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أمومي
Maternal

IT 497: Graduation Project Report
Product Release-2

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Maternal أمومي

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Abstract (English):
This report describes the development and evaluation of an application called Maternal (**أمومي**) that was designed to support and guide Arabic pregnant women through their pregnancy journey. The application was developed using an Agile methodology and was evaluated by a group of Arabic pregnant women. The evaluation found that the application was a valuable tool for Arabic pregnant women and that it provided them with the support and information they needed throughout their pregnancy journey. The application's unique Arabic artificial intelligence (AI) chatbot, powered by natural language processing (NLP) and machine learning (ML) models we made this incredible feature using AraGPT2 model with an Arabic knowledge base built it from scratch, was found to be particularly helpful as it was able to effectively answer questions, address concerns, and provide reassurance to Arabic mothers. The Maternal (**أمومي**) application represents a significant step forward in providing technology-driven pregnancy support for Arabic mothers and has the potential to improve pregnancy outcomes for Arabic women around the world.

Abstract (Arabic):
توضح هذه الورقة مراحل البحث والتطوير والاختبار لتطبيق أمومي والذي تم تصميمه لدعم وتوجيه النساء الحوامل العربيات خلال رحلة الحمل. تم تطوير التطبيق باستخدام منهجية Agile **وتم تقييمه من قبل مجموعة من النساء الحوامل العربيات. ووجد التقييم أن التطبيق كان أداة قيمة للنساء الحوامل العربيات وأنه يزودهن بالدعم والمعلومات التي يحتجنها طوال رحلة الحمل. تبين أن خاصية الدردشة مع الروبوت العربي الذكي المدعومة بمعالجة اللغة الطبيعية (NLP)وتعلم الاله (ML)، والتي تم عملها باستخدام نموذج** AraGPT2 **مع القاعدة المعرفية العربية التي تم إنشاؤها من الصفر، مفيدة لأنها قادره على الإجابة بشكل فعال على الأسئلة ومعالجة المخاوف وتوفير الطمأنينة للأمهات العربيات. يمثل تطبيق أمومي خطوة مهمة في توفير دعم الحمل القائم على التكنولوجيا للأمهات العربيات ولديه القدرة على تحسين نتائج الحمل للنساء العربيات في جميع أنحاء العالم.**

Keywords: NLP; ML; AI; Chatbot; AraGPT2.

1 Introduction

Every woman in her life will go through a pregnancy journey. Pregnancy triggers all kinds of new emotions and physical changes, and of course, being pregnant leads to overthinking. Also, at this phase the woman becomes more sensitive and affected by everything, asking her own doctor to help her will not be available all the time and sometimes she is a new mother where her experience and information are limited. However, it is important for a woman to know the stages, changes, and symptoms she will go through during her pregnancy to monitor her health and the health of the baby. So, getting early and regular prenatal care and being available to answer all questions improves the chances of a healthy pregnancy which is a demand for every mother.

Therefore, we are interested in creating an Arabic application called Maternal (أمومي), which is concerned with this domain, it is important because all the mothers in the world need help in their pregnancy journey like an answer to a question, consultation, and advice about the pregnancy. Also, they want to know what the Symptoms beginning every week and how to deal with them. So, they can know all of this and ask any question about pregnancy in the chatbot at any time without booking an appointment which is easier. Also, it saves time and gives privacy. So, our application will address all mother's needs and help her, it will make her feel reassured. Especially in Arabic countries, it's more important due to the lack of availability of Arabic applications, the lack of variety of services, and the low quality of pregnancy applications.

This chapter presents the project problem description, describes the objectives of the project on three levels: product, project, and learning, a brief definition of the problem’s scope, the project vision, a description of the approach, the proposed solution for this problem, and summary of the report structure.

1.1 The Problem

From the beginning of the pregnancy journey, many questions will be raised by pregnant women, she wants to ask any question about pregnancy without waiting for an appointment or wasting her time searching on the internet. Every week that passes she wants to be aware of developments and symptoms and how to deal with them. In addition, she wants to track the appointments, weight, contractions, etc. Moreover, when childbirth approaches, she needs to organize her time and make the necessary preparations for childbirth, like purchasing her needs and the needs of the baby. Also, she wants to be aware of how to deal with the new situation, questions, and information that every pregnant woman faces. Unfortunately, we could not find any Arabic application that satisfies all these problems.

1.2 Objectives

Product (customer focus-value): We believe that every mother should feel comfortable in her pregnancy journey and be reassured about herself and the baby's health. At the Maternal (أمومي) application we will help to satisfy and meet mother need by providing integrated services in Arabic version that respond immediately. Also, the high quality and accurate information.

Our application will solve many problems such as:

- The lack of availability of Arabic applications.
- The lack of high-quality products.
- The lack of providing a product reliably and accurately.
- Our application will help every mother in her pregnancy journey to answer all the questions she needs and reassure her fears and concerns. To achieve that the application will have many incredible features, such as:
- Ask questions and the chatbot will answer all the user questions related to pregnancy interactively.
- Have week-by-week pregnancy information, development, helpful advice, frequent questions, and articles to explain what a user expects in each pregnancy week.

- Have baby pregnancy week-by-week guides explaining what to expect in each pregnancy week.
- Measure contractions and know if the labor starts.
- Schedule in the pregnancy calendar the prenatal appointments, lab tests, and sonar appointments.
- Have a hospital bag list that helps to prepare the needs for the hospital visit of the mother and baby.
- Have a To-do list to list the user needs.
- Pregnancy due date calculator, pregnancy weight logs to monitor the weight changes, and alarm the mother if there is an unusual change.
- Name explorer to search for popular names and create a favorite list.
- Edit profile.
- Export the vital signs record such as blood pressure, weight, and sugar to PDF format.

Project (solution focus-plan): For this part, we have several steps to do to complete the project as we show below:

- We elicit requirements by using requirements discovery methods.
- We understand user needs to satisfy the user.
- We conducted interviews and sent questionnaires.
- We designed a database and a user-friendly interface.
- We collected a dataset about the pregnancy questions.
- We cleaned the dataset.
- We trained our model based on the dataset.
- We did a chatbot based on natural language processing (NLP) and machine learning (ML) models.
- We developed and tested the application.
- We released the project.

Learning (student focus): In this section, we list the new things that we will learn from this project that will significantly improve us such as:

- How to collect, clean, and train the dataset in the model.
- How to do chatbot based on natural language processing (NLP) and machine learning (ML) models.
- How to code in dart and Python languages.
- How to use the Flutter framework.
- How to work with NoSQL.
- How to manage Firebase Firestore.
- How to develop Android applications.
- How to release the app in Google Play.

1.3 Scope

We will develop an Arabic Android application to assist in pregnancy tracking week by week. by having features in our scope:

- The application will support the Arabic language.
- Basic pregnancy information to inform the mother of what she will experience in each pregnancy week.
- Articles and frequent questions.
- Baby development to explain what a mother expects in each pregnancy week.
- Vital signs record such as blood pressure, weight, and sugar.
- Generate a PDF report for the vital signs.
- Chatbot to answer all the mother's questions about pregnancy.
- Pregnancy due date calculator, pregnancy weight logs to monitor the weight changes, and alarm the mother if there is an unusual change.
- Contraction timer for measuring contractions to know if the labor starts.

- Pregnancy calendar to remind the mother of the appointments she needs to attend and the tests she must undergo.
- To-do list to list user needs.
- Name explorer to search for popular names and create a favorite list.
- Edit profile.
- Suggested checklist for the hospital bag.

Out of our scope:

- We will not support other languages.
- We will not provide an IOS version.
- We will not provide booking appointments.
- We will not provide pregnancy belly information.
- We will not provide the admin user and his privileges.

1.4 Product Vision

We aspire to be the first refuge for all Arabic pregnant women. Also, we intend to provide more versions in different languages in the future.

Product Vision:

For a pregnant woman who has questions and needs help. The Maternal (أمومي) is an Arabic android application that helps in pregnancy tracking week by week, unlike other applications our product has a chatbot that will answer all questions in Arabic immediately and correctly.

1.5 Brief Description of The Approach

The Maternal (أمومي) application was developed using Agile software development methodology, which is an iterative approach that involves continuous feedback and adaptation throughout the project lifecycle, by following an agile framework like Scrum. In the beginning, we conducted a requirement elicitation process by interviewing mothers including pregnant women and publishing a questionnaire to understand their needs, at the same time we were searching about how to develop an artificial intelligence (AI) chatbot based on natural language processing (NLP) and machine learning (ML) models.

After that, we started our focus meeting to design the Maternal (أمومي) application and plan for the development phase. So, we started to build the application based on user requirements. Also, we started to build our dataset based on the search we made then we finetuned the model we chose using our dataset.

Furthermore, Maternal (أمومي) application was developed using many tools, including Dart programming language and Flutter framework. Also, we designed the user interfaces using Figma. Moreover, we used Python programming language on Google Collaboratory to train the model. Also, we used the Firebase Firestore NoSQL database for storing and managing the application data. Finally, we used GitHub for controlling the versions, and Jira software to manage the project.

1.6 The Solution and Contribution

Every pregnant woman needs support and guidance throughout her pregnancy journey. An application that satisfies all her needs and provides early and regular prenatal care can significantly improve the chances of a healthy pregnancy. To address this need, we have developed Maternal (أمومي) an Arabic Android application specifically designed to assist Arabic pregnant women. Maternal (أمومي) offers many features, including a unique Arabic chatbot powered by natural language processing (NLP) and machine learning (ML) models. This incredible feature is rarely found in other pregnancy tracking applications and sets Maternal (أمومي) apart. By providing constant support and addressing all aspects of pregnancy care, Maternal (أمومي) empowers Arabic mothers to achieve healthy pregnancies.

The lack of Arabic-language pregnancy tracking applications, the scarcity of high-quality products, and the absence of reliable and accurate pregnancy support in the Arabic region highlight the significance of Maternal (أمومي). Our application aims to bridge this gap by providing comprehensive and reliable support to Arabic mothers throughout their pregnancy journey. By addressing their questions, concerns, and fears, Maternal (أمومي) empowers Arabic women to make informed decisions and experience a positive pregnancy journey.

Beyond its local impact, Maternal (أمومي) has the potential to be in the global pregnancy tracking application market. Our incredible Arabic chatbot, powered by natural language processing (NLP) and machine learning (ML) models, can be adapted by other communities and regions, particularly those interested in developing Arabic chatbots with natural language processing (NLP) and machine learning (ML) models capabilities. Additionally, the application's framework can be modified to support other languages.

Maternal (أمومي) represents a groundbreaking step towards providing comprehensive and technology-driven pregnancy support for Arabic mothers. Its local and global impact will be profound, improving pregnancy outcomes, and shaping the future of pregnancy care.

1.7 Report Structure

This report was organized into chapters, starting with the introduction chapter, which presents the general problem and domain area that Maternal (أمومي) addresses. Then, the background chapter included an explanation of topics encountered during the Maternal (أمومي) development. After that, the literature review chapter, which is the comparative analysis of Maternal (أمومي) and its competitors. Then, the system design and development chapter, including the methodology we used to develop Maternal (أمومي), system requirements, system design, data design, interface design, and implementation sections. Next, the system evaluation chapter, including the user acceptance testing, quality attributes, and the discussion that interprets the system evaluation results. Finally, the conclusion and future work chapter, provided a summary of the software development process, the importance of the developed technology, and the implications on the world (local and global impact). In addition, it presented the challenges encountered during the software development, the system's limitations, the main contribution of Maternal (أمومي), and future work.

2 Background

This section provides a theoretical background to obtain better insight and basic knowledge to obtain a comprehensive view of our project system domain. We begin with an introduction about pregnancy and present a definition that is related to pregnancy. Then we discuss the chatbot and the overview of artificial intelligence (AI) with the components related to it.

2.1 Pregnancy

Pregnancy is a transformative experience that brings about significant physical and emotional changes in a woman's life. It is a period of approximately 40 weeks, during which a new life develops. While pregnancy is often filled with excitement and happiness, it can also be accompanied by anxiety and uncertainty as women navigate the unique challenges that come with carrying a child [1].

To ensure the well-being of both the mother and the baby, antenatal care (ANC) known as prenatal care plays a crucial role. antenatal care (ANC) involves regular monitoring and follow-up of maternal and fetal health throughout the pregnancy [2]. It is recommended as a key strategy to reduce the risk of newborn death, regardless of the social and demographic background of the community. Research has shown that maternal deaths could have been prevented if pregnant women had been able to access quality antenatal care (ANC)[3].

In today's technologically advanced world, with an estimated 5.48 billion smartphone users having access to high-speed internet globally[4], digital healthcare presents an opportunity to improve access to and quality of prenatal care. Pregnancy is one area that can greatly benefit from digital healthcare solutions, providing expectant mothers with reassurance and facilitating close monitoring to identify any potential emergencies. This is particularly important in remote, or disadvantaged communities where healthcare access is limited, and the risk of unhealthy pregnancy outcomes is higher. The COVID-19 pandemic has further emphasized the value of mobile apps, as they enable pregnant women to access relevant information and engage in self-monitoring. Notably, several pregnancy apps have gained popularity and feature among the top 100 medical apps on platforms like the Apple App Store [4].

In conclusion, pregnancy is a significant period in a woman's life, and the benefit of digital healthcare can enhance accessibility and quality of care for expectant mothers. By utilizing mobile apps and other technological advancements, pregnant women can receive the support

and monitoring they require, regardless of their geographical location or social and economic status.

Here are some areas that we will explain in pregnancy such as the following:

2.1.1 Pregnancy due date

The duration of most pregnancies is approximately 40 weeks, which is equivalent to 38 weeks from conception [1]. To estimate the due date accurately, a common method is to count 40 weeks or 280 days from the first day of the woman's last menstrual period (LMP) [5].

2.1.2 Pregnancy weight

During pregnancy, women experience weight gain, which can be predicted and categorized. Weight gain plays a vital role in ensuring the supply of nutrients for both the mother and the baby. The increase in weight varies from month to month and is attributed to several factors [6]:

- Baby weight in uterus.
- Placenta.
- Amniotic fluid.
- Breasts.
- Uterus (the womb).
- Increase in blood quantity.
- Stored fats for breastfeeding.

The measurement of weight gain during pregnancy follows a pattern [7]:

- In the first three months, the woman typically gains 0-2 kg.
- From the fourth to the fifth month, she gains around 1 kg per month.
- During the sixth month, the weight gain is around 2 kg.
- In the last three months of pregnancy, the woman gains a total of 6 kg, with an average of 2 kg per month.

2.1.3 Contraction timer & labor

The initial stage of labor and birth starts when continuous contractions are felt, which progressively become stronger, more regular, and more frequent [8].When monitoring contractions, three factors are considered:

- **Contraction frequency:** This refers to how often contractions occur.
- **Contraction length:** It denotes the duration of each contraction.
- **Contraction regularity:** This factor determines whether the contractions are consistent, occurring at regular intervals and lasting a similar amount of time, or if they are intensifying progressively.

Higher frequency and regularity of contractions, coupled with shorter intervals between them, indicate that a woman is likely in active labor [9].

CONTRACTIONS: HOW TO KNOW IF THEY'RE TRUE LABOR OR FALSE LABOR		
	TRUE LABOR	**FALSE LABOR** (Braxton-Hicks contractions)
Are the contractions regular?	**Yes.** • They're regular and get closer together over time. • They last 30 to 70 seconds each.	**No.** • They're irregular and stay irregular. They don't get closer together over time. • You're more likely to have them late in the day or after a lot of physical activity.
Are the contractions strong?	**Yes.** • They get stronger over time. • They're so strong you can't walk or talk. • They keep coming even when you move around.	**Sometimes.** • They're usually mild and don't get stronger over time. • They may be strong and then weak. • They can be painful. • They may stop when you walk or change position.

Figure 1: true/false labor table [10] in 2.1.3

2.2 Chatbot

Chatbot is a computer program that simulates and processes human conversation (either written or spoken), allowing humans to interact with digital devices as if they were communicating with a real person [11]. Its primary purpose is to assist users by performing tasks like answering questions, scheduling appointments, or facilitating transactions. Chatbot has several types [12]:

- Menu/button-based chatbots.
- Linguistic Based (Rule-Based Chatbots).
- The hybrid model.
- Voice bots.
- Chatbots with artificial intelligence (AI).

We will talk more about Chatbots with artificial intelligence (AI) because it is the one that we use.

2.2.1 Chatbot with artificial intelligence (AI)

Chatbot empowered with artificial intelligence (AI) has the ability to engage in intelligent conversations with users. Their artificial intelligence (AI) capability, supported by machine learning (ML) and natural language processing (NLP) techniques, forms the foundation of their functionality.

An artificial intelligence (AI) chatbot can understand the context of user input and provide appropriate responses in a natural and conversational manner. It can continuously learn from user feedback and previous dialogues, constantly enhancing the quality of its responses.

While AI-powered chatbots were previously widespread mainly in large companies, they have now become accessible to medium-sized companies as well. These intelligent bots, available in over 125 languages, can cater to a wide range of global use cases [13].This type of chatbot was specifically chosen to effectively address the inquiries of expectant mothers, providing a user-friendly and human-like experience.

2.3 Artificial intelligence (AI)

Artificial Intelligence (AI) is a field that focuses on the development of computer systems capable of performing tasks that typically require human intelligence. This includes tasks like recognizing images, understanding speech, making decisions, and translating languages. Artificial intelligence (AI) achieves this by employing techniques such as machine learning (ML), deep learning, natural language processing (NLP), and computer vision. These techniques enable artificial intelligence (AI) systems to simulate human intelligence, learn from data, and improve their performance on various tasks. artificial intelligence (AI) finds applications in diverse areas such as robotics, healthcare, finance, education, and entertainment [14].

Natural language processing (NLP) and machine learning (ML) models are two essential components of artificial intelligence (AI) that work together to enable machines to understand and process human language. Natural language processing (NLP) focuses on the interaction between computers and human language, allowing machines to comprehend and generate human-like language. Machine learning (ML) on the other hand, provides machines with the ability to learn and improve their performance without being programmed. Together, natural language processing (NLP) and machine learning (ML) models enhance the language processing capabilities of artificial intelligence (AI) systems, enabling them to analyze, translate, and respond to human language effectively. So, let's take an overview of them.

2.3.1 Natural Language Processing (NLP)

Natural Language Processing (NLP) is a specialized subfield of artificial intelligence (AI) that focuses on the interaction between computers and humans through natural language. It encompasses the development of algorithms and models that enable computers to understand, interpret, and generate human language, including both speech and text. natural language processing (NLP) techniques find application in various domains, including sentiment analysis, machine translation, chatbots, and speech recognition [15].

2.3.2 Machine Learning (ML)

Machine learning (ML) is a subfield of artificial intelligence (AI) that focuses on the development of algorithms and models capable of learning from data and improving their performance through experience. Machine learning (ML) techniques are extensively used in natural language processing (NLP) to analyze and understand human language [16].

Sequence-to-sequence models are a type of model in machine learning (ML) that is used for tasks such as machine translation, answer generation, text summarization, and image captioning. Sequence-to-sequence models based on Recurrent Neural Networks (RNNs) or Transformer-based models like the Transformer-XL or BERT, AraGPT2, are used in answer generation tasks [17].

To summarize, the combination of artificial intelligence (AI), natural language processing (NLP), and machine learning (ML) has a huge impact on the way machines understand, process language, and make chatbots.

2.3.3 Transformers

The transformer, along with other programming and technological components, makes up the chatbot's brain and determines how it speaks, learns, and engages with people. Transformer models help artificial intelligence (AI) chatbots to learn context, track information, and remember things like a human would. They can translate text, images, speech, and more in combination with data sources and chatbots.

Transformers are an architecture of programming that is a form of neural network that works in a stack of inputs and outputs [18]. The transformer consists of an encoder and a decoder. The encoder processes the input sequence, and the decoder generates the output sequence. Each encoder and decoder are composed of multiple layers [19]. There are many types of transformers, and many artificial intelligence (AI) chatbots have different forms of transformers from one another [18].

Several models have been developed based on transformer architecture such as

GPT-2, GPT-3, BERT, mT0, and AraGPT2. When comparing these models, factors such as model size, training data, computational requirements, and task-specific performance play a crucial role. GPT-3 stands out for its massive size and broad range of capabilities, while BERT excels in fine-tuning for specific tasks. mT0 and AraGPT2 cater to specific language domains.

Each model contributes to the continuous evolution of language models, enabling more sophisticated and context-aware natural language processing applications. So, let's take an overview of the model we chose which is AraGPT2.

2.3.3.1 AraGPT2 model

We will talk about AraGPT2 because we used the medium AraGPT2 model for training. So, AraGPT2 is a stacked transformer-decoder model trained using the causal language modeling objective. The model is trained on 77GB of Arabic text. AraGPT2 comes in four variants, the smallest model, base, has the same size as AraBERT-base which makes it accessible for the larger part of researchers. Larger model variants (medium, large, X-Large) offer improved performance but are harder to fine-tune and computationally more expensive [20].

3 Literature Review

In the literature review section, we reviewed similar software applications related to pregnancy and we compared Maternal (أمومي) applications and similar systems that will help us in requirements gathering, maintaining, adding a function, and avoiding some of their drawbacks.

3.1 Competitive Product Analysis

In this section, before building the Maternal (أمومي) application we will discuss other competitors that have a similar concept to our system in three different standards of Arabic pregnancy applications. Since Arabic pregnancy applications are our domain, we will see the strengths and weaknesses of each application then we will list the others for more knowledge.

