.

- Strongly agree (1)
  - Somewhat agree (2)
  - Neither agree nor disagree (3)
  - Somewhat disagree (4)
  - Strongly disagree (5)
- 

Q93 In the following questions, you will see parts from the report followed by a question.

---

PEU-Terminology

In general, I am comfortable with my ability to find definition of the terminology in this way

- Strongly agree (1)
  - Somewhat agree (2)
  - Neither agree nor disagree (3)
  - Somewhat disagree (4)
  - Strongly disagree (5)
-

PEU- ReportExplana

I am comfortable with my ability to find more detailed explanation about the case in this way

- Strongly agree (1)
  - Somewhat agree (2)
  - Neither agree nor disagree (3)
  - Somewhat disagree (4)
  - Strongly disagree (5)
- 

PU- Terminology

Providing a definition of medical terminology helped me to understand the report

- Strongly agree (1)
  - Somewhat agree (2)
  - Neither agree nor disagree (3)
  - Somewhat disagree (4)
  - Strongly disagree (5)
-

## PU-Terminology2

Adding illustrative images in the definition helped me to understand the terminology

- Strongly agree (1)
  - Somewhat agree (2)
  - Neither agree nor disagree (3)
  - Somewhat disagree (4)
  - Strongly disagree (5)
- 

## PU-ICONS

Adding normal and abnormal icons helped me to understand the report

- Strongly agree (1)
  - Somewhat agree (2)
  - Neither agree nor disagree (3)
  - Somewhat disagree (4)
  - Strongly disagree (5)
-

PU- CondtionDef

Providing a definition of a medical condition in this way is important to understand the report

- Strongly agree (1)
  - Somewhat agree (2)
  - Neither agree nor disagree (3)
  - Somewhat disagree (4)
  - Strongly disagree (5)
- 

PU- IllustrativeImag

Adding illustrative image in the image sections helped me to understand the ultrasound image

- Strongly agree (1)
  - Somewhat agree (2)
  - Neither agree nor disagree (3)
  - Somewhat disagree (4)
  - Strongly disagree (5)
-

PU- ImageAnnotation

Adding annotation and coloring in the image increased my understanding of the image

- Strongly agree (1)
  - Somewhat agree (2)
  - Neither agree nor disagree (3)
  - Somewhat disagree (4)
  - Strongly disagree (5)
- 

PU- ResultRExplanati

Providing more information about the case from other sources is useful for a pregnant women to learn more about her case

- Strongly agree (1)
  - Somewhat agree (2)
  - Neither agree nor disagree (3)
  - Somewhat disagree (4)
  - Strongly disagree (5)
- 

PU- AboutUltrasound

I found it useful to have information about the safety, preparation, and other information about the obstetric ultrasound exam.

- Strongly agree (1)
  - Somewhat agree (2)
  - Neither agree nor disagree (3)
  - Somewhat disagree (4)
  - Strongly disagree (5)
- 

PU- What's Next

I found it useful to provide healthy lifestyle recommendations for pregnant women

- Strongly agree (1)
- Somewhat agree (2)
- Neither agree nor disagree (3)
- Somewhat disagree (4)
- Strongly disagree (5)

End of Block: 1st interventional group

---

Start of Block: 2nd interventional group

Q65 A link bellow will direct you to an obstetric ultrasound report. You will have two sections, image, and notes. Based on these two sections you will have a short quiz about the report content followed by questions about your acceptance level of the report.

please click the link below, look at the report and come back to complete the survey

[https://www.figma.com/proto/RrGC2gl42ARpMzUhegsCTn/POUR-\(dilated-renal-pelvice\)?node-id=376%3A1&scaling=min-zoom](https://www.figma.com/proto/RrGC2gl42ARpMzUhegsCTn/POUR-(dilated-renal-pelvice)?node-id=376%3A1&scaling=min-zoom)

Note: The name of the patient and healthcare providers that appeared in the report are Fictional.

---

Q66 According to the report, what is the position of the fetus?

- Baby's head is up (1)
  - Baby's head is down (2)
  - I do not know (3)
- 

Q67 According to the report, cervix length is.....