Arabic pregnancy applications:

3.1.1 I am pregnant (انا حامل)

In Figure 2, we present an application that helps to calculate the birth date in Gregorian and Hijri dates. It also provides you with information on the expected date of birth and the current age of the child. It has additional features such as:

- It provides proactive information about the upcoming months of pregnancy.
- It provides educational lessons for the pregnant woman and her child.
- It provides calculators for weight, menstrual cycle, body fat, and sleep hours.
- A non-scientific calculator called Umm Ziyad (ام زياد) that finds out the gender of the baby.
- It provides daily tips.
- It allows the pregnant woman the ability to ask questions and they are answered by pregnant women, not specialists, and blogs.
- However, it has a problem with registration and navigating the app.

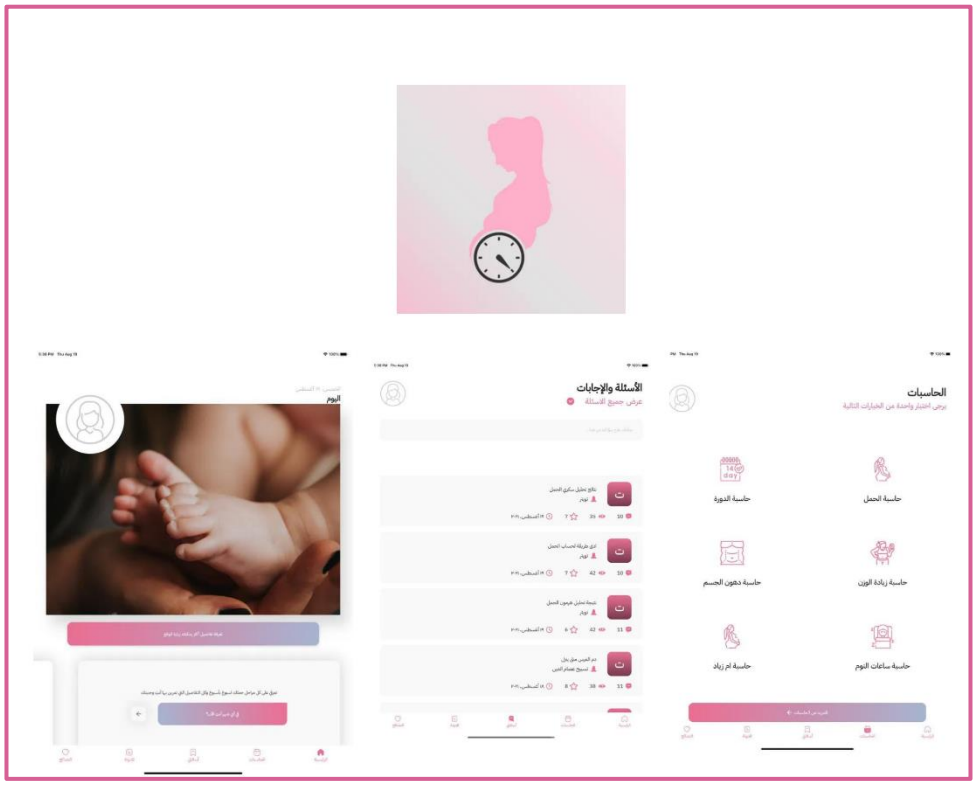


Figure 2: I am pregnant UI in 3.1.1

3.1.2 AL Tubby Mama (الطبي ماما)

In Figure 3, we present an application that takes care of you and your baby at every moment during the wonderful pregnancy and motherhood journey, as it answers any question or inquiry that comes to your mind during pregnancy and postpartum. It has a lot of features like:

- Doctors are available around the clock to answer your questions through text chat service, or phone calls.
- Ovulation calculator to determine the ovulation days in which a woman's fertility is highest, which helps to plan pregnancy and naturally regulate pregnancy.
- Pregnancy calculator to calculate the weeks of pregnancy and the birth date of delivery in the Hijri and Gregorian calendars.
- A schedule of pregnancy weeks to follow up on the pregnancy and know the weekly (and monthly) pregnancy guidelines and the changes expected to occur in the mother and fetus during each week of pregnancy, in addition to an approximation of the size of the fetus at each stage.
- Reliable articles and questions and answers from doctors about everything that concerns the mother in terms of pregnancy, maternal care during the puerperal period after natural or cesarean delivery, and newborn baby care.
- Dates of immunizations and vaccinations by country.
- But they do not provide free service, they have Subscriptions to the application with nominal values.

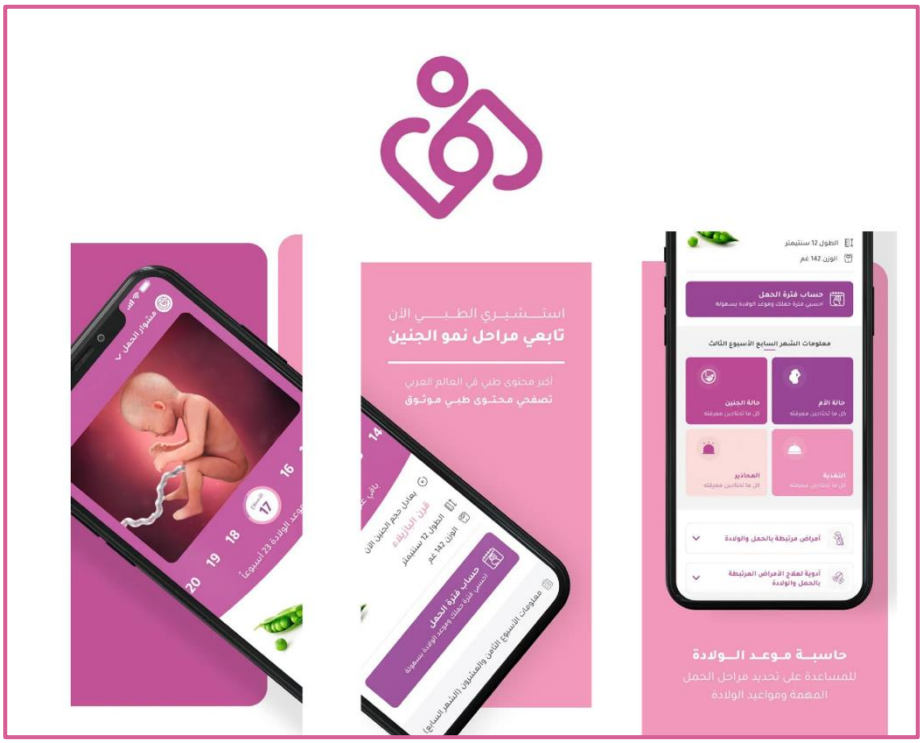


Figure 3:Altubby Mama UI in 3.1.2

3.1.3 My baby live (طفلي لايف)

In Figure 4, we present an application aimed at the comfort of the mother and the health of the child in all countries of the Arab world. It has a lot of features like:

- Articles and information about mother and baby daily based on the type of user.
- Moms' forum.
- Sonar reading.
- Fetal sex test.
- Mom's tools include (stages of pregnancy development, birth date calculator, pregnancy dairy, and pregnancy checkup schedule).
- Baby's tool includes (nutritional supplements for baby, and baby songs).
- Support Arabic and English languages.
- However, users complained about the app and said that the application lags a lot.

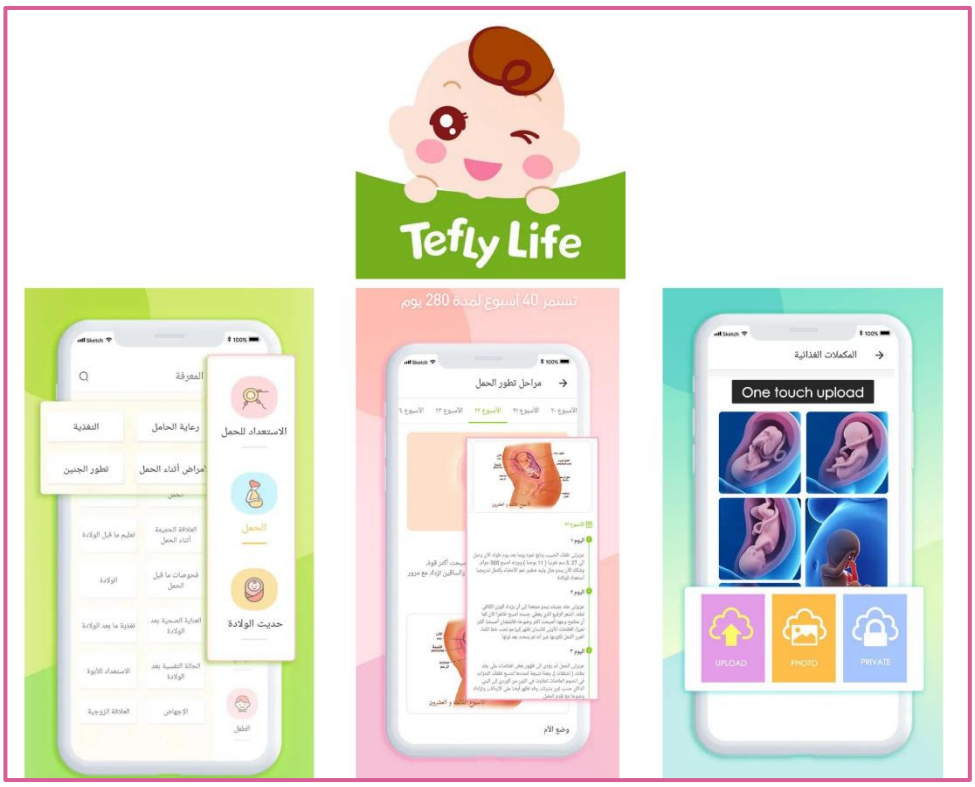


Figure 4: My baby live UI in 3.1.3

3.1.4 You and pregnancy (انت و الحمل)

In Figure 5, we present an application that is about pregnant women and is available in all Arab countries it will answer all questions about pregnancy, from the latest studies presented by the largest hospitals and international medical universities on maternal and fetal care. It has a lot of features like:

- Symptoms of pregnancy and how to deal with them.
- Suggested food system for the pregnant woman.
- Daily and weekly developments of the pregnant woman and your baby.
- Birth date calculator.
- Music for you and your baby.

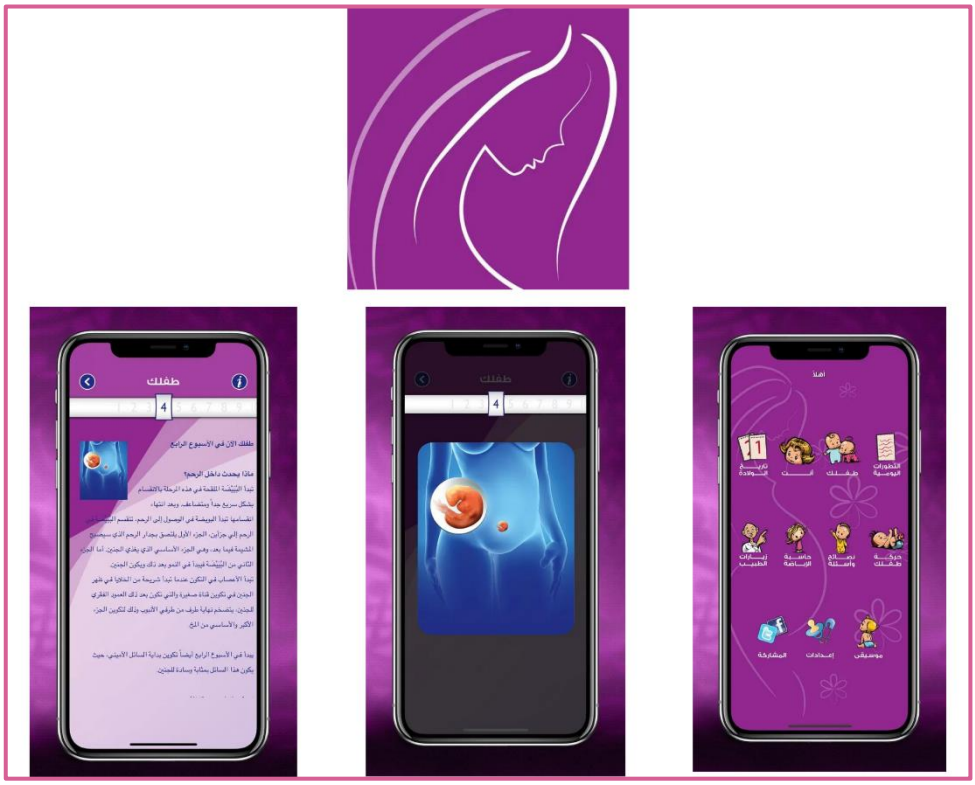


Figure 5: You and pregnancy UI in 3.1.4

3.1.5 Tubaby (طب بيبي)

In Figure 6, we present an application that has everything useful for the mother and her child that will help you on the pregnancy journey. And will help you to take care of the baby at all stages of motherhood for many years to come. It has a lot of features like:

- Articles and medical advice for each stage.
- Pregnancy daily and weekly calculator.
- Photo album.
- Fitness and food advice for each stage.
- Baby photo for each stage.

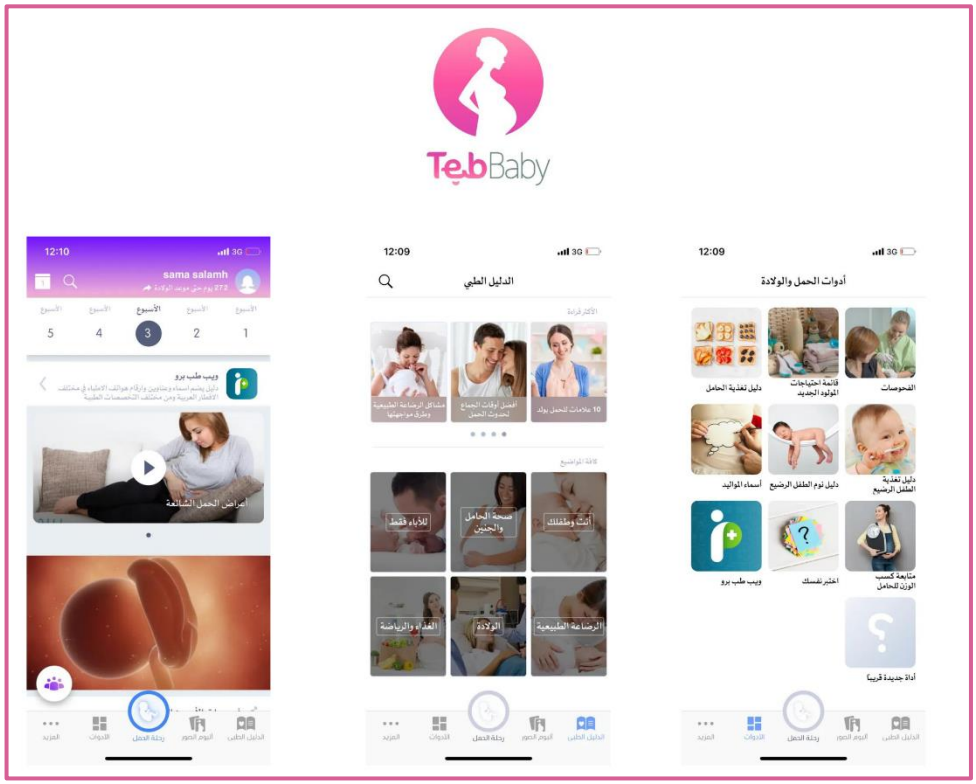


Figure 6: Tubaby UI in 3.1.5

3.1.6 Pregnancy calculator (حاسبة الحمل)

In Figure 7, we present an application that provides information and facts about pregnancy in an easy and simplified way with the following features:

- Determine the birth date of pregnancy, passing through the stages of pregnancy.
- Determine the beginning of pregnancy, showing the current period in days, weeks, and months.
- Provide facts and general information about pregnancy.
- Add scheduled alerts.
- Every week of the pregnancy period, it provides a brief for everything related to information, whether about the fetus or the pregnant woman.
- Supports the Hijri and Gregorian calendars.
- It contains an interactive community for pregnant women.
- Hosting female consultants specializing in obstetrics and gynecology and the injured and therapeutic aspects of women.

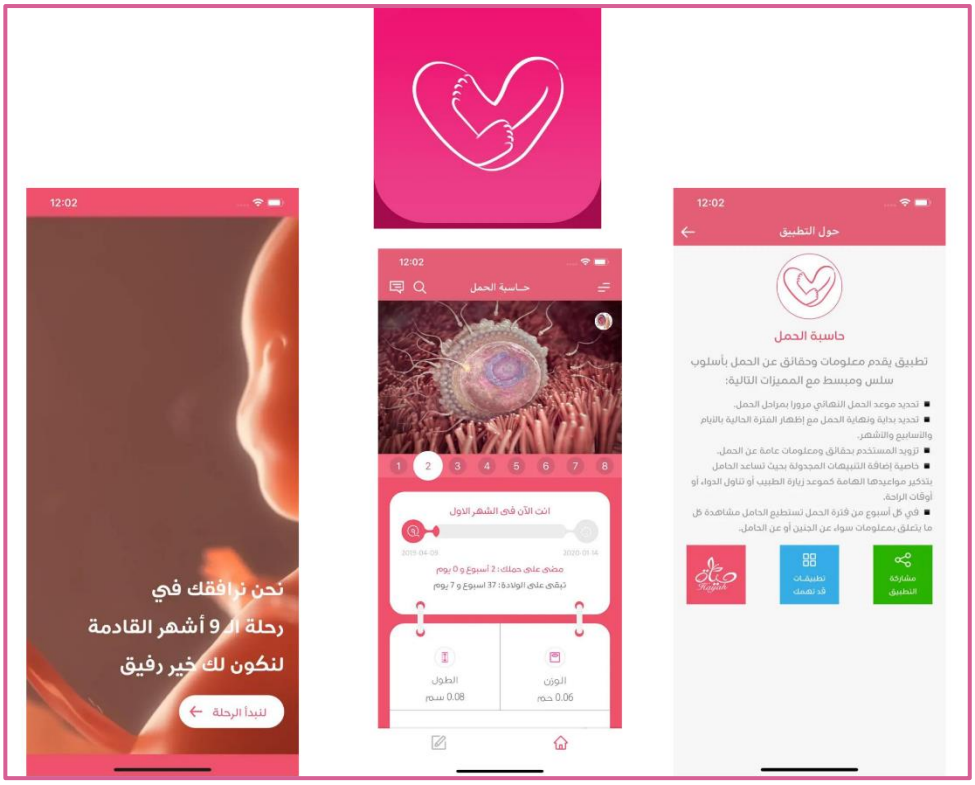


Figure 7: Pregnancy calculator UI in 3.1.6

3.1.7 Nine months (تسعة أشهر)

In Figure 8, we present an application that provides you with all the changes that happen to a pregnant woman and her baby weekly and reviews her pregnancy changes and fetal developments through pregnancy tips, pregnancy articles, and renewed videos. It has a lot of features like:

- Pregnancy calculator to calculate the date of birth.
- Follow up pregnancy symptoms week by week, the nine-month pregnancy program not only provides a follow-up of the growth of the fetus but also a weekly follow-up of all pregnancy symptoms.
- Weekly tips for a healthy pregnancy.
- A forum for mothers during pregnancy, communicate with mothers during pregnancy to exchange answers and questions.
- Suggestions for male and female baby names.
- Articles and topics on pregnancy and pregnant nutrition, while following up the pregnancy day by day with the best advice and directions for specialists to maintain a healthy pregnancy and a healthy fetus.

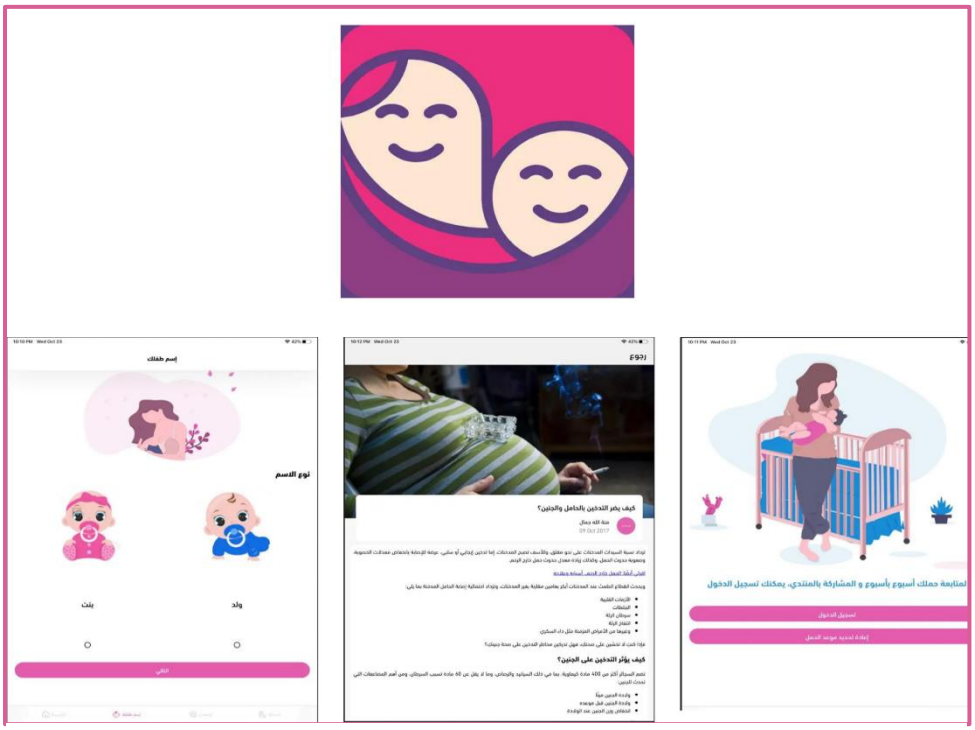


Figure 8: Nine months UI in 3.1.7

3.1.8 The queen (الملكة)

In Figure 9, we present an application that shows all the changes a pregnant woman and her unborn child experience. It has a lot of features like:

- Period calculator, Follow-up symptoms of premenstrual syndrome, treatment of menstrual pain, causes of delayed menstruation for girls, sends alerts before the dates of menstruation days.
- Pregnancy calculator to know your birth due date accurately.
- Follow-up pregnancy week by week.
- Monitoring fetal growth.
- Featured articles on pregnancy, fetal development, and pregnancy follow-up.
- The most important pregnancy follow-up tools, the mother's weight calculator, the kicking calculator, the contractions calculator, alerts of the most important medical examinations necessary for a safe pregnancy without difficulties, and nutritional advice.
- Provisions of fasting and purity for pregnant women in Ramadan (reviewed by specialists).

Figure 9: The queen UI in 3.1.8

3.1.9 Pregnancy plus (+ الحمل)

In Figure 10, we present a pregnancy tracker application for week-by-week pregnancy information and articles. It has unique, interactive 3D models showing your baby's development also it has additional features like:

- Baby Size Guide helps you visualize your baby's size in fruits, animals & sweets.
- 2D & 3D Scans by pregnancy week for you to browse.
- Daily Blog Posts with tips, tricks & helpful advice.
- Upload photos in My Bump to create a visual pregnancy diary.
- Birth Date Calculator helps you work out when your bundle will arrive.
- Kick Counter tracks your baby's movements & activity.
- Pregnancy Weight Log helps you keep an eye on changes in your weight.
- Contraction Timer measures contractions throughout your labor.
- Pregnancy Calendar enables you to plan & document your prenatal appointments.
- Hospital Bag helps you prepare for your hospital visit, for Mother, Birth Partner, and Baby.
- Birth Plan allows you to customize, organize, and export your needs and wishes.
- To-Do List and Baby Shopping List for ideas of what you need to do and buy.
- Search thousands of Baby Names for inspiration and share your favorites.
- It supports 21 languages such as Arabic, English, Czech, Danish, and others.

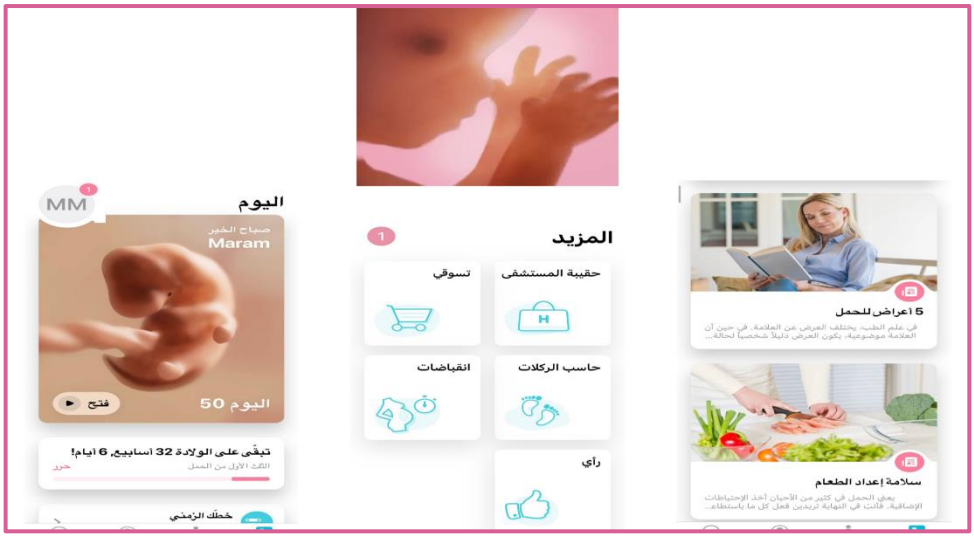


Figure 10: Pregnancy plus UI in 3.1.9

3.1.10Pregnancy tracker (تتبع الحمل)

In Figure 11, we present an application that is about what happens with a pregnant woman and her unborn baby week-by-week and it will tell you how to handle new situations. It has a lot of features like:

- Weekly Priority List.
- Test your knowledge to find if a pregnant woman is ready for childbirth.
- One-size-fits-all pregnancy diet and multitudes of tips on nutrition and compatible/incompatible food and medicines.
- Week-by-week pregnancy tips.
- Constant reminders of important dates on your pregnancy calendar.
- Checklists for all trimesters, and adjustable to-do lists for each quarter during the pregnancy.
- Prenatal to-do list.
- List of things you'll need in the hospital directly after the delivery of your child.
- Calculates birth date.
- The Guide of Pregnancy Women and Pregnancy Tracking features a smart contractions counter that allows you to know the time to go to the hospital.

Figure 11: Pregnancy tracker UI in 3.1.10

3.2 Comparison Between Similar Systems

Arabic pregnancy application	Features												
	Name explorer and make favorite list	To do list for user needs	Checklist for the hospital bag	Pregnancy calendar	Arabic Chatbot	Week by week pregnancy information about the mother and the baby	Pregnancy due date calculator	Pregnancy weight logs to track the weight changes and an alarm the mother if there is unusual change	contraction timer	PDF format for vital signs	Articles and frequent question	Edit profile
I am pregnant (انا حامل)							✓	✓			✓	
Altubby Mama (الطبي ماما)			✓			✓	✓		✓		✓	✓
The queen (الملكة)		✓	✓			✓	✓	✓	✓		✓	✓
Pregnancy calculator (حاسبة الحمل)						✓	✓					✓
Nine months (تسعة أشهر)	✓					✓	✓				✓	✓
My baby live (طفلي لايف)						✓	✓		✓		✓	
You and pregnancy (انت و الحمل)						✓	✓		✓		✓	✓
Tubaby (طب بيبي)	✓	✓				✓	✓				✓	✓
Pregnancy plus (الحمل +)	✓	✓		✓		✓	✓	✓			✓	
Pregnancy tracker (تتبع الحمل)	✓		✓	✓		✓	✓	✓	✓	✓		✓
Maternal (أمومي)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Table 1: Competitors comparing table in 3.2

In Table 1, we compared our product to the others in the Arabic pregnancy applications market, surely some applications are similar to our application. But we have an amazing feature called an Arabic artificial intelligence (AI) chatbot that does not exist in other applications. On the other hand, we have matched features with the other application like you see in the tables above but still, our application has an incredible feature that is difficult to find in any other application.

4 System Design and Development

4.1 Methodology

4.1.1 Agile Approach

Maternal (أمومي) was developed using the Agile software development methodology. Agile is an iterative approach to project management and software development that helps the Maternal (أمومي) team deliver value to their customers faster [21]. The requirements, plans, and results are evaluated continuously. So, Maternal (أمومي) team can quickly respond to changes to satisfy the customer and adapt to their needs. Agile divides the process into small iterative phases called sprints. Each sprint consists of planning the sprint tasks to be completed, developing and testing the developed increment, and demonstrating the final sprint result. The sprint is completed when the stakeholder considers the performed work complete.

Maternal (أمومي) was produced in six sprints. We focused on developing the application and starting to build the artificial intelligence (AI) chatbot in the three sprints of release-1. During the three sprints of release-2, we focused on implementing the rest of the application features and finishing the main feature which is the chatbot then integrating between them and finally deploying the application.

4.1.2 Scrum Framework

Scrum is a framework of rules, roles, events, and artifacts. It is an iterative approach, consisting of sprints that typically last for four to five weeks [22]. Each sprint is a group of user stories, and a group of sprints is called a release. In Maternal (أمومي), there are two releases, the first consisting of three sprints, which ended in the first semester, and the second composed of three sprints, which ended in the second semester. Scrum requires particular roles and responsibilities, including product owners, who have a clear vision and thorough market understanding. Scrum masters ensure that the team understands and practices scrum during each sprint. The development team has the requisite expertise to carry out the backlog items. Scrum is composed of several events. The sprint and its timeframe are the primary events. Sprint planning is a meeting held at the beginning of each sprint to plan the sprint backlog items. The daily scrum is a 15-minute meeting scheduled daily to track progress toward the sprint goal and sprint review, which takes place at the end of each sprint to demonstrate the work that has been accomplished to the stakeholders. Finally, a sprint retrospective is a meeting

held at the end of the sprint and just after the sprint review to highlight areas for future sprint improvements. Scrum emphasizes the delivery of working software at the end of each sprint over comprehensive documentation. It consists of the product backlog and a list of possible features for the final product. The sprint backlog is a subset of the product backlog that the team intends to achieve during the sprint. The increment is the work delivered by the end of each sprint. Scrum artifacts were implemented by first building our product backlog and then dividing it into sprint backlogs [23]. Before it began, we planned each sprint with the product owner, Dr. Ameera Almasoud. Once the sprint was completed, we held a sprint review with our scrum master, Dr. Hend Alrasheed, and took any recommendations. In addition, we had a sprint retrospective after each sprint review to discuss future improvements.

4.1.3 Jira and GitHub

Jira served as our centralized hub for project management, housing our product backlog, sprint plans, task assignments, and all submitted documents. Also, it facilitated the documentation of our meetings with the product owner and scrum masters[1]. In addition, for code management, we utilized GitHub, our project repository, where the Maternal (أمومي) team could easily access, pull, and push code changes[2].

[1] https://2023-3rd-gp5.atlassian.net/jira/software/projects/DT2023/boards/1

[2] https://github.com/sarahturki/2023-GP1-G5

4.2 System Requirements

4.2.1 System Users

In the System user's subsection, we describe the general characteristics of Maternal (أمومي) application users including their experience, and technical expertise. We have only one type of user:

- Speaks the Arabic language.
- 18 and above years old.
- Have at least an intermediate education level.
- Have access to a smartphone supporting the Android operating system and basic knowledge of how to use the device.

4.2.2 Requirements Elicitation and Analysis

We made and published an electronic questionnaire to some pregnant women and women who have gone through the experience of pregnancy in Saudi Arabia to help us define the right requirements for our application. We received 30 responses that clarified the following:

The first question was about the respondent's age and If we look at the age distribution of the respondents to the questions, we can see that (46.7%)of them are between the ages of 26 and 36, followed by the youngest age group, which is between 18 and 30 years old, with a percentage of (30%)the age group representing 36 to 45 years old with (20%), and the over-50-year-old category, which makes up the remaining minority.

Secondly, we asked them if this was their first pregnancy, and (60%) said yes while the rest said no. After that, we asked them if they had ever used a pregnancy app, and the results were (70%) had and (30%) had not.

From here our questionnaire is divided into two parts depending on the answer the respondents give to the third question. If the respondent answered the third question with yes, the next related questions were as follows:

We asked them about the app's name with the possibility to write more than one answer and the findings were (67,5%) use pregnancy calculator (19.1) , (حاسبة الحمل%) use nine months

(4) ,(تسعة أشهر%) or less for each of these apps, pregnancy(الحمل), my pregnancy(حملي), meet you, you and the pregnancy (أنتِ والحمل), baby center (بيبي سنتر).

Then, we asked them about the features they like about the app they use or have used they could choose more than one answer, and the majority said they liked the pregnancy due date calculator, providing week by week pregnancy information about mother and baby, pregnancy calendar and tracking pregnancy weight.

Also, we asked them about the features they would like to add, and most of them said suggested a list for the hospital bag, a list for the baby's shopping needs, providing legal provisions for pregnant women, and tracking pregnant women's symptoms or health information.

In addition, we asked them how frequently they use the pregnancy app, and the majority of responses with a percentage of (52.4%) mentioned weekly use while (42.9%) mentioned daily use and the minority mentioned monthly use.

On top of that, we asked them if the app they used was in Arabic language or not, and all of them answered yes it was Arabic language.

Also, when we asked them if the app they use provides them with an Arabic artificial intelligence (AI) chatbot, all of them said no. Moreover, we asked them if they would recommend the app they use to other pregnant women, and (95.2%) chose yes.

Furthermore, when we asked them about the factors that influenced their decision to use the pregnancy app, (61.9%) chose better care while (23.8%) said they were just curious, and (14.3%) said another pregnant woman recommended it.

Also, we asked them about the difficulties they face while using pregnancy tracking applications, and most of them said the required paying to get the necessary information or extra advantages and not reliable and don't have accurate information.

If the respondent answered the third question with no the related questions were as follows:

If there is an application that will help you during pregnancy, will you use it? (66.7%) said yes and the rest said maybe.

Also, we asked them about the things they wish to be present in the pregnancy application, with the possibility to choose more than one answer, all of them said the pregnancy due date

calculator, (77.8%) said to alarm the mother at the beginning of each week and provide legal provisions of pregnant women and (66.7%) choose the advantage that the app track pregnant women symptoms or health information.

Furthermore, we asked them about the preferred language in applications they use, and all of them said Arabic, also, we asked them if there is an application in the market that provides them with an Arabic artificial intelligence (AI) chatbot, would they use it, and the findings were (66.7%) said yes and the rest said maybe. Finally, we asked them about the factors that reduce their use of the application, the majority said the premium version for more features and it doesn't have accurate information. By following the statistics, we can draw many conclusions, including that the majority of respondents who are interested in pregnancy follow-up applications are from the age group between the mid-twenties and early thirties.

Everyone is very interested in the date of childbirth and considers it the most important feature of any pregnancy follow-up application.

The feature of having to pay for special features is the biggest barrier that prevents mothers from using pregnancy follow-up applications, which makes the free application one of the most important features that must be available.

The Arabic language is the easiest and everyone agrees to want to use it.

It is very important to pay attention to the components and features that most users are interested in using.

In addition, we conducted interviews with 4 women to know their opinions, requirements, and experience with pregnancy apps.

Firstly, we asked them about their age, two of them were in their twenties, the other one in her thirties, and the last one in her forties. Secondly, we asked if that was their first pregnancy, and (75%) said no whereas the rest said yes. Thirdly, we asked them if they had used any pregnancy app during their pregnancy journey, and (75%) answered yes, all of them used the pregnancy calculator app (حاسبة الحمل), and the features they liked that the app provides weekly information about the mother and the baby and it has a community for pregnant women.

After that, we asked them how they learned about the pregnancy app they used and what factors influenced their decision to use it, the majority said a recommendation from another

pregnant woman, and they used it for better care during the pregnancy. While others found the app by themselves and used the app to monitor their pregnancy.

Then, we asked them If they found the information and advice provided by the pregnancy app accurate and reliable, and whether were they able to apply it to their pregnancy experience, everyone agreed that the available information was not accurate and that it was not specific to each case but was general to all.

In addition, we asked them if they used the app to track their symptoms, appointments, or other aspects of their pregnancy, half of them replied yes, and the other half replied no.

Moreover, we asked if the pregnancy app provided any tools or resources to help them prepare for childbirth and did they found them useful, (75%) said no, and the rest said yes they were approximately useful.

Furthermore, we asked them if the app offered personalized recommendations or advice based on their specific pregnancy or based on generic information for all users, and all of them said it provided only general information. Also, we asked them if they would use an application that provides them with an artificial intelligence (AI) chatbot, and all of them said yes they would.

After that, we asked them if they had any concerns or doubts about using the pregnancy app such as privacy or security issues, and the results were that most of them didn't have any concerns.

Then, we asked them if they would recommend the app they used to other pregnant women and why, all of them said yes but the reasons differ, some said because it is easy to use and useful and some said because the app will help them during their pregnancy journey.

On top of that, we asked them what features or improvements would they suggest for pregnancy apps to better serve the needs of pregnant women, the findings were different because some suggested putting rules so that no one could answer other people's questions other than specialists or doctors, some suggested tracking weight and a suggested list of baby's names, and some suggested providing a calendar for scheduling appointments, and some suggested to calculate the weeks correctly and to give advice in each week, especially about food. For more details regarding this questionnaire and interviews, refer to Appendix A: Questionnaire and interviews

4.2.3 User Interactions

The use case diagram in Figure 12, shows our system's function and its interaction with the user.

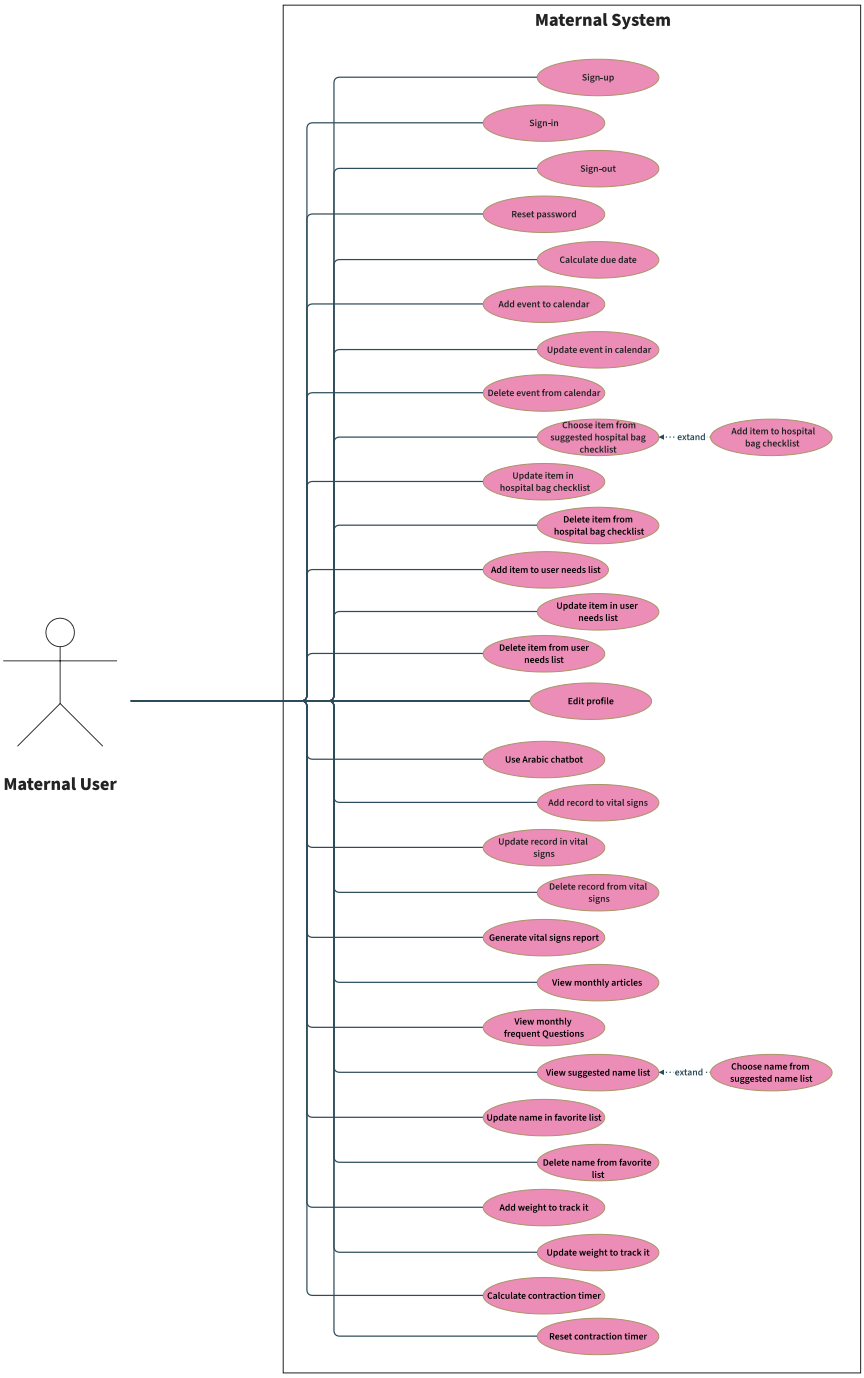


Figure 12: User interaction in 4.2.3

4.2.4 Roadmap and Product Backlog

4.2.4.1 Roadmap

The Figure 13 shows the roadmap of the Maternal (أمومي) application. Sprint 0 is from 26 MAR to 11 APR. By this time, we did the documents of domain analysis, requirement engineering, and learning new tools and languages. Also, from 26 APR to 16 MAY, we achieved sprint 1. As a result, we had the design of the user interface, databases, registration process, and preprocessing with the knowledge base. In addition, we performed sprint 2 from 21 MAY to 7 JUN. At this point, we obtained the weekly information about the mother and baby, a to-do list for babies' needs, name explorer, checklist for the hospital bag, pregnancy due date calculator, and information retrieval. furthermore, in sprint 3 from 20 AUG to 14 SEP we did the pregnancy weight logs, pregnancy calendar, the PDF format for vital signs record, articles, frequent questions, and edit profile. Moreover, we did in sprint 4 from 25 SEP to 19 OCT the dialog manager, response generator, and contraction timer. Finally, in sprint 5 from 5 NOV to 7 DES we tested and then deployed the application.