- Normal (1)
  - Abnormal (2)
  - I do not know (3)
-

Q68 According to the report, the placenta position is posterior which means.....

- The placenta is in the front wall of the uterus (1)
  - The placenta is in the back wall of the uterus (2)
  - I do not know (3)
- 

Q69 According to the report, gestational age(GA) by ultrasound (US) is 25 weeks and Gestational age by last menstrual period (LMP) is 27 weeks. Does two weeks difference indicate any problem with the baby growth?

- Yes (1)
  - No (2)
- 

Q70 According to the report, Amniotic Fluid Index (AFI) is.....

- Normal (1)
  - Abnormal (2)
  - I do not know (3)
-

Q71 I am comfortable with my ability to find information in notes and the images

- Strongly agree (1)
  - Somewhat agree (2)
  - Neither agree nor disagree (3)
  - Somewhat disagree (4)
  - Strongly disagree (5)
- 

Q72 I am comfortable with my ability to figure out the location of issues in the image

- Strongly agree (1)
  - Somewhat agree (2)
  - Neither agree nor disagree (3)
  - Somewhat disagree (4)
  - Strongly disagree (5)
-

Q73 In general, I am comfortable with my ability to understand this report and the severity of the case

- Strongly agree (1)
  - Somewhat agree (2)
  - Neither agree nor disagree (3)
  - Somewhat disagree (4)
  - Strongly disagree (5)
- 

Q74 Using this report, I may not need to seek further information and more explanation from the internet

- Strongly agree (1)
  - Somewhat agree (2)
  - Neither agree nor disagree (3)
  - Somewhat disagree (4)
  - Strongly disagree (5)
-

Q75 I may not need to communicate with healthcare provider for more explanation of the report

- Strongly agree (1)
  - Somewhat agree (2)
  - Neither agree nor disagree (3)
  - Somewhat disagree (4)
  - Strongly disagree (5)
- 

Q76 If I have this report, I'll be more aware of my pregnancy status

- Strongly agree (1)
  - Somewhat agree (2)
  - Neither agree nor disagree (3)
  - Somewhat disagree (4)
  - Strongly disagree (5)
-

Q77 Assuming I have access to the report, I intend to use it

- Strongly agree (1)
  - Somewhat agree (2)
  - Neither agree nor disagree (3)
  - Somewhat disagree (4)
  - Strongly disagree (5)
- 

Q78 I would like to receive my obstetric ultrasound report in this design

- Strongly agree (1)
  - Somewhat agree (2)
  - Neither agree nor disagree (3)
  - Somewhat disagree (4)
  - Strongly disagree (5)
-

Q79 I feel the design of this report is pleasant

- Strongly agree (1)
  - Somewhat agree (2)
  - Neither agree nor disagree (3)
  - Somewhat disagree (4)
  - Strongly disagree (5)
- 

Q80 I feel the design of this report is clean.

- Strongly agree (1)
  - Somewhat agree (2)
  - Neither agree nor disagree (3)
  - Somewhat disagree (4)
  - Strongly disagree (5)
-

Q81 I feel the design of this report is fascinating.

- Strongly agree (1)
  - Somewhat agree (2)
  - Neither agree nor disagree (3)
  - Somewhat disagree (4)
  - Strongly disagree (5)
- 

**Q83 In the following questions, you will see parts from the report followed by a question.**

---

PEU-Terminology

In general, I am comfortable with my ability to find definition of the terminology in this way

- Strongly Agree (1)
  - Agree (2)
  - Neutral (3)
  - Disagree (4)
  - Strongly disagree (5)
-

PEU- ReportExplana

I am comfortable with my ability to find explanation about the report content using an Infobutton (Exclamation Icons)

- Strongly Agree (1)
- Agree (2)
- Neutral (3)
- Disagree (4)
- Strongly disagree (5)

---

Page Break

PEU- ResultExplana

I am comfortable with my ability to find more detailed explanation about the case in this way

- Strongly Agree (1)
  - Agree (2)
  - Neutral (3)
  - Disagree (4)
  - Strongly disagree (5)
- 