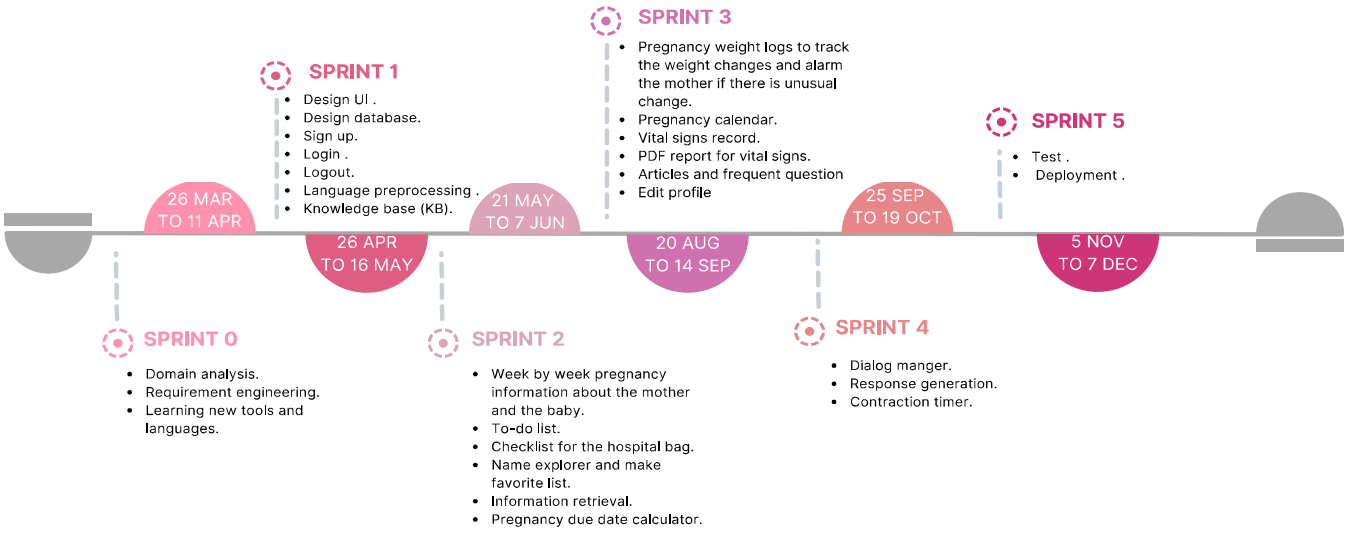


Figure 13: Roadmap in 4.2.4.1

4.2.4.2 Product Backlog

The Maternal (أمومي) product backlog was presented in Table 2, which displayed a prioritized list of user stories along with their corresponding acceptance criteria used for approval and completion.

ID	PBI	Size	Type	Status	Acceptance Criteria
1	As a user, I want to sign up so that I can use the Maternal (أمومي) application to manage my pregnancy.	3	Feature	Done	-As a user, if I click on sign-up button, then will redirect me to register page so I can fill the form and create an account. -As a user, if I don't fill in a mandatory field correctly in the sign-up form, then I will receive an error message. -As a user, if I complete all mandatory field correctly and submits the sign-up form, then I be redirected to App home page.
2	As a user, I want to be able to sign-in, so that I can access the Maternal (أمومي) application.	2	Feature	Done	-As a user, if I don't fill a mandatory field, then I will receive an error message. -As a user, if I fill a field in a wrong format, then I will receive an error message. -As a user, if I enter the wrong credentials, then I will receive an error message.

					-As a user, if I complete the form correctly, then I will be redirected to my home page.
3	As a user, I want to be able to sign-out, so that I can get myself out of my account.	1	Feature	Done	-As a user, if I click on the sign-out button, then I will be redirected to the welcome page.
4	As a user, I want to be able to reset my password, so that I can regain access to my account in case I forget my password.	2	Feature	Done	-As a user, if I click the forget password button, then the reset password page should appear. -As a user, if I add my email and click the reset password button, then I should receive a confirmation email to complete the rest password process.
5	As user, I want to be able to observe the weekly information for me and my baby, so that I can track it easily.	3	Feature	Done	-As a user, if I click the week button, then it will represent the information of the selected week.
6	As a user, I want to be able to add to the list of user needs, so that I can manage it easily.	2	Feature	Done	-As a user, if I click the add button, then I can add to the list of user needs.
7	As a user, I want to be able to update the list of user needs, so that I don't need to create a new list.	2	Feature	Done	-As a user, if I click the update button, then I should be able to update the list of user needs.
8	As a user, I want to be able to delete form the list of user needs, so that I don't have to buy that much of stuff.	2	Feature	Done	-As a user, if I click on the delete button, then I should be able to delete the unwanted user needs that I don't want it.
9	As a user, I want to add to the hospital bag checklist, so that I don't forget anything.	2	Feature	Done	-As a user, if I click add to the hospital bag button, then I can add to the checklist.

10	As a user, I want to choose from the suggested checklist for the hospital bag, so that if I forget something it will help me remember it.	2	Feature	Done	-As a user, if I click the hospital bag checklist button, then I can choose from the checklist.
11	As a user, I want to be able to update the hospital bag checklist, so if I make mistake, I can fix it.	2	Feature	Done	-As a user, if I click update hospital bag button, then I can update the checklist.
12	As a user, I want to be able to delete items from the hospital bag checklist, so that I can customize the list to my own needs and preferences.	2	Feature	Done	-As a user, if I click delete from the hospital bag button, then I can delete from the checklist.
13	As a user, I want to view the suggested name list of babies, so that it is inspires me to choose a name.	3	Feature	Done	-As a user, if I click the baby's name button, then I have to choose a baby girl or baby boy. -As a user, if I choose between a baby girl or a baby boy in the name list, then the list will appear depending on my choice.
14	As a user, I want to be able to add to the baby names favorite list that I made, so that it limits options of selecting a name.	2	Feature	Done	-As a user, if I click on the add button next to the name and write the new name, then the name will be added to the favorite list.
15	As a user, I want to be able to update the favourite list of baby names that I made in the app, so that I can keep track of my top choices and make changes as needed.	2	Feature	Done	-As a user, if I click on the update button next to the name and add an updated name, then the name will be updated in the favorite list.

16	As a user, I want to be able to delete from the baby names favorite list, so that it will not confuse me.	2	Feature	Done	-As a user, if I click on the delete button next to the name in the favorite list, then the selected name will be deleted from the favorite list.
17	As a user, I want to be able to calculate the pregnancy due date, so that I can count down to my baby birth date.	2	Feature	Done	-As a user, if I enter my last period, then it will calculate and display the pregnancy due date.
18	As a user, I want to be able to add event to the calendar, so that I can schedule my appointments.	3	Feature	Done	-As a user, if I click on the add to the calendar button, then I should be able to add my event.
19	As a user, I want to be able to update event in the calendar, so that I don't miss any of my appointments.	3	Feature	Done	-As a user, if I click on the update previous event button, then I can update it.
20	As a user, I want to be able to delete event from the calendar, so that I make sure that the calendar is accurate.	3	Feature	Done	-As a user, if I click on the previous event, then I can delete it.
21	As a user, I want to be able to add my vital signs record, such as blood pressure and weight, to the app, so that I can monitor my health and track changes over time.	3	Feature	Done	-As a user, if I click on the add vital signs button, then the vital signs page should appear. -As a user, if I complete filling out the vital signs form and click the save button, then the form should be saved in the vital signs list.
22	As a user, I want to be able to update my vital signs record, such as blood pressure and weight, in the app, so that I can ensure that my health information is accurate and up to date.	3	Feature	Done	-As a user, if I click on the update vital signs button, then the selected vital signs record should appear. -As a user, if I complete the update vital signs record and

					click the update button, then the form should be updated in the vital signs list.
23	As a user, I want to be able to delete my vital signs record in the app, so that I can keep my health information current and accurate and remove any outdated or incorrect data.	2	Feature	Done	-As a user, if I click the delete button, then the selected vital signs record should be deleted from the vital signs list.
24	As a user, I want to be able to generate PDF file of my vital signs record and share it, so that my doctor can track it.	2	Feature	Done	-As a user, if I click on share button it will generate a PDF file of my vital signs such as blood pressure, weight, and sugar, then I can share it with my doctor by email or social media.
25	As a user, I want to be able to add my weight, so that I can track it to know if my weight is normal or not.	3	Feature	Done	-As a user, if I click on add weight button, then I should be able to add my weight and save it. - As a user, if I add my weight periodically then the system will show if I am in a normal or unnormal state.
26	As a user, I want to be able to update my weight, so that if I made any mistake I can correct it.	2	Feature	Done	-As a user, If I click on update button, then I enter my weight it will be updated.

27	As a user, I want to be able to edit my profile, so that every information in the app will be accurate.	2	Feature	Done	-As a user, if I click the edit my profile button, then I should be able to edit my profile. -As a user, if I click the save my profile button, then my profile information should be updated in time not exceeding 7 seconds.
28	As a user, I want to be able to access articles that are tailored to each month of my pregnancy, so that I can stay informed about the changes happening.	1	Feature	Done	-As a user, if I click on the article button, then all articles related to my month should appear. -As a user, if I click on a specific article, then I can read the chosen article.
29	As a user, I want to access a list of frequent questions for each month of my pregnancy in the app, so that I can better understand what to expect during my pregnancy and get answers to common concerns.	1	Feature	Done	-As a user, if I click on frequent question button, then all frequent questions related to my month should appear.
30	As a user, I want to be able to count my contraction time, so that I can track it to know if my labor start or not.	3	Feature	Done	-As a user, if I click the start button, then the system should start recording time. - As a user, if I click the stop button, then the system should stop recording time and generate the total time of contraction.
31	As a user, I want to be able to reset the timer of the contraction so that I can measure the duration of each	3	Feature	Done	-As a user, if I click the reset button, then the system should reset the timer.

	contraction accurately and keep track of my progress during labor.				
32	As a user, I want to be able to use Arabic chatbot, so that I can ask any question about pregnancy anytime.	4	Feature	Done	-As a user, if I click on the chatbot button, then I can ask about pregnancy anytime.
33	As a user, I want the application to be available 99% of the time, so that I can ask the chatbot necessary questions whenever I need.	2	Feature	Done	-As a user, if I open the application, then it will open immediately.
34	As a user, I want the application to be secure, so that my data and information no one can access it.	2	Feature	Done	-As a user, if I enter my password wrong, then the system shouldn't log me in.
35	As a user, I want the app to be simple to use, so that I don't waste time and effort to find out how it works.	2	Feature	Done	-As a user, if I want something in the app, then I can easily find it.
36	As a user, I want the application's performance to be consistent, so that no matter how long I use the application the system won't crash.	2	Feature	Done	-As a user, if I use the application, then I can use it as long as I want without crashing.
37	As a user, I want the response to be displayed in less than 1 minute with a stable internet connection so that I don't feel overwhelmed.	2	Feature	Done	-As a user, if I click something, then the respond appears in less than a minute.

Table 2: Product backlog in 4.2.4.2

4.2.5 System Design

4.2.6 Architectural Diagram

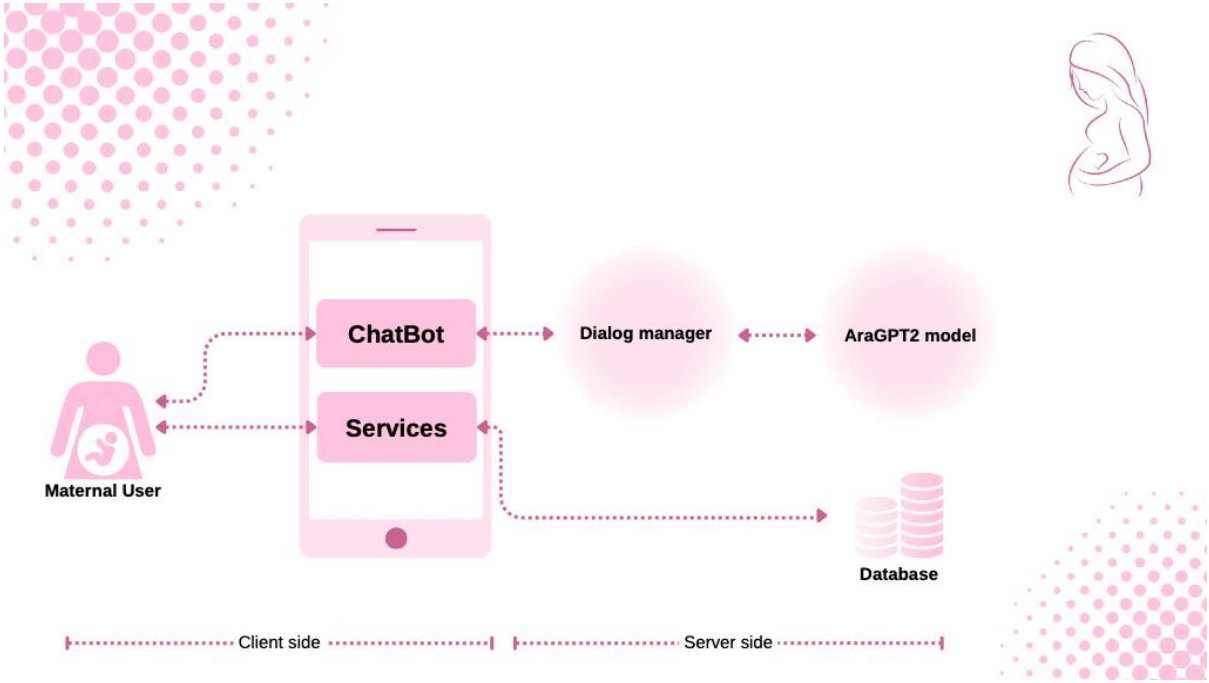


Figure 14: Architectural diagram in 4.2.6

As shown in Figure 14, our application uses a client-server architecture. On the client side, the user can either chat with a bot or request a service. On the other hand, on the server side, the services will need only the database but the artificial intelligence (AI) chatbot goes through a process that contains two main steps which are as follows:

4.2.6.1 Database

User information, services, and chatbot logs are kept in a Firebase Firestore database.

4.2.6.2 Dialog manager

The first step is in charge of directing the discussion between the user and the bot and it is called dialog manager. It will manage the conversation by answering based on the specific month the user asked about and answering questions related to the domain only otherwise it will generate an appropriate message. Also, it will generate greeting and goodbye messages.

4.2.6.3 AraGPT2 model

The second step is the AraGPT2 model, which contains three major parts:

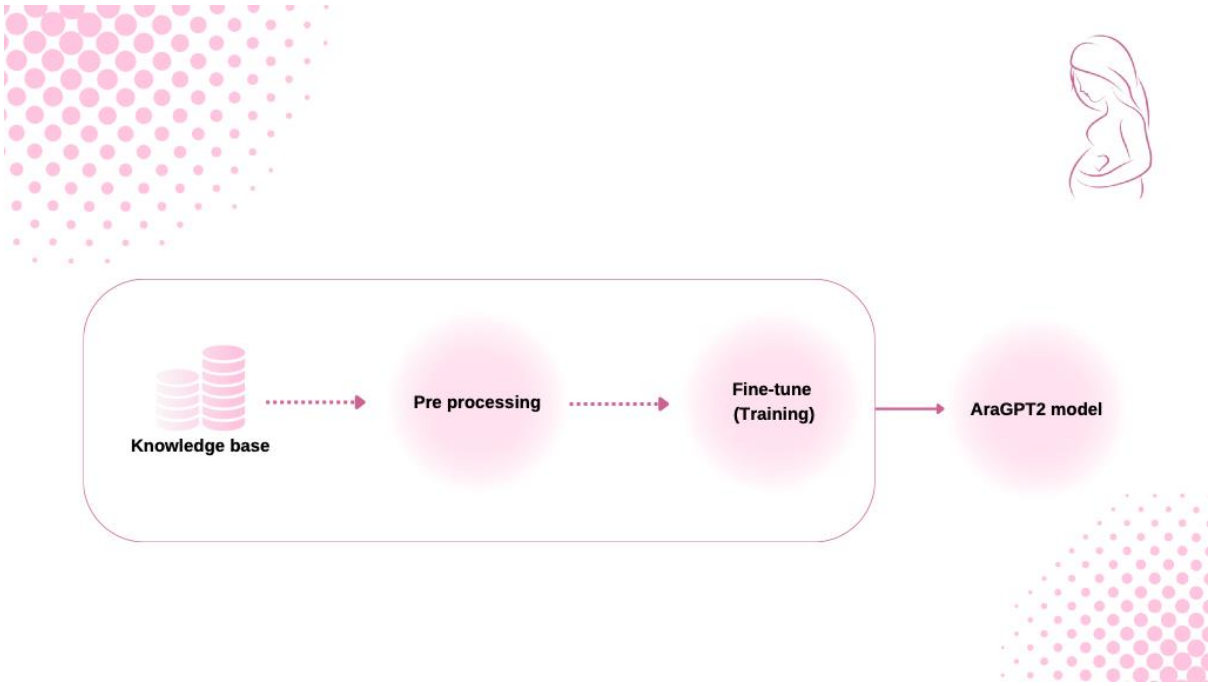


Figure 15: Architectural diagram in 4.2.6.3

- knowledge base

  The first part is the knowledge base consisting of data gathered from different resources and we store it in CSV file contains two columns one for question and the other one answer.

- Pre-processing

  The second part is pre-processing which start by reading each row from the CSV file while reading the file we implement in each row pre-processing from AraBERT which includes cleaning the data after that we added at the end of each row <|endoftext|> which is a sign for the model to understand it is the end of each input, then we add it to text file. Also, we have a pretrained tokenizer from transformers which the model will use it while tokenizing.

- Fine-tune

  The final part is fine-tuning which is the process of training the model based on our cleaned knowledge base which is the text file.

4.2.7 Class Diagram

In this section, we will use the class diagram to show the general understanding of how Maternal (أمومي) application is decomposed.

As shown in Figure 16, similar to any application, the Maternal (أمومي) application has a User class; this class contains many attributes for the user such as firstName, lastName, password, email, and more attributes. In addition, it has editProfile(), calculateDueDate(), signUp(), signIn(), signOut(), forgotPassword(), editPassword(), viewArticles(), viewWeeklyInfo(), and viewFrequentQ() functions. The User class has a relationship with the Events class; this class will help the user manage his events in a calendar. So, it has several attributes which are eventID, date, eventTitle, notes, and functions such as addEvent(), updateEvent(), and deleteEvent(). Furthermore, the User class has another relationship with the ContractionTimer class; this class helps the user to know if the labor starts. So, it has several attributes which are durationContraction, intervalContractions, numRounds, date, time, and functions like addContraction() and resetContraction(). Moreover, the User class has a relationship with the Chatbot class; this class helps the user to chat with the bot. It has userInput and machineOutput attributes and one function called chatbot(). Also, the User class has a relationship with VitalSigns class; this class will addRecord(), deleteRecord(), and updateRecord() for the user and can generateReport() to help the user track his vital signs easily. The VitalSigns class contains sugar, vitaminD, bloodPressure, and more attributes. In addition, the User class has a relationship with the List class. The List class controls the lists of the user such as todoList, hospitalBagList, and favoriteList, it has a relationship with the Suggestion class. Next, the User class has a relationship with the WeightEntry class; this class will manage the WeightTracker class by addWeightEntry() and updateWeightEntry() then the WeightTracker class will getTotalWeightGain() and compareWeight(). Finally, the remaining three classes are Articles, WeeklyInfo, and FrequentQ each has different attributes but they have similar function that is related to the user which are viewArticles(), viewWeeklyInfo(), and viewFrequentQ().

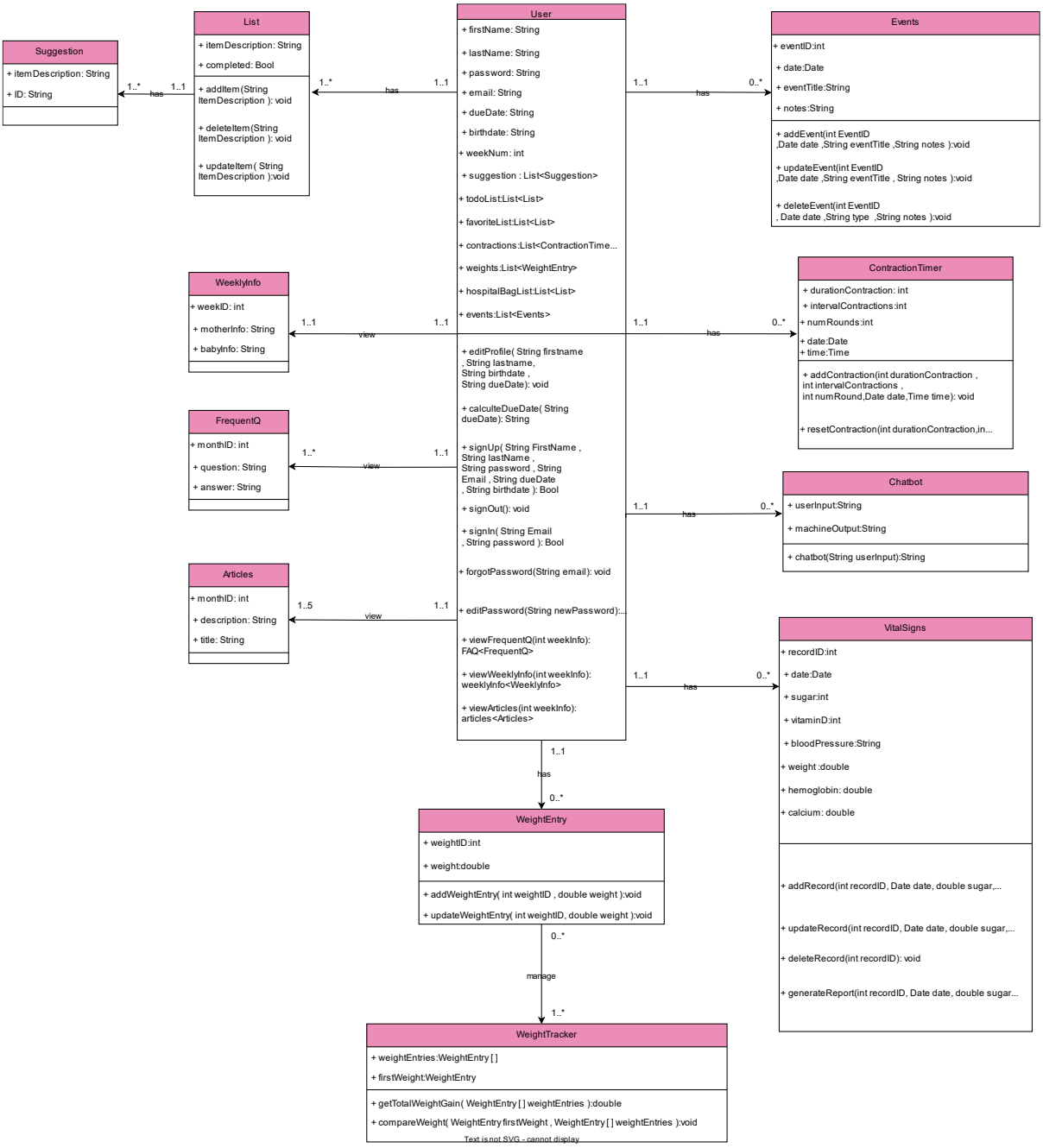


Figure 16: Class diagram in 4.2.7

4.2.8 Component Level Design

In this section, we presented three flowchart diagrams of Maternal (أمومي) application key components: Sign up, name explorer, and chatbot. Also, we provided a description for each diagram.

4.2.8.1 Sign up flowchart diagram

As shown in Figure 17, when a Maternal (أمومي) user wants to sign up, the user must enter the first name, last name, email, date of birth, password and rewrite the password. Then the application will check if the email is not already in the database it will continue, if it already exists the user should enter a new email. Also, the application will check if the password is strong or not and if the rewritten password is matched with the password or not. If it's strong and matched it will continue. Otherwise, the Maternal (أمومي) user must enter a new password. Or if the rewrite password is not correct the user has to rewrite the password again. After entering the information correctly Maternal (أمومي) user must enter the date of the first day in the last period. Finally, Maternal (أمومي) user can sign up.

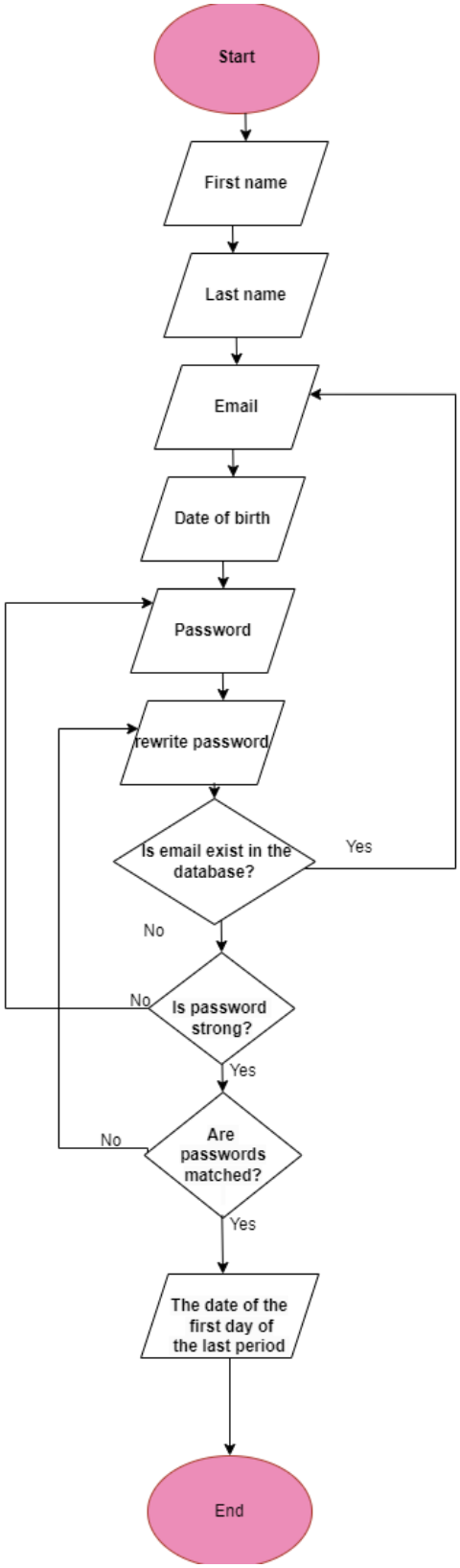


Figure 17: Sign-up flowchart diagram in 4.2.8.1

4.2.8.2 Name explorer flowchart diagram

As shown in Figure 18, when a Maternal (أمومي) user wants to use the name explorer function, the user can choose the gender of the baby to view the list of names for the specific gender. Also, the user can add the name to the favorite list, view the favorite list, edit, add, and delete from it.

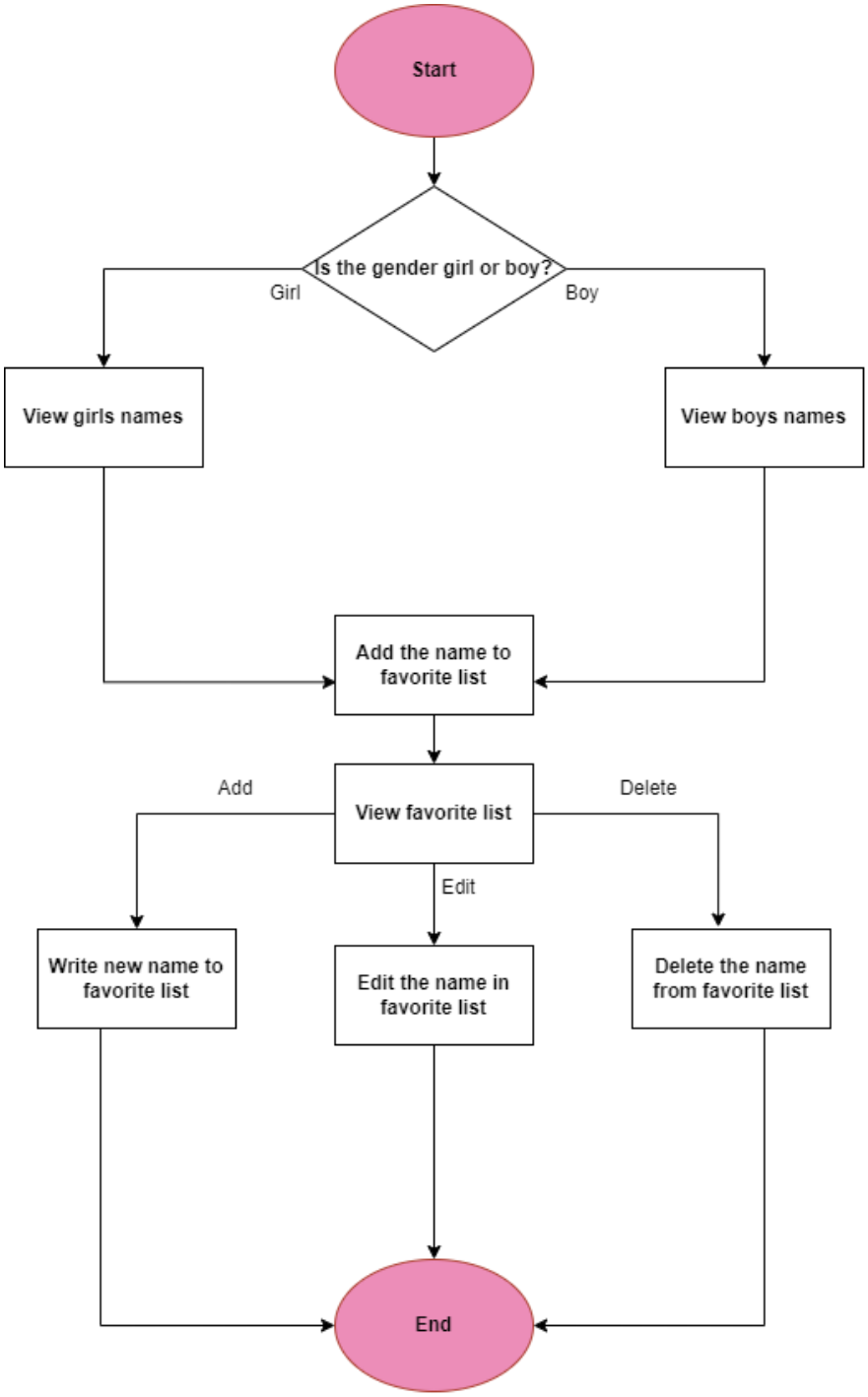


Figure 18: Name explorer flowchart diagram in 4.2.8.2

4.2.8.3 Chatbot flowchart diagram

As shown in Figure 19, when a Maternal (أمومي) user wants to use a chatbot, the user can enter the question then the app will go through dialog manager which manages the flow of the chat. Then it will continue to generate the answer in this step it will use the AraGPT2 model. Last step if the user has another question the user can ask again.

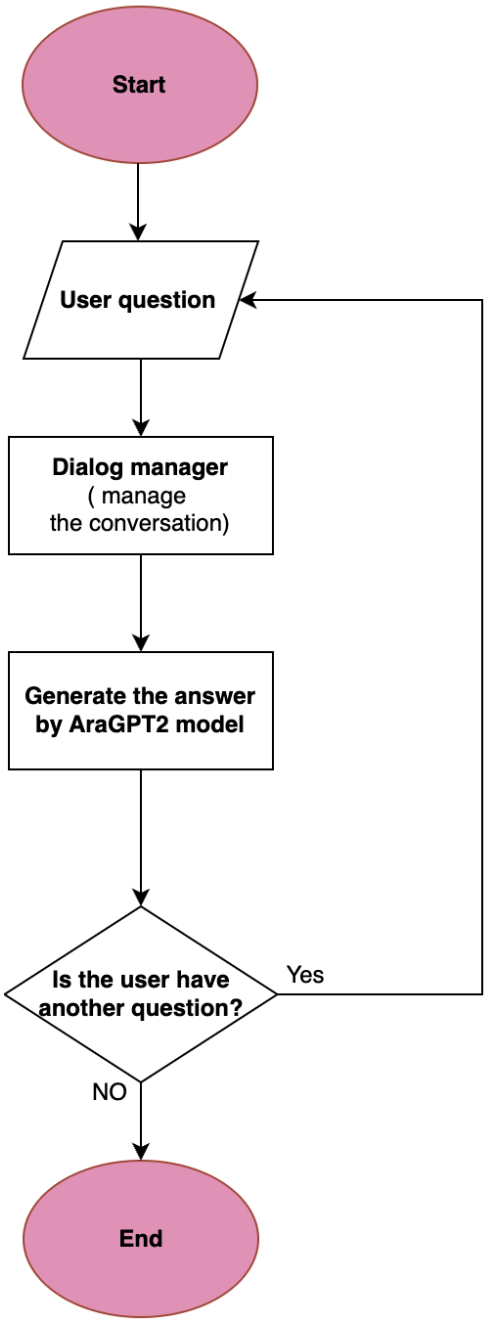


Figure 19: Chatbot flowchart diagram in 4.2.8.3

4.3 Data Design

4.3.1 Data Models

This section describes and illustrates data flow in our non-relational database using an ER diagram and a non-relational data model. We are going to use for non-relational database Firebase Firestore cloud database.

4.3.1.1 NoSQL database

- The ER diagram

As shown in Figure 20, Maternal (أمومي) ER diagram that displays the relationship of entity sets stored in the Firebase Firestore database. We used this database to store our application and users' information.

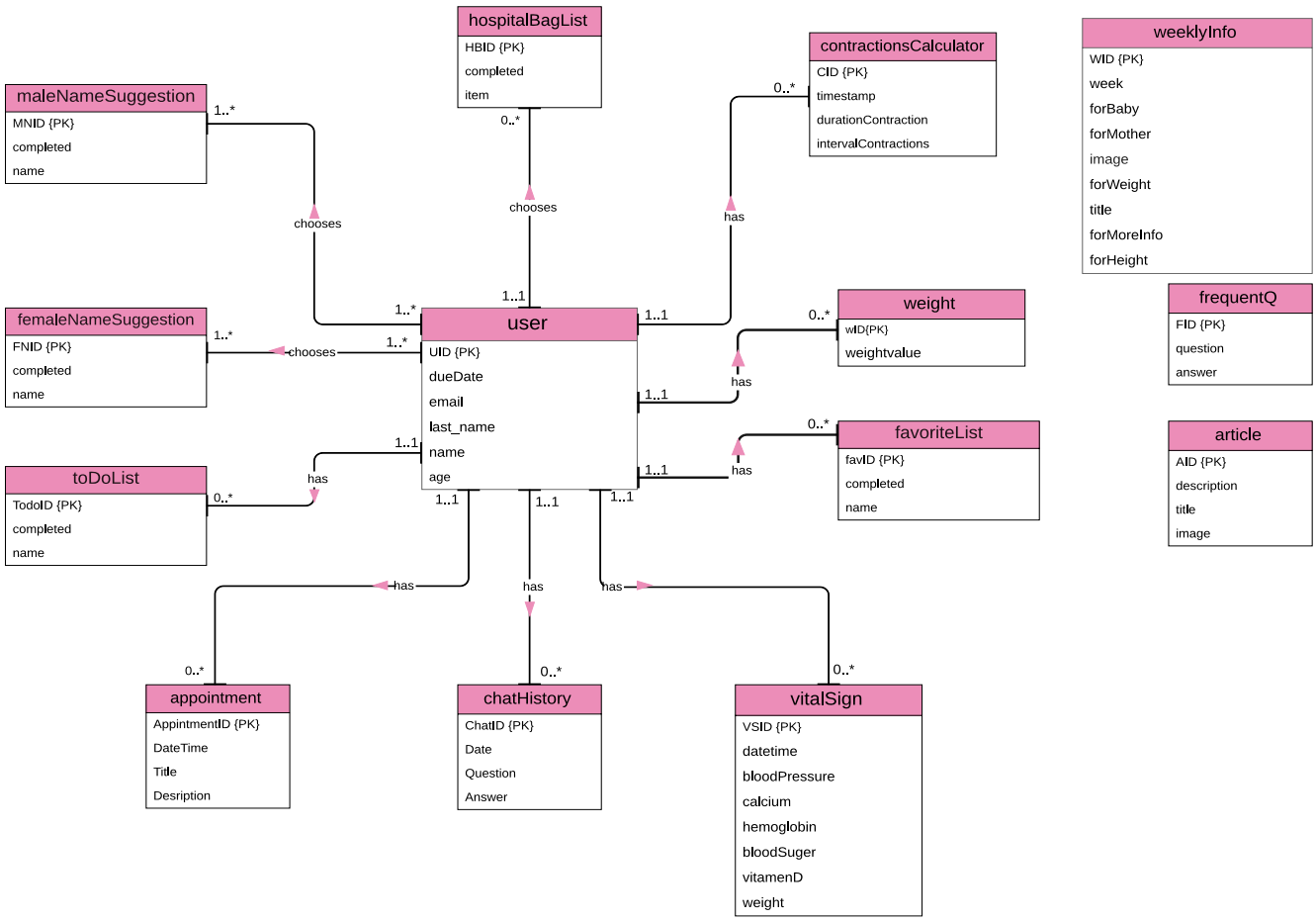


Figure 20: ER diagram in 4.3.1.1

- The non-relational data model.

As shown in Figure 21, we presented a model to show how the data will be stored on the Firebase Firestore database. We didn't present the password because we are using authentication services offered by Firebase that will hash and hide the password.

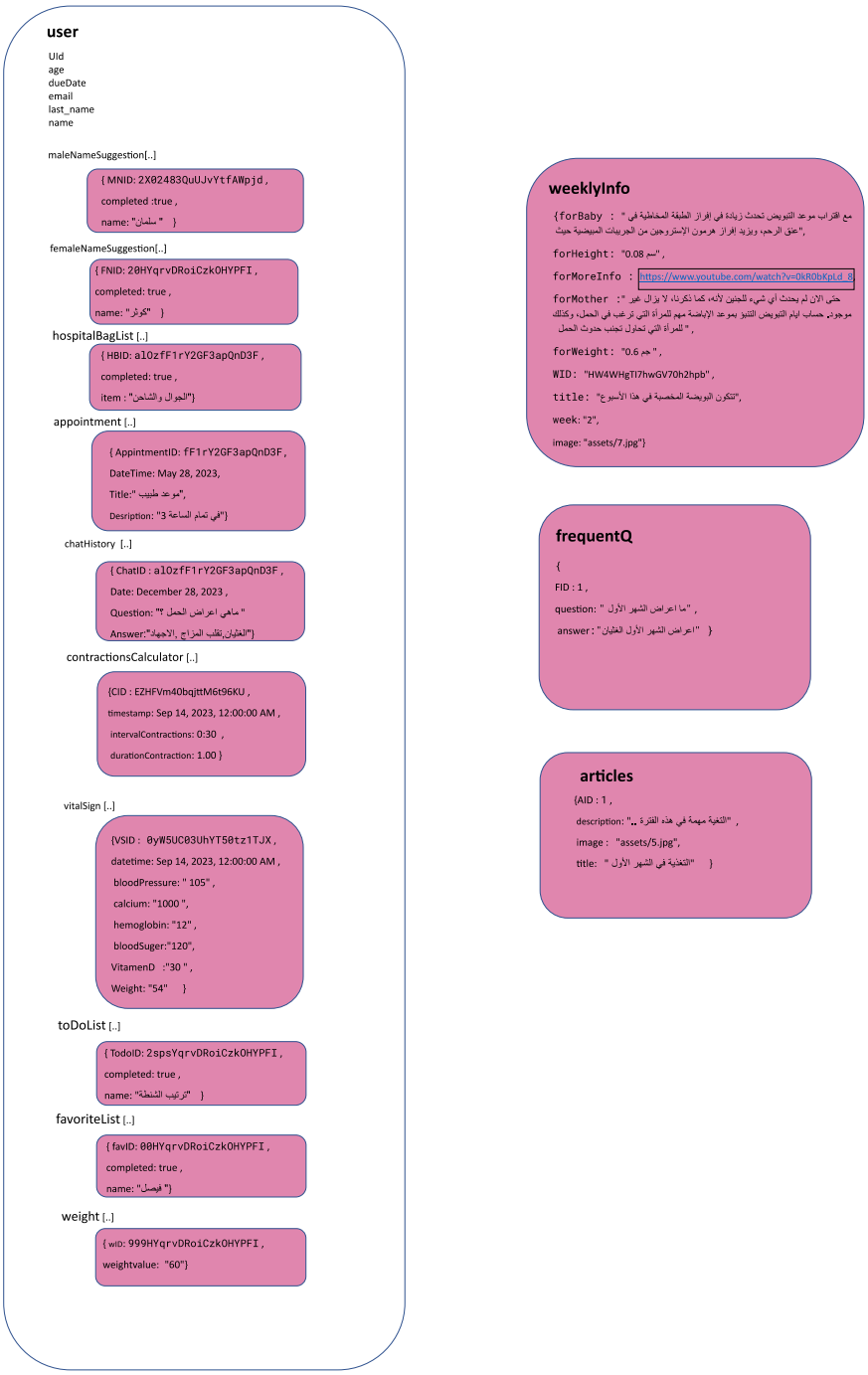


Figure 21: Non-relational data model in 4.3.1.1

4.3.2 Data Collection and Preparation

In this section, we will discuss the data creation, collection, and organization processes of our system, focusing on the external sources from which the data is acquired. Additionally, we will outline the various data preprocessing procedures employed to ensure that the data is clean, consistent, and ready for use in our system.

Our system collects data from various external sources, and we take precise steps to ensure the accuracy and reliability of this data. The data creation and collection process for our application involved two main sections:

Firstly, we gathered information about the application itself, including weekly baby and mother information, hospital bag information, Articles, frequent questions, and baby names. We extensively researched competing applications, such as pregnancy calculator, nine-month, The Queen, and pregnancy trackers.

Each application was individually analyzed, and we collected and stored relevant information from each one. This precise process ensured that we had a comprehensive understanding of the features and data available in these applications.

In parallel, we focused on building an Arabic knowledge base for pregnancy-related inquiries of our artificial intelligence (AI) chatbot. We sourced data from a variety of reliable sources including dedicated Telegram channels that catered to pregnant women's concerns and queries, pregnancy forums for women, and internet resources such as Altibbi [24] , Webteb [25] , and Mawdoo3[26].

We gathered and organized all the questions and inquiries, categorizing them into two sections those with answers and those without answers.

In case the inquiries had no answers, we precisely reviewed the inquiries and questions then we conducted thorough research to find suitable and validated answers. For the section with answers, we ensured the accuracy and reliability of the answers by searching and asking some doctors about some answers to critical questions. This precise approach guaranteed that all the inquiries were addressed with accurate information.

After the completion of the previous process, we divided the knowledge base into two datasets one for training and the other for testing, we stored the two datasets in different CSV files. The training file contains a total of 2054 questions and answers that were collected preprocessed

and then trained by the model. On the other hand, the testing file contains a total of 200 questions and answers that were collected preprocessed then tested by the model.

Finally, once we confirm the accuracy and completeness of the collected data for the application itself like articles we store it in our database, enabling easy access and the ability to retrieve it within our application. This comprehensive data collection, organization, and preprocessing process for the application data and chatbot knowledge base allowed us to deliver reliable and valuable information to our users throughout their pregnancy journey.