PU- Terminology

Providing a definition of medical terminology helped me to understand the report

- Strongly Agree (1)
  - Agree (2)
  - Neutral (3)
  - Disagree (4)
  - Strongly disagree (5)
- 

PU- Terminology2

Adding illustrative images in the definition helped me to understand the terminology

- Strongly Agree (1)
  - Agree (2)
  - Neutral (3)
  - Disagree (4)
  - Strongly disagree (5)
- 

#### PU-ICONS

Adding normal and abnormal icons helped me to understand the report:

- Strongly Agree (1)
  - Agree (2)
  - Neutral (3)
  - Disagree (4)
  - Strongly disagree (5)
-

PU- ConditionDefinit

Providing a definition of a medical condition in this way is important to understand the report

- Strongly Agree (1)
  - Agree (2)
  - Neutral (3)
  - Disagree (4)
  - Strongly disagree (5)
- 

PU- IllustrativeImag

Adding illustrative image in the image sections helped me to understand the ultrasound image

- Strongly Agree (1)
  - Agree (2)
  - Neutral (3)
  - Disagree (4)
  - Strongly disagree (5)
- 

PU- Annotation

Adding annotation and coloring in the image increased my understanding of the image

- Strongly Agree (1)
  - Agree (2)
  - Neutral (3)
  - Disagree (4)
  - Strongly disagree (5)
- 

PU- ResulExplanation

Providing more information about the case from other sources is useful for a pregnant women to learn more about her case

- Strongly Agree (1)
  - Agree (2)
  - Neutral (3)
  - Disagree (4)
  - Strongly disagree (5)
- 

PU- AboutUltrasound

I found it useful to have information about the safety, preparation, and other information about the obstetric ultrasound exam.

- Strongly Agree (1)
  - Agree (2)
  - Neutral (3)
  - Disagree (4)
  - Strongly disagree (5)
- 

PU- What'sNext

I found it useful to provide healthy lifestyle recommendations for pregnant women

- Strongly Agree (1)
- Agree (2)
- Neutral (3)
- Disagree (4)
- Strongly disagree (5)

End of Block: 2nd interventional group

---

## Appendix D: IRB Approval



Melody Harries  
IRB Manager  
Institutional Review Board  
Engelmann 270  
P. O. Box 413  
Milwaukee, WI 53201-0413  
414-662-3544

### New Study - Notice of IRB Expedited Approval

[uwm.edu/irb](http://uwm.edu/irb)  
[harries@uwm.edu](mailto:harries@uwm.edu)

**Date:** August 25, 2021

**To:** Jake Luo  
**Dept:** Biomedical and Health Informatics

**CC:** Eman Mohammed G Alanazi

**IRB #:** 22.004

**Title:** Patient-Centric Solution to Mitigate Information Need of Obstetric Ultrasound Exam Among Pregnant Women: Design-Thinking Approach

After review of your research protocol by the University of Wisconsin – Milwaukee Institutional Review Board, your protocol has been approved as minimal risk Expedited under **Category 7** as governed by 45 CFR 46.110. Your protocol has also been granted approval to waive documentation of informed consent as governed by 45 CFR 46.117 (c).

This protocol has been approved on **August 25, 2021** for one year. IRB approval will expire on **August 24, 2022**. Before the expiration date, you will receive an email explaining how to either keep the study open or close it.

This study may be selected for a post-approval review by the IRB. The review will include an in-person meeting with members of the IRB to verify that study activities are consistent with the approved protocol and to review signed consent forms and other study-related records.

Any proposed changes to the protocol must be reviewed by the IRB before implementation, unless the change is specifically necessary to eliminate apparent immediate hazards to the subjects. It is the principal investigator's responsibility to adhere to the policies and guidelines set forth by the UWM IRB, maintain proper documentation of study records and promptly report to the IRB any adverse events which require reporting. The principal investigator is also responsible for ensuring that all study staff receive appropriate training in the ethical guidelines of conducting human subjects research.