4.4 Interface Design

4.4.1 Navigation Diagram

In Figure 22, we presented the Maternal (أمومي) application navigation diagram which provides an overview of how the entire Maternal (أمومي) application will link together and how the user is expected to navigate between different interfaces.

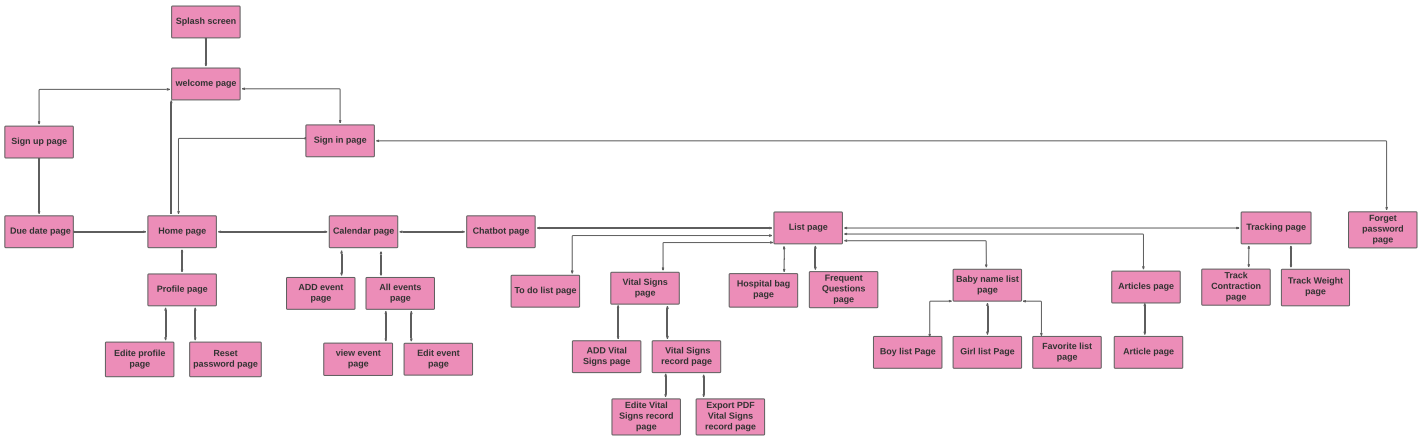


Figure 22: Application navigation diagram in 4.4.1

4.4.2 User Experience Guidelines

In Table 3, we presented rules and guidelines based on the user experience design course.

#Rule	Principle		How is this principle applied
1	Learnability	Familiarity	The Maternal (أمومي) app employs metaphors that are easily recognizable to users, such as a heart shaped "Like" button, a plus icon for the "Add" button, Trash icon for the "Delete" button, and an Arabic chatbot represented by a robot icon.
2		Synthesizability	Synthesizability (immediate honestly) Offer instant feedback on password requirements during the sign-up process and notify users when they attempt to register with an email address that has already been used by another user.
3		Consistency	Consistency in the use of colors, buttons, font, and icons across the app.
4		Generalizability	The Maternal (أمومي) app uses the hamburger icon like other apps, as well as the Date format (DD-MM-YYYY).
5	Flexibility	Dialog Initiative	The Maternal (أمومي) App utilizes a pre-emptive system, which is

			exemplified when a user removes an item from their favorites list.
6	Robustness	Recoverability	If Maternal (أمومي) user forgets or want to reset the password, the user can reset it by clicking on "Forgot Password" or "Reset Password" and entering a new one.
7		Reachability	The Maternal (أمومي) user can navigate between the navigation bar options easily.

Table 3: User experience guidelines in 4.2.2

4.5 Implementation

This section describes the processes of implementing the Maternal (أمومي) application along with the challenges that we faced and how we solved them.

First, we faced two major challenges the first part was coding using the Flutter framework with Dart programming language and Google Collaboratory environment with Python programming language it was a new framework, environment, and languages that we hadn't used before. So, we took a long time to learn and implement the codes for the desired functionalities, but thankfully we gained a self-learning skill that made us capable of coding using Dart and Python programming languages. The other part was the implementation of the main feature in our application which is an artificial intelligence (AI) chatbot based on natural language processing (NLP) and machine learning (ML) models, it was a new field to us especially since we wanted it as an answer generator, and should build it without using APIs. In the beginning, we found many models but we couldn't choose a suitable model and we couldn't find any knowledge base related to pregnancy in the Arabic language. So, we had a couple of meetings with specialists they helped us by explaining some ambiguities we had and giving us the motivation to search and find a suitable model. Based on our search we found many generator models like mT0, GPT2, GPT3.5, Arabert, and AraGPT2 but these models need to be finetuned using pregnancy knowledge base. Regarding the knowledge base we built it from scratch then we found more than one format for saving the knowledge base the formats were Jason file, Text file, or CSV but finally we chose to save it in CSV file because it is easier to recognize the question from the answer. The knowledge base will be used only in training the model.

In the beginning, we used the Figma tool to design and visualize our user interface then we coded it using Dart language in the Flutter framework. Also, we used the Lucidchart tool to design the ER diagram, and draw.io tool for the Class diagram, and the Moqups tool for the User interactions and Navigation diagram. Then we convert the ER diagram to the NoSQL database in the Firebase Firestore. After that, we continued to make the desired functionalities in each sprint using two main components Flutter framework and Firebase Firestore.

In parallel, we started to work on the artificial intelligence (AI) chatbot using Python programming language by trying to break it into four sections preprocessing, information retrieval, answer generator, and dialog manager. The first section was the preprocessing we

used CAMeL and Farasa tools, experimenting with different methods and mixing them. The results were initially good. However, when we moved on to the second section which is information retrieval, we found that this approach was not sufficient. Therefore, we switched to using a regular expression library in Python and tokenization from NLTK, which resulted in a more accurate and effective preprocessing of the data.

The second section was the information retrieval that will retrieve the data from different collections (KB, Weekly-Info, Frequent-Q, and Articles) in Firestore Firebase. we have decided to utilize word embedding models for the information retrieval step. Initially, we tried using the fastText model with different similarity types such as Cosine, HyperD, and Nclodian. We found that using Cosine similarity provided the most accurate results. However, we encountered issues when we connected the fastText model with a large knowledge base, as the similarity results between the user input and our data were often near 1, which was unacceptable.

Then, we experimented Word2Vec model, but we found that it produced irrational and inaccurate results, regardless of whether we used a small or large knowledge base.

As a result, we decided to switch to the TF-IDF technique, which assigns weights to words based on their frequency and importance in a document. We found that this approach was highly accurate and effective for our specific use case.

In addition, it’s important to note that different word embedding models perform differently because it depends on the data size and storage format. Therefore, it's essential to experiment with various models and techniques to find the best for our specific needs. Overall, we found that the TF-IDF technique with cosine similarity and storing the knowledge base in the Firebase Firestore database was the most effective for our artificial intelligence (AI) chatbot model.

After that, when we reached the third section which is the answer generator, we realized that there are several models to generate the answer and they are already doing the previous sections which are preprocessing and information retrieval. So, we made a huge and long search for the models then we tried multiple models like mT0 and AraGPT2. Firstly, we tried the base version of the models on our computers the results were not good then we tried the bigger versions, but the system was always crashing we faced this problem on each model we tried. So, we figured that there is an environment that could help to run our code without worrying about the size of the computer RAM which is the Google Collaboratory environment.

After we tried these models, we chose two models which are the mT0 and AraGPT2 model then we finetuned the models based on our knowledge base. AraGPT2 was the most sufficient and accurate result.

Moreover, the knowledge base was stored on the Firestore Firebase. While training several models to choose the best one, we found that is better to store the knowledge base locally on our computers to use it only while training the model. Also, we tried several structures for the knowledge base the first structure was question and answer columns on a CSV file then we tried to add some articles and conversions but sadly the results were worse. So, we decided to make it only question and answer columns and save it as a CSV file. After the preprocessing step, we integrate each row in the CSV file and add it into a text file, then we add a sign at the end of each integrated question and answer called <|endoftext|> that indicates each row is separated. The reason behind changing the file format is a CSV file is clearer and better for organizing and storing the data while gathering but the text file is easier for the model while training.

Next, we integrate the trained model with the application. first, we uploaded the model to the Hugging Face website then we made a request in the application code to our model by writing our own API URL and using our own tokens to authorize the request. In addition, we implement the encode and decode codes from Dart packages that will extract the response that comes from the model. After that, each conversation between the user and bot represents a chat log that will last for 24 hours and then will be stored in the chat history to use in the future for improving the model.

In deploying the application, we created an account on the Google Play Store then we followed the instructions in a YouTube video to deploy the application [27]. Finally, here is the link of our GitHub repository [3].

[3] https://github.com/sarahturki/2023-GP1-G5

5 System Evaluation

System evaluation chapter will present the experimental results, user acceptance testing, non-functional requirements testing and discussion summarizing the outcomes.

5.1 Experimental Results

In this section, we will present the experimental results from the development of our Arabic artificial intelligence (AI) chatbot, which includes creating the Arabic knowledge base, choosing the answer generator model, and testing the models. We will provide details about the knowledge base file format, models used, and the outcomes of the experiments.

In the beginning, we had to create an Arabic knowledge base related to our topic. This stage involved searching and gathering data from a variety of reliable sources and then experimenting with various storage formats to determine the most appropriate one. Initially, we stored the knowledge base in a JSON file, organized by tags that represent the month. However, we faced an issue when trying to read the file because it was reading the file line by line for example if the answer is about two lines it will read the first line and ignore the rest. After that, we tried storing the knowledge base in a text file, but again we faced similar issues when trying to read the file. Eventually, we settled on using a CSV file format to store the knowledge base. This format worked well for us as each cell contained the required information, and we could read the data cell by cell. Also, we tried several structures the first structure was question and answer columns then we tried to add some articles and conversions but sadly the results were worse. So, we decided to make it only question and answer columns and save it as a CSV file. After the preprocessing step, we integrate each row in the CSV file and add it into a text file, then we add a sign at the end of each integrated question and answer called <|endoftext|> that indicates each row is separated. The reason behind changing the file format is a CSV file is clearer and better for organizing and storing the data while gathering but the text file is easier for the model while training. In the end, we decided to store the knowledge base locally on our computers to use it only while training the model. This proved to be the most effective for our specific use case.

After creating our knowledge base, we had a journey with natural language processing (NLP) which includes preprocessing and information retrieval. Initially, we used in preprocessing step CAMeL and Farasa tools, experimenting with different methods and mixing them. The results

were initially good. However, when we moved on to the second step, we found that this approach was not sufficient. Therefore, we switched to using a regular expression library in Python and tokenization from NLTK, which resulted in a more accurate and effective preprocessing of the data. In addition, we have decided to utilize word embedding models for the information retrieval step. Initially, we tried using the fastText model with different similarity types such as Cosine, HyperD, and Nclodian. We found that using Cosine similarity provided the most accurate results. However, we encountered issues when we connected the fastText model with a large knowledge base, as the similarity results between the user input and our data were often near 1, which was unacceptable. Then, we experimented Word2Vec model, but we found that it produced irrational and inaccurate results, regardless of whether we used a small or large knowledge base. As a result, we decided to switch to the TF-IDF technique, which assigns weights to words based on their frequency and importance in a document. It's important to note that different word embedding models perform differently because it depends on the data size and storage format. Back then we found that this approach was highly accurate and effective.

Then, when we reached the answer generation step, we figured that there are several models that can generate the answer based on neural networks trained on a large amount of text. So, we tried multiple models with different sizes like mT0 and AraGPT2. Firstly, we tried the base version of the models on our computers the results were not good then we tried the bigger versions, but the system was always crashing we faced this problem on each model we tried. So, we figured that there is an environment that could help to run our code without worrying about the size of the computer RAM which is the Google Collaboratory environment. Then, we started to train the AraGPT2-Base model with 500 datasets the results after testing it with 100 questions weren't good enough because it had 33% accuracy. So, we used the AraGPT2-Meduim model with the 2054 dataset and it shows a significant difference with 70% accuracy results from the testing with 100 questions. In addition, we tried the mT0-Large model with the 2054 dataset it was good but not the best since it got 41% accuracy results from the testing with 100 questions. Comparing the accuracy of the models shows that the AraGPT2-Meduim model with the 2054 dataset is the best model for our specific use case [28]. So, we made another test with 200 questions for the AraGPT2-Meduim model with 2054 and it got 81% accuracy [29]. Finally, we chose the AraGPT2-Meduim model because it is the most sufficient and accurate result.

5.2 User Acceptance Testing

In this section, we are presenting the User Acceptance Testing (UAT) process, which is conducted to ensure that our application satisfies the user's requirements. To carry out the UAT, we carefully selected a group of Maternal users to act as testers. The testers performed the specific tests, and subsequently, evaluated the application's performance by answering the questionnaire. Then we analyzed the results, deliberated on any issues that were identified, and decided whether the existing functionality was satisfactory or required further improvement.

5.2.1 Demographics of Participants

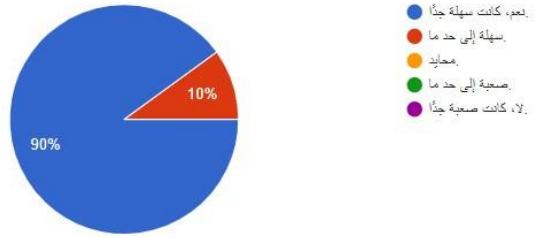
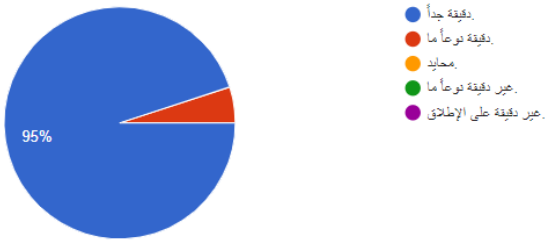
We conducted testing of our Maternal (أمومي) application on a sample of twenty mothers with varying education and technical backgrounds. The demographic details of the participants are provided in Table 4.

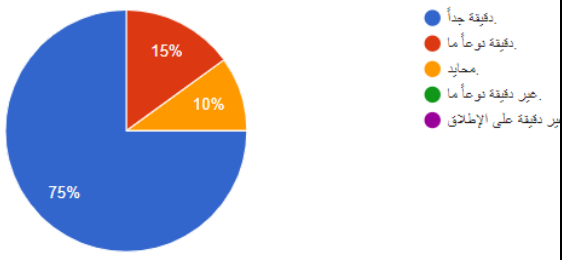
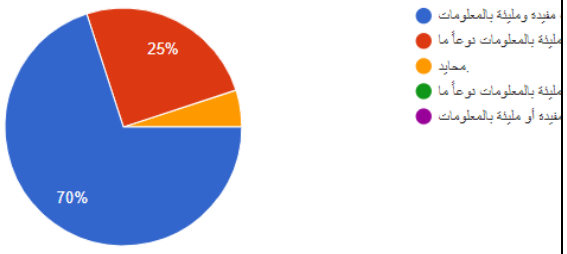
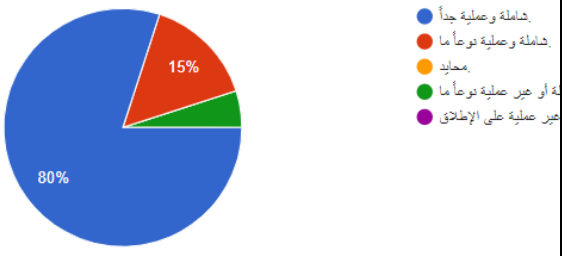
Variable	Classification	Number of participants
Gender	Male	0
	Female	20
Age	18 - 25	6
	26 - 35	11
	36 - 45	3
Education Level	High school Degree	1
	Bachelor’s Degree	17
	Master's Degree	2
Technical Level	Low	0
	Medium	18
	High	2

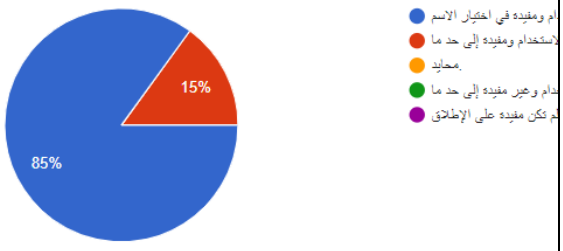
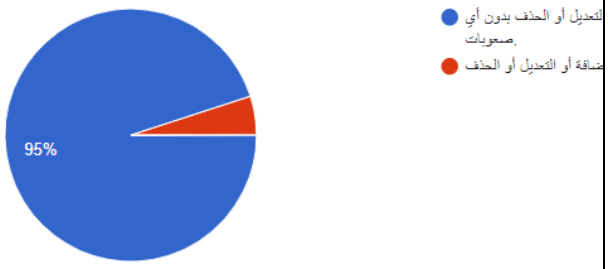
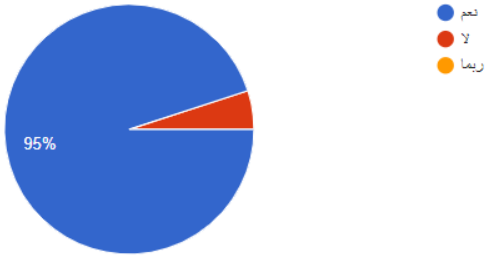
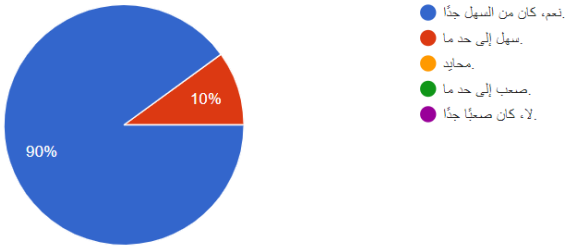
Table 4: Demographics of participants in 5.2.1

5.2.2 Questionnaire Results

Table 5 presents the results of a questionnaire conducted to gather feedback from users on the Maternal (أمومي) application, we administered an electronic questionnaire to the participants to gather their feedback about the application. The questionnaire contains 12 questions, and each of the twenty participants completed it in approximately three minutes. The purpose of the questionnaire was to obtain valuable insights into the user's experience and identify any areas for improvement in the system. For more details regarding these questionnaires, refer to Appendix B: UAT Questionnaire

Question number	Question	Response
1	هل وجدت عملية التسجيل سهلة وواضحة لإكمالها، مع الحقول المطلوبة (الاسم الأول، الاسم الأخير، تاريخ الميلاد، عنوان البريد الإلكتروني، كلمة المرور)؟	 **Figure 23: Users' feedback regarding registration process in 5.2.2**
2	ما مدى دقة حاسبة تاريخ الولادة في تحديد تاريخ الولادة المتوقع؟	 **Figure 24: Users' feedback regarding due date accuracy in 5.2.2**

3	ما مدى دقة إجابات المساعدة أمومي على اسئلتك؟	 **Figure 25: Users' feedback regarding Ammomy chatbot accuracy in 5.2.2**
4	هل وجدت معلومات الحمل الأسبوعية والمقالات الشهرية مفيدة ومليئة بالمعلومات لتتبع تقدمك خلال الحمل؟	 **Figure 26: Users' feedback regarding weekly information and Monthly articles in 5.2.2**
5	ما مدى شمولية وعملية قائمة حقيبة المستشفى للأم والطفل؟	 **Figure 27: Users' feedback regarding hospital bag in 5.2.2**

6	هل وجدت ميزة استكشاف الأسماء سهلة الاستخدام ومفيدة في اختيار اسم لطفلك؟	 **Figure 28: Users' feedback regarding name explorer in 5.2.2**
7	هل تمكنت من الإضافة، التعديل أو الحذف في التطبيق بسهولة وبدون مواجهة أي صعوبات؟	 **Figure 29: Users' feedback regarding add, update, and delete in 5.2.2**
8	هل ساعدتك خاصية تتبع الوزن في التطبيق في تحديد ما إذا كان وزنك طبيعي، مرتفع أو ناقص؟	 **Figure 30: Users' feedback regarding weight tracker function in 5.2.2**
9	هل كان من السهل التنقل في التطبيق والعثور على الميزات التي كنت تبحث عنها؟	 **Figure 31: Users' feedback regarding navigation in 5.2.2**

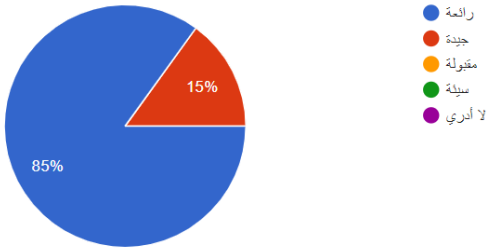
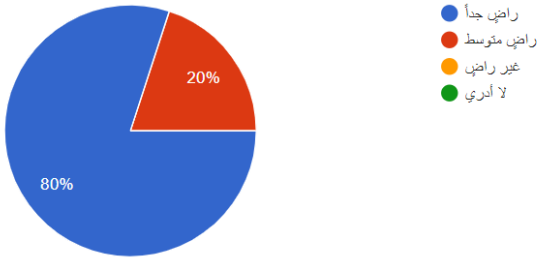
10	كيف تُقيم تجربتك العامة للتطبيق؟	 **Figure 32: Users' UX rating in 5.2.2**
11	الى أي مدى أنت راضٍ عن واجهة وتصميم التطبيق؟	 **Figure 33: Users' feedback regarding interface and design of the application in 5.2.2**
12	هل هناك شيء آخر تود إضافته حول تجربتك في استخدام التطبيق؟	 **Figure 34: Users' opinion and experience in 5.2.2**

Table 5: Questionnaire results in 5.2.2

5.3 Quality Attributes (NFR testing)

In Table 6, we documented the non-functional requirements (NFR) for our application. We choose three NFR availability, security, and Responsiveness. To test the performance of the Maternal (أمومي) application.

User story	**Quality Attribute**	**Measure**	**Results**
As a user, I want the application to be available 99% of the time, so that I can ask the chatbot necessary questions whenever I need.	Availability: How often is Maternal (أمومي) application available for users to access?	The percentage of time Maternal (أمومي) application is available.	Test scenario: 1-A group of 20 users was selected 2-During their testing session, we calculate the percentage of time the application is available Result: Maternal(أمومي) application was available 100% of the time. Since the testing was done out of scheduled maintenance.
As a user, I want the application to be secure, so that my data and information no one can access it.	Security: Ability to protect information from unauthorized access while providing service to authorized users.	Authentication: can be measured by the rate of successful login, by unauthorized users.	Test scenario: 1-A group of 20 users was selected 2-During their testing session, the users try to login with wrong credentials. Result: The application didn't allow any unauthorized access.
As a user, I want the response to be displayed	Responsiveness: Ability to react quickly and in a	Compute the response time for adding vital sign	Test scenario:

in less than 1 minute with a stable internet connection so that I don't feel overwhelmed.	positive way to something.	record 20 times then calculate average: Responsiveness= total number of second/ number of people.	1-A group of 20 users was selected 2-During their testing session, the users try to add vital sign record. Result: The application takes on average 1.35 second.

Table 6: Quality attributes (NFR testing) in 5.3

5.4 Discussion

In this section, we documented the discussion of the results of the User acceptance testing (UAT) and non-functional requirements (NFR). Based on the results of the UAT, we found that the users' reactions and thoughts of our application were positive and good. They showed that they enjoyed using the application and provided many recommendations to improve our application, such as adding more suggestions in the hospital bag list, giving the doctor access to track, adding more articles, and in the contraction timer alerting the mother if labor starts. For the NFR testing, we found that the results were satisfying our goal, but we aim to improve it more to let the user have a good experience.

6 Conclusions and Future Work

In conclusion, as pregnant women's concerns each month are increasing, the Maternal (أمومي) application simply creates a positive impact by helping each pregnant woman to get early and regular prenatal care that will improve the chances of a healthy pregnancy which is a demand for every pregnant woman. During the whole process, we went through several useful stages.

The first stage was the introduction chapter which clarifies the problem, solution, and product and gives a general introduction to the Maternal (أمومي) application. The introduction chapter is followed by the background chapter which has an important role in preparing the reader to understand the Maternal (أمومي) application details, by providing a brief explanation of knowledge aspects that the Maternal (أمومي) application falls in, such as pregnancy, what is a chatbot, and moreover. To deliver an application that fills the gap in the applications market, and to specify Maternal (أمومي) application features, we reviewed and discussed mobile applications in the same field and were represented in the literature review chapter. we started the system requirements and design chapter which transforms Maternal (أمومي) application features into a form used to facilitate the implementation of the application and support the understanding of some components and how they interact with each other. After that, we started partially developing the Maternal (أمومي) application using the Flutter framework and testing it to check if the system fulfills business requirements and can be used by the end users.

6.1 Global and local impact.

6.1.1 Local impact

In terms of local impact, based on the lack of applications that support the Arabic language, the lack of high-quality products, and the lack of providing a product reliably and accurately in the Arabic region. Our application will help every Arabic mother in her pregnancy journey to answer all the questions she needs and reassure her fears and concerns.

6.1.2 Global impact

In terms of global impact, we believe that the Maternal (أمومي) application will open a new market space in developing pregnancy tracking applications. Our application can be adopted by other communities and regions especially those who are interested in creating an Arabic artificial intelligence (AI) chatbot based on natural language processing (NLP) and machine learning (ML) models. Also, they can change and implement other languages based on their needs.

6.2 Problems and challenges encountered during the software development

We faced two significant obstacles. The first portion of the project was coding using the Flutter framework with Dart programming language and Google Collaboratory with Python programming language. The artificial intelligence (AI) chatbot was the other portion, it was a new field to us especially since we wanted it as an answer generator and should build it without using APIs. Also, we couldn't find any knowledge base related to pregnancy in the Arabic language.

6.3 Limitations of the system.

The Maternal (أمومي) application will not support other languages, not provide other operating systems, and will not provide admin user and his privileges.

6.4 The main contribution of the project

Every woman in her pregnancy journey needs someone or something to help her in so many ways. having an application that satisfies all her needs and getting early and regular prenatal care will improve the chances of a healthy pregnancy which is a demand for every pregnant woman. In this project, we develop an application called Maternal (أمومي) for tracking the pregnancy and help all Arabic pregnant women. Our application has a lot of incredible features, but our main feature that is difficult to find in any other application is the Arabic artificial intelligence (AI) chatbot this feature is based on natural language processing (NLP) and machine learning (ML) models. The Maternal (أمومي) application improves the chances of a healthy pregnancy for all pregnant women by being available when they need it and helping them with all their needs.

6.5 Future work

In the future, we want to see the Maternal (أمومي) application internationally. So, we will work to add more languages such as English, French, and Spanish. Also, we want it to be more useful by connecting the application with the doctor. So, the doctor can track his patient (Maternal (أمومي) user) easily. On the other hand, the patient (Maternal (أمومي) user) can book an appointment in the doctor's schedule. Moreover, we want to have Admin User. So, it can update the content of the application like the weekly information, articles, and frequent questions. Finally, we want the Maternal (أمومي) application available on all mobile operating systems.

7 Acknowledgements

At first, we owe everything to Allah, who gave us the strength to start and the courage to face challenges in our graduation project. We're really grateful. A special shout-out to our supervisor, Dr. Ameerah Almasoud. She's been amazing, always supporting us and giving us helpful advice. We appreciate her time and effort in guiding our work. A big thank you also goes to the scrum team. They shared their knowledge about the Agile framework with us, and that was super helpful. Teamwork makes the dream work!

Also, we want to thank the College of Computer and Information Sciences at King Saud University, especially the Information Technology department. They gave us a great learning opportunity, and we're thankful for that.

Last but not least, a huge thank you to our family and friends. They supported us all the way and encouraged us to successfully finish the project. We couldn't have done it without them. As we look back on our journey, we see how every challenge became easier with the support of Allah and everyone around us. Together, we've made it through and achieved something special.

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9 Appendix

9.1 Appendix A: Questionnaire and interviews

9.1.1 Questionnaire

- **The first 3 questions result:**

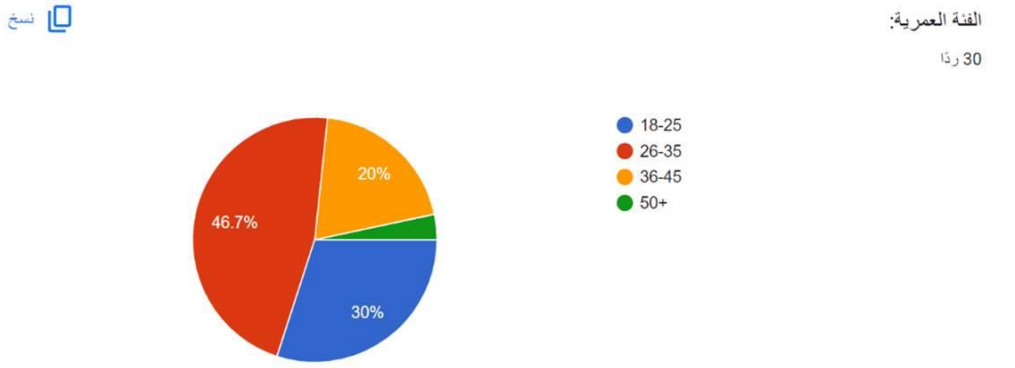

Figure 35: Users' age in 9.1.1

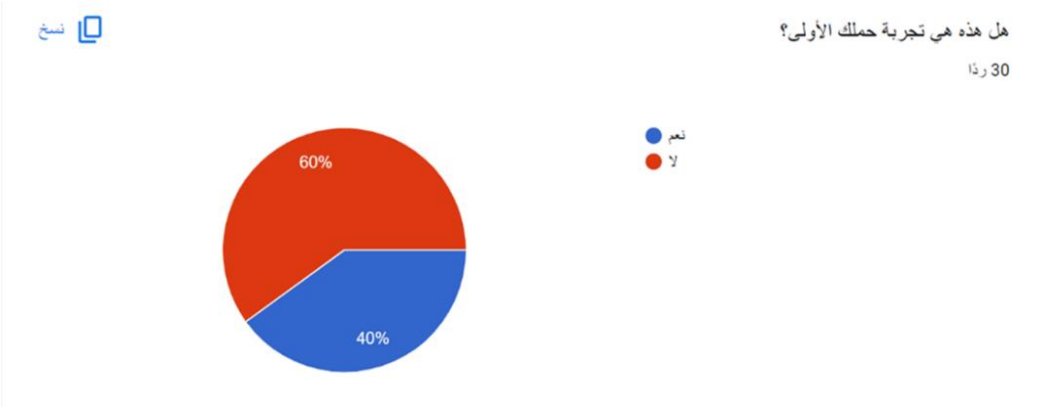

Figure 36: Users' number of pregnancy in 9.1.1

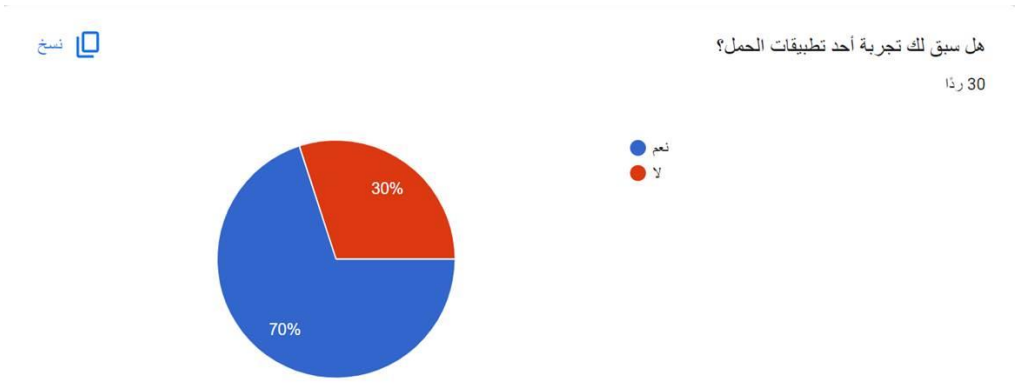

Figure 37: Users' number of pregnancy app usage in 9.1.1

- **If the answer is yes here is the related questions result:**

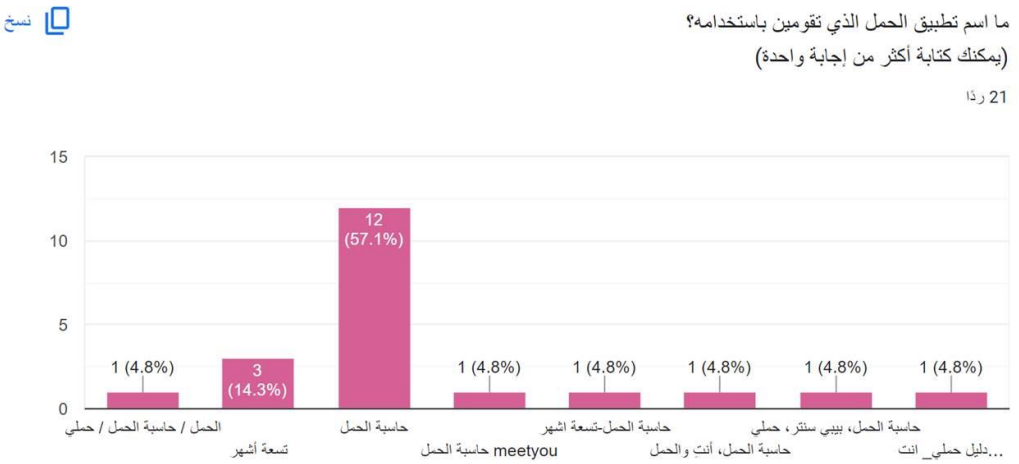

Figure 38: Users' feedback regarding name of pregnancy application in 9.1.1

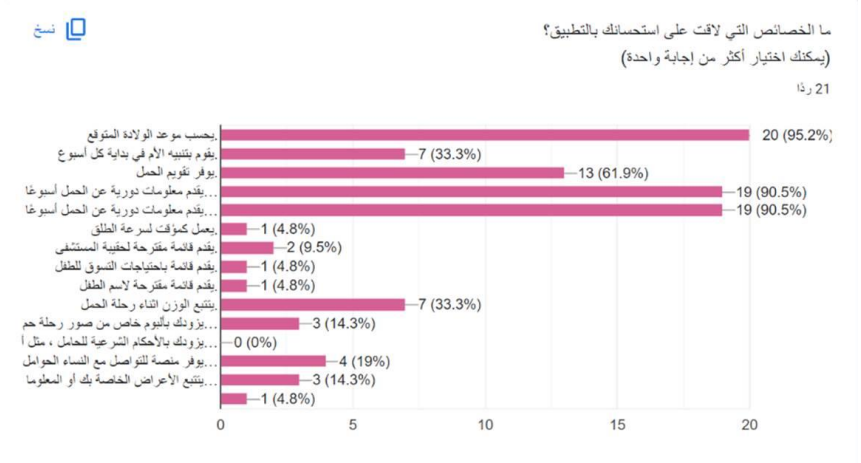

Figure 39: Users' feedback regarding pregnancy application features in 9.1.1

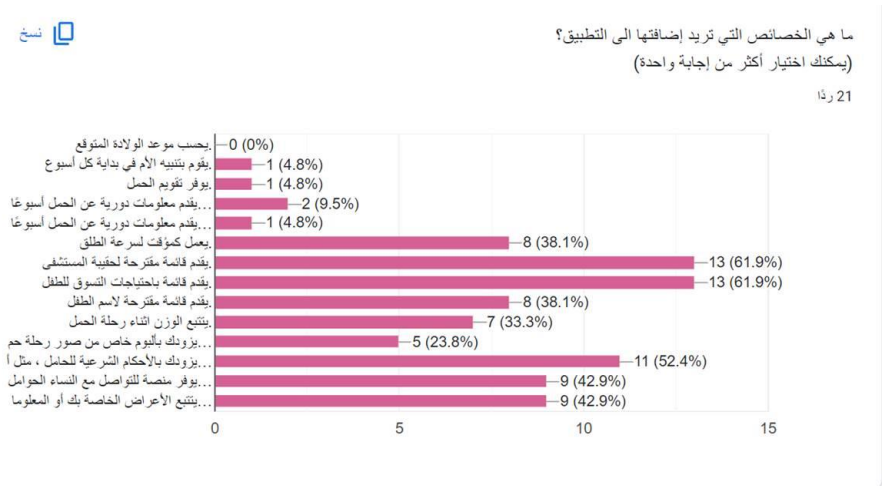

Figure 40: Users' feedback regarding features they want to add on pregnancy apps in 9.1.1