As Principal Investigator, it is your responsibility to adhere to UWM and UW System Policies, and any applicable state and federal laws governing activities which are independent of IRB review/approval (e.g., [FERPA](#), [Radiation Safety](#), [UWM Data Security](#), [UW System policy on Prizes, Awards and Gifts](#), state gambling laws, etc.). When conducting research at institutions outside of UWM, be sure to obtain permission and/or approval as required by their policies.

Contact the IRB office if you have any further questions. Thank you for your cooperation and best wishes for a successful project.

Respectfully,

Melody Harries  
IRB Manager

# Eman Alanazi

Milwaukee, Wisconsin  
ealanazi@uwm.edu

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## PROFESSIONAL SUMMARY

A Ph.D. student at the University of Wisconsin- Milwaukee. My dissertation related to User Experience Research field. I applied design thinking approach to meet customers' information need in the designing process as well as using different concepts to measure the usability of the design.

## EDUCATION

### **University of Wisconsin- Milwaukee**

*Doctoral of Philosophy, Current*

Biomedical and Health Informatics

### **Northern Kentucky University, Highland Height, Kentucky United States**

*Master of Science, December 2013*

Health Informatics

### **King Saud University, Riyadh, Saudi Arabia**

*Bachelor of Science, February 2008*

Radiological Science

Internship at King Faisal Specialist Hospital and Research Center.

## PROFESSIONAL EXPERIENCE

### **SAUDI ELECTRONIC UNIVERSITY, Riyadh, Saudi Arabia**

Lecturer, Health Informatics department, February 2015 – Current

- Teach several courses including Introduction to Health Informatics, Electronic Health Records, Medical Coding and Billing, Public Health Informatics, Telehealth and telemedicine
- Participate in administrative tasks
- Developing activities to expand learning opportunities
- Participate in committees and extracurricular activities
- Academic advising

### **PRINCESS NORA BINT ABDUL RAHMAN UNIVERSITY, Riyadh, Saudi Arabia**

Adjunct Lecturer, College of Dentistry, September 2016 – May 2017

- Teach Health Informatics course to students at both college of medicine and college of dentistry.

## **NEW NAJRAN GENERAL HOSPITAL, Najran, Saudi Arabia**

PACS Administrator, September 2014 – December 2014

- Responsible for day-to-day operation of PACS equipment including image workflow and archiving.
- Investigates, identifies, and prepares proposals to solve specific operational problems within all clinical operational areas.
- Works closely with the senior manager of radiology computing and information sciences, in the development of operating standards, policies, and procedures.
- Works closely with radiology's quality management personnel to identify and design future needs and efficient workflow processes.
- Works closely with partners' corporate manager, medical imaging, to oversee and coordinate strategic planning for medical imaging initiatives.

## **KING ABDULAZIZ MEDICAL CITY, Riyadh, Saudi Arabia**

Ultrasound technologist, December 2009 – May 2010

- Provide sonogram and oral or written summary of technical findings to physician for use in medical diagnosis.
- Decide which images to include, looking for differences between healthy and pathological areas.
- Operate ultrasound equipment to produce and record images of the motion, shape and composition of blood, organs, tissues and bodily masses such as fluid accumulations.
- Observe screen during scan to ensure that image produced is satisfactory for diagnostic purposes, making adjustments to equipment as required.
- Prepare patient for exam by explaining procedure, transferring them to ultrasound table, scrubbing skin and applying gel, and positioning them properly.
- Observe and care for patients throughout examinations to ensure their safety and comfort.
- Obtain and record accurate patient history, including prior test results and information from physical examinations.
- Determine whether scope of exam should be extended, based on findings.
- Clean, check and maintain sonographic equipment, submitting maintenance requests or performing minor repairs as necessary.

### **PUBLISHED RESEARCH:**

- Does a Mobile Phone Depression-Screening App Motivate Mobile Phone Users With High Depressive Symptoms to Seek a Health Care Professional's Help?  
Published date: Jun 2016  
Journal name: *Journal of Medical Internet Research (JMIR)*  
Link: <https://www.jmir.org/2016/6/e156/>
- Predicting Risk of Stroke From Lab Tests Using Machine Learning Algorithms: Development and Evaluation of Prediction Models  
Published date Oct 2021  
Journal name: *Journal of Informative Research (JFR)*  
Link: <https://formative.jmir.org/author/proofGalley/23440/1>

- Unmet Information Needs and Gaps of Obstetric Ultrasound Exam: A Qualitative Content Analysis of Social Media Platforms.  
Published date Dec 2021  
Journal name: . *Informatics In Medicine Journal Unlock*  
Link: <https://doi.org/10.1016/j.imu.2021.100830>

### **MANUSCRIPT (UNDER REVIEW):**

- What Makes a Patient Friendly Obstetric Ultrasound Report: Design Thinking Approach  
submission date Feb 28, 2022  
Journal name: Ultrasound Journal
- Evaluating a prototype of a Smart Patient Oriented Obstetric Report (SPOUR): Interventional study  
submission date Feb 5, 2021  
Journal name: Digital Imaging

### **REVIEWR:**

- AMIA 2021 Annual Symposium

### **RESEARCH LABS AND CENTERS:**

- Jake Luo Lab - University of Wisconsin- Milwaukee  
September 2018- Current

### **CONFERENCES, SYMPOSIUMS, AND COURSES (PARTICIPATION):**

- HIMSS22 Global Health Conference and Exhibition  
March 14. Orange County Convention Center, Orlando, FL  
Poster: Evaluating a User Interface (Prototype) of a Smart Patient- Oriented Obstetric Ultrasound Report (SPOUR): Second Trimester Report
- The Annual Student Research Poster Competition- College of Engineering and Applied Science at the University of Wisconsin Milwaukee  
April 30, 2022  
[Student Research Poster Competition - College of Engineering & Applied Science \(uwm.edu\)](#)
- UWM Innovator Exbo- Lubar Entrepreneurship Center at the University of Wisconsin Milwaukee  
May 6, 2022  
[UWM Innovators Expo - Lubar Entrepreneurship Center](#)

## **CONFERENCES, SYMPOSIUMS, AND COURSES (ATTENDANCE):**

- Introduction to Computer Vision  
Feb 25,2022- Jun 2, 2022. Udacity
- Python Basics for Data Science
- Feb 2, 2022- March 2, 2022. edX InterSystems Virtual Summit  
Oct 30-29, 2020
- AMIA Virtual informatics summit  
March 23, 2020
- Data analysis using SPSS workshop  
December 14-15,2016, in Saudi Electronic University. Riyadh KSA
- Workshop on Research Methods in Health Informatics  
May 17, 2015, in King Saud University. Riyadh, KSA
- HIMSS13 (Healthcare Information and Management Systems Society) Annual Conference & Exhibition  
March 31<sup>st</sup> & April 1<sup>st</sup> , 2015 in Riyadh, KSA .
- Multiple Choice Questions (MCQs) in Assessment Workshop  
February 12<sup>th</sup> & February 19<sup>th</sup>. 2015. King Saud University. Riyadh, KSA.
- Mobile Health without borders. (Online course)  
May 13<sup>th</sup> - Jun 22<sup>nd</sup> , 2013. Stanford University
- Mini Symposium in Obstetric and Gynecology Ultrasound  
2009 in Riyadh, KSA
- Nuclear Cardiology course  
2009 in Riyadh, KSA

## **CAPSTONE PROJECT:**

- Worked as an assistant project Manager.  
Project name: PACS system Upgrade (McKesson).  
January 2013- May 2013, Saint Elizabeth Hospital. Kentucky, USA
- Worked as a content developer and assistant project manager  
Project name: “Developing an Endocrinology Educational software with Dr Bradley Eilerman”  
September 2013-December 2013 Saint Elizabeth Hospital. Kentucky, USA

## **TECHNICAL SKILLS**

- SPSS
- WEKA
- SQL
- HTML
- Basic python

## **SOFT SKILLS**

- Excellent communication and negotiation.
- Will easily fit in multinational environment.
- Neat and organized.

**LANGUAGE:**

Language	Writing	Reading	Communication
Arabic	Excellent	Excellent	Native language
English	Excellent	Excellent	Good