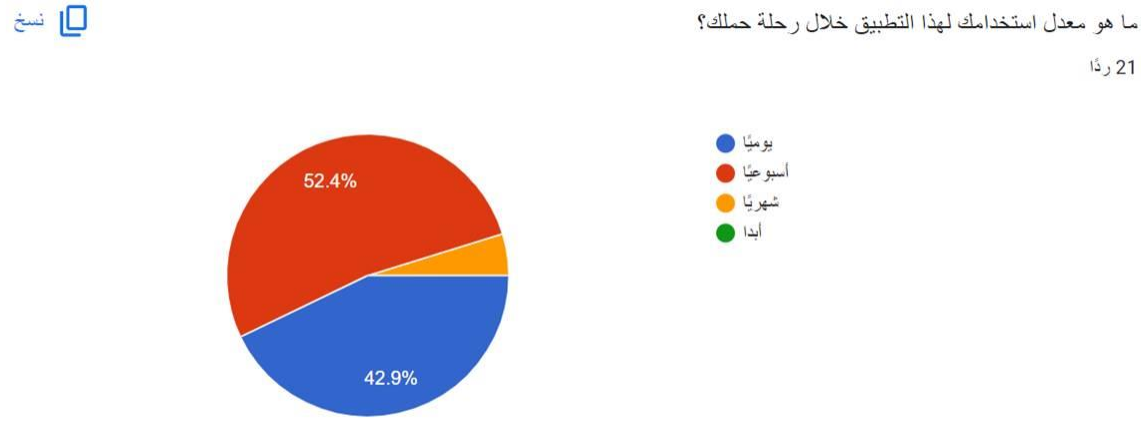

Figure 41: Users' number of application usage in 9.1.1

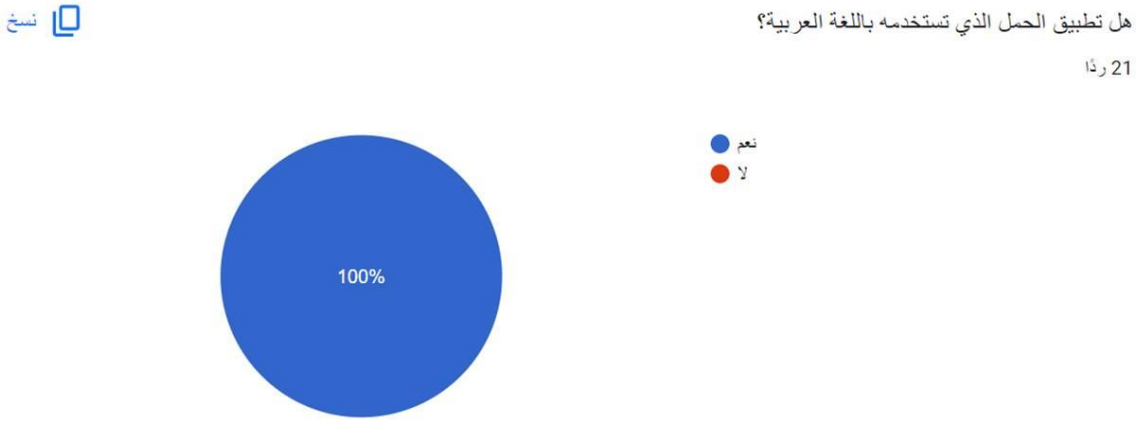

Figure 42: Users' Arabic application usage in 9.1.1

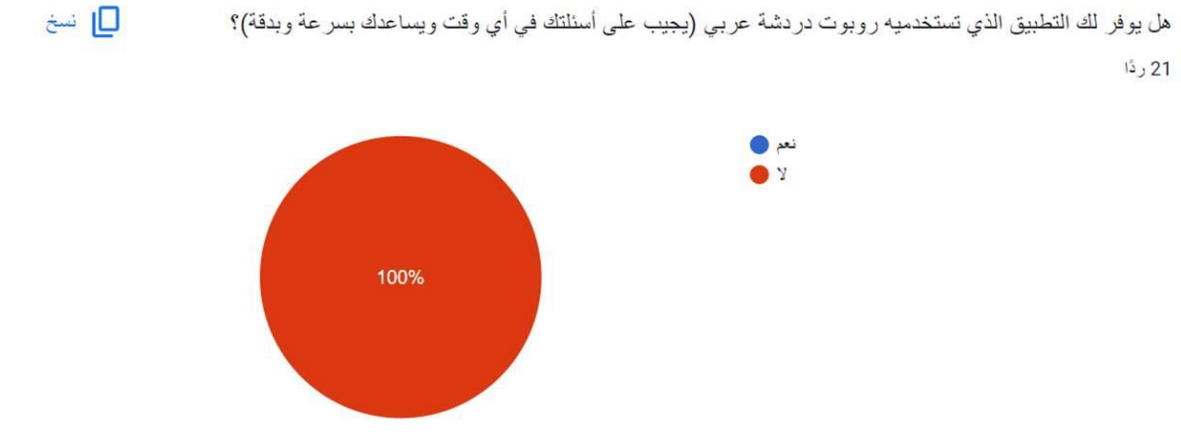

Figure 43: Chatbot on users' application in 9.1.1

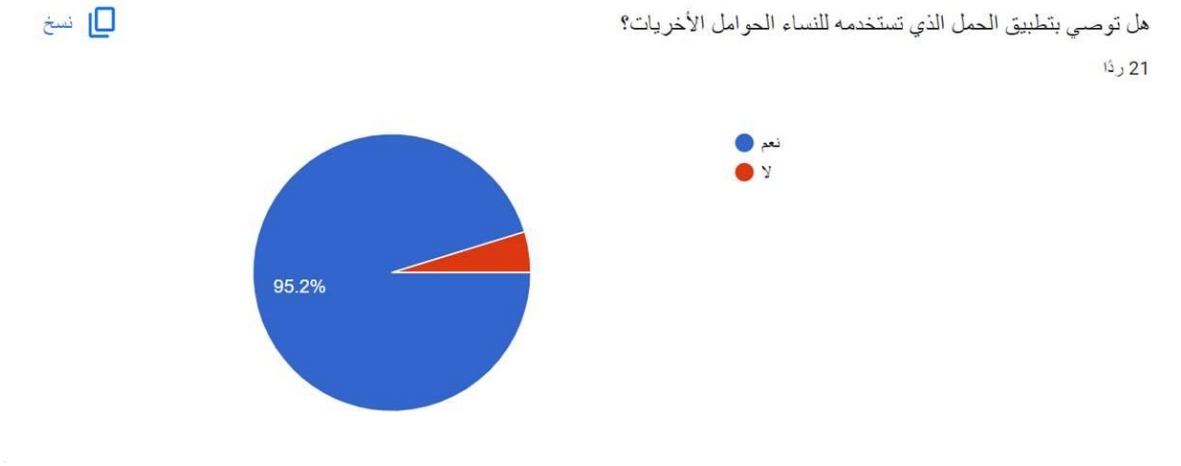

Figure 44: Users' recommendation in 9.1.1

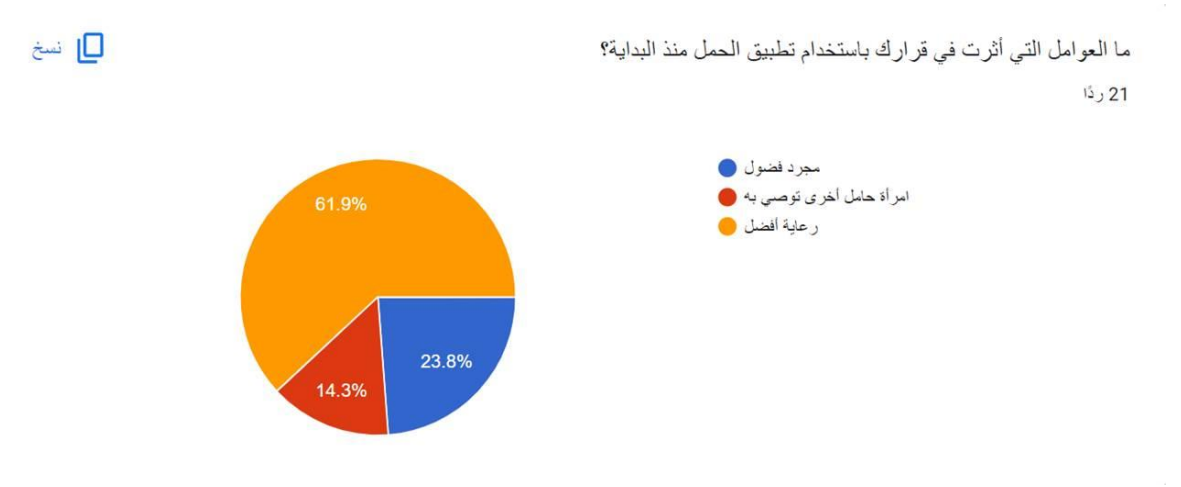

Figure 45: Users' influencing factors in 9.1.1

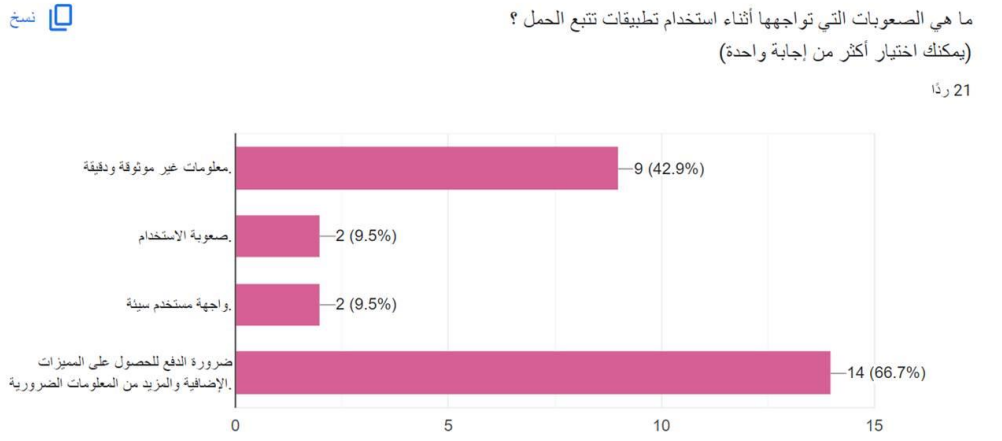

Figure 46: Users' feedback regarding difficulties of using the app in 9.1.1

- **If the answer is no here is the related questions result:**

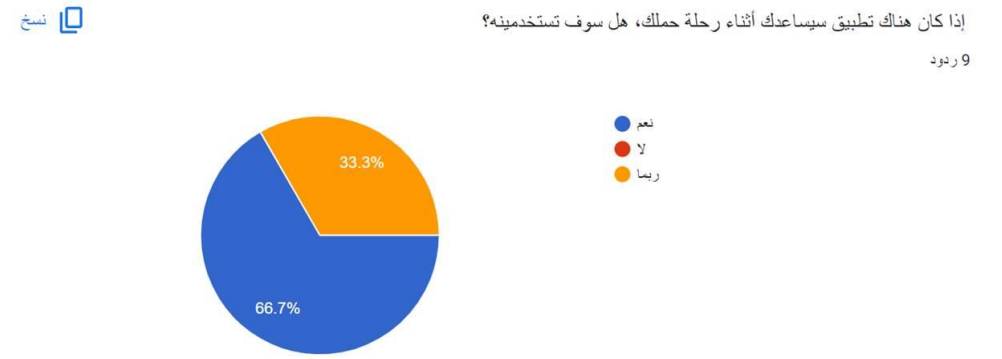

Figure 47: Users' usage of pregnancy apps in 9.1.1

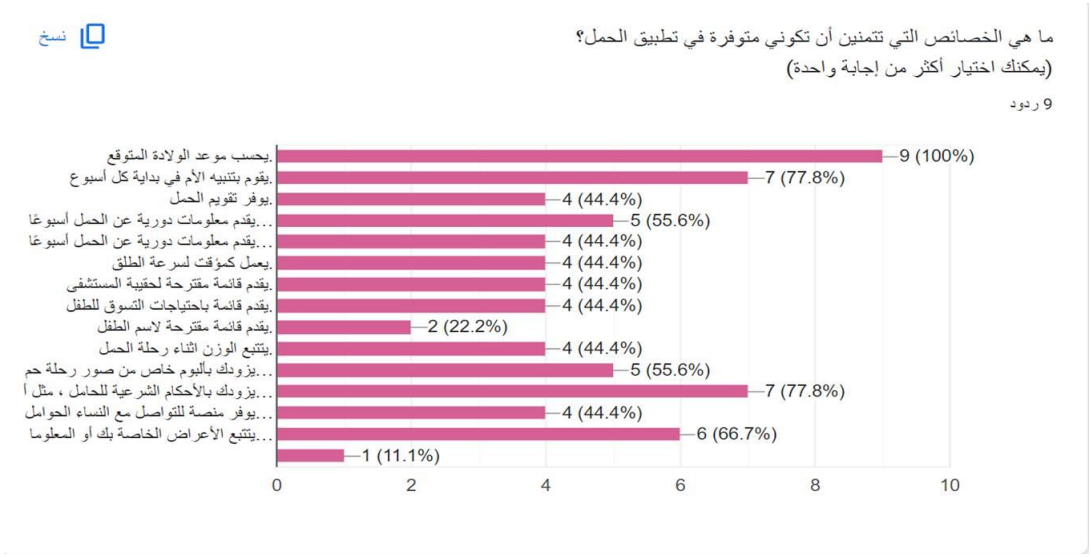

Figure 48: Users' feedback regarding most wanted features in 9.1.1

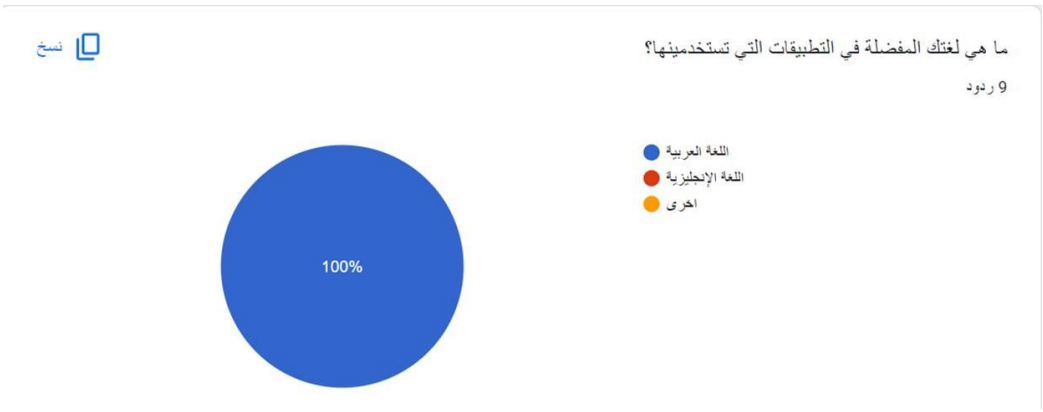

Figure 49: Users' favorite language in 9.1.1

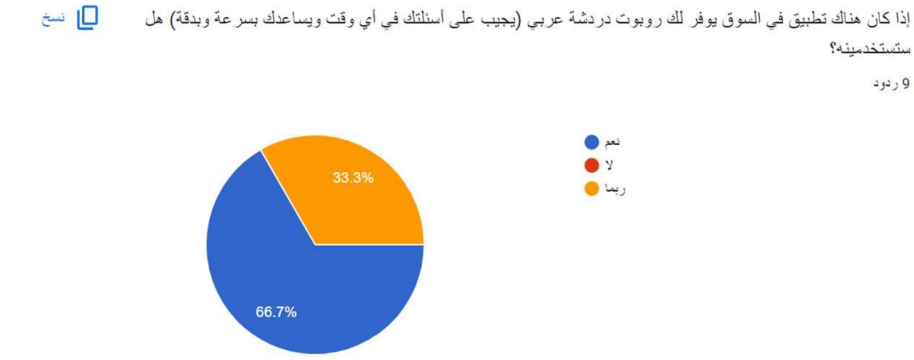

Figure 50: Users' usage of Arabic chatbot in 9.1.1

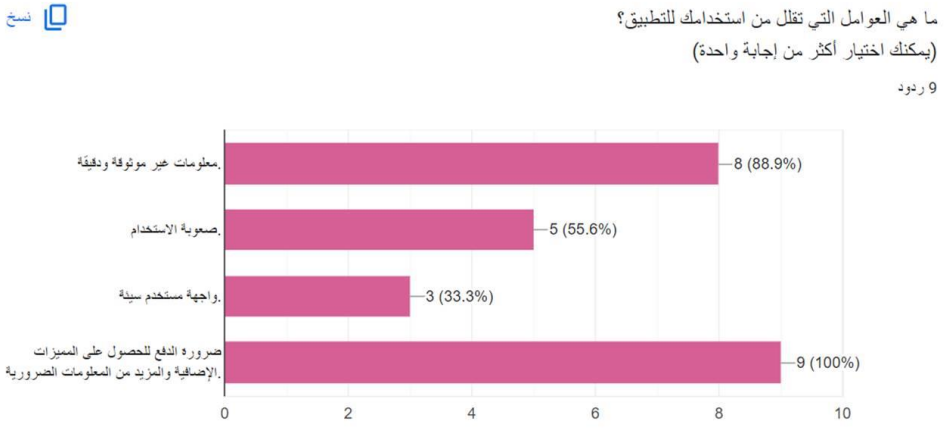

Figure 51: Users' feedback regarding the apps in 9.1.1

9.1.2 Interviews

First Interview

How old are you?
28.

Is this your first pregnancy?
No.

Have you used any pregnancy apps during your pregnancy journey? If so, which ones and what features did you find most helpful?
Yes, (تتبع الحمل).
Providing weekly information about the mother and baby
A pregnancy women community you can talk to and ask.

How did you learn about the pregnancy app(s) you used, and what factors influenced your decision to download and use them?
I figured it by myself, I needed an app that i can monitor my pregnancy.

Did you find the information and advice provided by the pregnancy app(s) to be accurate and reliable and were you able to apply it to your own pregnancy experience?
No, not really especially in community.

Did you use the pregnancy app(s) to track your symptoms, appointments, or other aspects of your pregnancy? If so, how did it help you manage your pregnancy journey?
Yes, as I said I want an app that can help me to monitor my pregnancy and manage it which it's really did.

Did the pregnancy app(s) provide any tools or resources to help you prepare for childbirth, and did you find them useful?
No.

Did you feel like the pregnancy app(s) offered personalized recommendations or advice based on your specific pregnancy journey, or did it provide generic information for all users?
I think no, I'm not sure They probably Provides general information.

If there is an application in the market that provides you with a chatbot that can answer your questions at any time, would you use it?
Yes.

Did you have any concerns or doubts about using a pregnancy app, such as privacy or security issues? How did you address those concerns?

Well, I didn't think about security part but surely I prefer that my information get secure and protected.

Would you recommend the pregnancy app(s) you used to other pregnant women, and why?
Yes, because it helps me in pregnancy.

What features or improvements would you suggest for pregnancy apps to better serve the needs of pregnant women?
I think in the community they should put rules or instructions that no one answer other without being a doctor or similar.

How did using a pregnancy app affect your overall pregnancy experience, and do you feel like it was a positive addition to your prenatal care?
Sure in good way as I said.
Yes, it was positive experience, and I would use the app again.

Second Interview

How old are you?
21.

Is this your first pregnancy?
Yes.

Have you used any pregnancy apps during your pregnancy journey? If so, which ones and what features did you find most helpful?
Yes, I have used pregnancy calculator app(حاسبة الحمل).
The most important developments for the baby and the most important changes that happen to me during pregnancy on a weekly basis.

How did you learn about the pregnancy app(s) you used, and what factors influenced your decision to download and use them?
from my friend whom she was pregnant as well, I used the app for better care during the pregnancy.

Did you find the information and advice provided by the pregnancy app(s) to be accurate and reliable and were you able to apply it to your own pregnancy experience?
not really.

Did you use the pregnancy app(s) to track your symptoms, appointments, or other aspects of your pregnancy? If so, how did it help you manage your pregnancy journey?
Yes, I did.
It helped me a lot to know what to expect and to know many things about the body changes that may occur.

Did the pregnancy app(s) provide any tools or resources to help you prepare for childbirth, and did you find them useful?
Yes, they were somewhat useful.

Did you feel like the pregnancy app(s) offered personalized recommendations or advice based on your specific pregnancy journey, or did it provide generic information for all users?
It provides generic information for all users.

If there is an application in the market that provides you with a chatbot that can answer your questions at any time, would you use it
Yes, I would.

Did you have any concerns or doubts about using a pregnancy app, such as privacy or security issues? How did you address those concerns?
No, I didn't have.

Would you recommend the pregnancy app(s) you used to other pregnant women, and why?
Yes , because the app will help them a lot during their pregnancy journey.

What features or improvements would you suggest for pregnancy apps to better serve the needs of pregnant women?
tracking weight and suggested list for baby name.

How did using a pregnancy app affect your overall pregnancy experience, and do you feel like it was a positive addition to your prenatal care?
using pregnancy app made my experience much better, and it was positive addition.

Third Interview

How old are you?
32.

Is this your first pregnancy?
No.

Have you used any pregnancy apps during your pregnancy journey? If so, which ones and what features did you find most helpful?
Yes, (حاسبة الحمل).
Providing weekly information about the fetus.

How did you learn about the pregnancy app(s) you used, and what factors influenced your decision to download and use them?
It was recommended by a friend and its interface is easy to use.

Did you find the information and advice provided by the pregnancy app(s) to be accurate and reliable and were you able to apply it to your own pregnancy experience?
No, it wasn't very accurate.

Did you use the pregnancy app(s) to track your symptoms, appointments, or other aspects of your pregnancy? If so, how did it help you manage your pregnancy journey?
No, I go to the doctor if I have any symptoms.

Did the pregnancy app(s) provide any tools or resources to help you prepare for childbirth, and did you find them useful?
No.

Did you feel like the pregnancy app(s) offered personalized recommendations or advice based on your specific pregnancy journey, or did it provide generic information for all users?
No, Provides general information.

If there is an application in the market that provides you with a chatbot that can answer your questions at any time, would you use it?
Yes.

Did you have any concerns or doubts about using a pregnancy app, such as privacy or security issues? How did you address those concerns?
No.

Would you recommend the pregnancy app(s) you used to other pregnant women, and why?
Yes, because it is easy to use and useful.

What features or improvements would you suggest for pregnancy apps to better serve the needs of pregnant women?
Providing a calendar for scheduling appointments and suggestions for baby names.

How did using a pregnancy app affect your overall pregnancy experience, and do you feel like it was a positive addition to your prenatal care?
Yes, a positive and easy experience and It gives a useful information.

Fourth Interview
How old are you?
48.

Is this your first pregnancy?
No i have 4 children.

Have you used any pregnancy apps during your pregnancy journey? If so, which ones and what features did you find most helpful?

No I didn't use applications but I visited a lot of websites that helped me but it was very confusing because moving between websites cause me dispersion.

How did you learn about the pregnancy app(s) you used, and what factors influenced your decision to download and use them?
Since I didn't use apps like I said but I search on google and I find some websites.

Did you find the information and advice provided by the pregnancy app(s) to be accurate and reliable and were you able to apply it to your own pregnancy experience?
No it wasn't accurate and reliable sadly I used to check with my doctor every time.
Did you use the pregnancy app(s) to track your symptoms, appointments, or other aspects of your pregnancy? If so, how did it help you manage your pregnancy journey?
No the websites don't have these features.

Did the pregnancy app(s) provide any tools or resources to help you prepare for childbirth, and did you find them useful?
No it didn't.

Did you feel like the pregnancy app(s) offered personalized recommendations or advice based on your specific pregnancy journey, or did it provide generic information for all users?
No.

If there is an application in the market that provides you with a chatbot that can answer your questions at any time, would you use it?
of course it will be very useful.

Did you have any concerns or doubts about using a pregnancy app, such as privacy or security issues? How did you address those concerns?
No I don't actually I'm one of the supporters of this kind of application.

Would you recommend the pregnancy app(s) you used to other pregnant women, and why?
I didn't use it so I can't recommend it.

What features or improvements would you suggest for pregnancy apps to better serve the needs of pregnant women?
calculate the weeks correctly and give advice in each week specially food advice like what to eat and what to avoid.

How did using a pregnancy app affect your overall pregnancy experience, and do you feel like it was a positive addition to your prenatal care?
As i said before I didn't use an application.

9.2 Appendix B: UAT Questionnaire

1. هل وجدت عملية التسجيل سهلة وواضحة لإكمالها، مع الحقول المطلوبة (الاسم الأول، الاسم الأخير، تاريخ الميلاد، عنوان البريد الإلكتروني، كلمة المرور)؟

- نعم، كانت سهلة جدًا.
- سهلة إلى حد ما.
- محايد.
- صعبة إلى حد ما.
- لا، كانت صعبة جدًا.

2. ما مدى دقة حاسبة تاريخ الولادة في تحديد تاريخ الولادة المتوقع؟

- دقيقة جداً.
- دقيقة نوعاً ما.
- محايد.
- غير دقيقة نوعاً ما.
- غير دقيقة على الإطلاق.

3. ما مدى دقة إجابات المساعدة أمومي على اسئلتك؟

- دقيقة جداً.
- دقيقة نوعاً ما.
- محايد.
- غير دقيقة نوعاً ما.
- غير دقيقة على الإطلاق.

4. هل وجدت معلومات الحمل الأسبوعية والمقالات الشهرية مفيدة ومليئة بالمعلومات لتتبع تقدمك خلال الحمل؟

- نعم، كانت مفيدة ومليئة بالمعلومات.
- مفيدة ومليئة بالمعلومات نوعاً ما.
- محايد.
- غير مفيدة أو غير مليئة بالمعلومات نوعاً ما.
- لا، لم تكن مفيدة أو مليئة بالمعلومات.

5. ما مدى شمولية وعملية قائمة حقيبة المستشفى للأم والطفل؟

- شاملة وعملية جداً.
- شاملة وعملية نوعاً ما.
- محايد.
- غير شاملة أو غير عملية نوعاً ما.
- غير شاملة أو غير عملية على الإطلاق.

6. هل وجدت ميزة استكشاف الأسماء سهلة الاستخدام ومفيدة في اختيار اسم لطفلك؟

- نعم، سهلة الاستخدام ومفيدة في اختيار الاسم.
- سهلة الاستخدام ومفيدة إلى حد ما.
- محايد.
- صعبة الاستخدام وغير مفيدة إلى حد ما.
- لا، صعبة جدًا في الاستخدام ولم تكن مفيدة على الإطلاق.

7. هل تمكنت من الإضافة، التعديل أو الحذف في التطبيق بسهولة وبدون مواجهة أي صعوبات؟

- نعم، تمكنت من الإضافة أو التعديل أو الحذف بدون أي صعوبات.
- لا، واجهت صعوبة في الإضافة أو التعديل أو الحذف.

8. هل ساعدتك خاصية تتبع الوزن في التطبيق في تحديد ما إذا كان وزنك طبيعي، مرتفع أو ناقص؟

- نعم.
- لا.
- ربما.

9. هل كان من السهل التنقل في التطبيق والعثور على الميزات التي كنت تبحث عنها؟

- نعم، كان من السهل جدًا.
- سهل إلى حد ما.
- محايد.
- صعب إلى حد ما.
- لا، كان صعبًا جدًا.

10. كيف تُقيم تجربتك العامة للتطبيق؟

- رائعة.
- جيدة.
- مقبولة.
- سيئة.
- لا أدري.

11. الى أي مدى أنت راضٍ عن واجهة وتصميم التطبيق؟

- راضٍ جداً.
- راضٍ متوسط.
- غير راضٍ.
- لا أدري.

12. هل هناك شيء آخر تود إضافته حول تجربتك في استخدام التطبيق؟ [رد مفتوح]