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以ｅ化健康照護系統提供周產期婦女自我管理

Utilizing e-Healthcare Systems to Empower Women to Self-management during the Perinatal Period

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Utilizing e-Healthcare Systems to Empower Women to Self-management during the Perinatal Period

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摘要

本研究主要是研發一個孕期健康管理系統，可以幫忙懷孕婦女不只在懷孕期間，甚至在產後均可提供完善的照顧，使媽媽們能掌握自己及嬰兒的健康。高品質的護理照顧對懷孕婦女來說是很重要的，在專業護理師們及研發人員討論下，本研究設計出一個不只是網站系統還可在手機執行的孕期健康管理系統。

本系統依懷孕時間可分成四大系統，第一個是產前健康管理系統，功能有孕婦的基本資料管理、孕期產檢記錄、孕婦自我健康管理記錄及衛教指導資訊，第二個是孕婦體重管理系統，功能有利用估計的方法計算出食物的熱量卡路里、孕婦體重的正常曲線範圍及健康專區包含飲食指南等，第三個是訓練拉梅茲呼吸法的工具，功能分別為文字說明拉梅茲呼吸指引、影片解說各階段操作方法、自我練習導引，可透過即時反應呼吸的波形曲線來加強練習及修正及每次的使用紀錄，最後一個是產後妊娠高血壓健康管理系統，功能有自我健康管理記錄，包含血壓、脈搏、體重、用藥紀錄等，再來是適合產後運動的教學影片，還有智慧聊天室，一些常見的問與答及衛教資訊均已建置於系統中。護理師可透過這系統的後台管理介面追踪孕婦的健康狀況，一旦健康監測值超出正常範圍，護理師會直接與孕婦聯繫，確保該婦女的健康是安全無虞的。

本研究在系統建置完成後，以問卷調查的方式進行系統滿意度評估。結果顯示，大部份的使用者對整體系統感到滿意並認為本系統對於孕期前後的健康照護有所幫助。

關鍵字:孕期照護、產後照護、妊娠高血壓、智慧醫療、跨平臺、行動裝置

Abstract

This study aimed to develop a comprehensive pregnancy health management system to assist pregnant women throughout their pregnancy and postpartum phases. It collaborated with professional nurses and researchers to create a web-based and mobile phone-executable pregnancy health management system.

The system was structured into four main components, each corresponding to a specific stage of pregnancy. The first component, the Prenatal Health Management System, encompassed various features such as managing the pregnant woman's basic information, recording maternity checkups, documenting self-health management, and offering health education guidance. The second component, the Maternal Weight Management System, included functionalities like estimating calorie intake from food, establishing a normal weight range curve, and providing dietary guidance. The third component was a tool for training Lamaze Breathing techniques. This tool explained Lamaze Breathing Guidelines through text and demonstrated each stage's operation via video. Records of practice sessions were maintained as well. The final component, the Postpartum Hypertension Health Management System, enabled self-health management recording, covering parameters like blood pressure, pulse, weight, and medication. Additionally, the system featured instructional postpartum exercise videos and a smart chat room. Nurses could monitor pregnant women's health through the system's backend management interface.

To evaluate the system's effectiveness, a questionnaire survey was conducted after system implementation. Users expressed high satisfaction with the system's capabilities, underscoring its utility in maternal health management.

Keywords: Maternity Care, Postpartum Care, Hypertension Disorders of Pregnancy, eHealth, Multi-platform, Mobile devices

誌謝

這篇論文終於完成，首先要感謝恩師—侯廷偉教授細心的教導及有耐心地一步步引導我而邁向成功的大道，在這麼多年的研究生活中，除了學業上的指導，不斷給予鼓勵與支持，讓學生可以發揮所長，貢獻在研究領域上。以及護理系許玉雲教授每每提供專業的護理諮詢，每次遇到難題時，總會適時伸出援手，解決我困惑已久的問題。此外，承蒙口試委員陳奕明教授、李維聰教授、曾紹崟博士及許任銘助理教授於論文口試時給予諸多寶貴的意見，使本論文內容更加完整，學生衷心感佩，銘記在心。

在這段漫長的研究生涯期間，特別感謝每一段研究成果的合作夥伴，實驗室的美珊學妹、政憲學弟、彥余學弟、宗霖學弟及森智學弟和我一起討論並規劃系統的建置，以及護理系的宜靜、依茜二位專業護理師提供想法，並透過多次的會議討論，促使我研究中的四個孕婦照護系統依序成形，最後可以提供給孕婦們使用。尤其是宜靜，我的第一個產前護理系統就是和她合作，那時她只是碩士生，到我的最後一個妊娠高血壓產後照護系統，還是找她合作，不過她已經是博士生了，其間給予我許多專業的諮詢，甚至我一度想放棄而休學的期間，她仍鼓勵我堅持下去，希望我可以順利畢業，最後終於順利完成系統建置並發表國際期刊成功，既然我都順利畢業了，宜靜你也可以的，繼續加油。

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List of Abbreviations

BMI	Body Mass Index
BP	blood pressure
LMP	Last Menstrual Period
HDP	hypertension disorders of pregnancy
RCT	randomized controlled trial
SBP	systolic blood pressure
DBP	diastolic blood pressure
SNAP-HT	Self-Management of Postnatal Hypertension
TASMIN	Telemonitoring and Self-Management in Hypertension
ACS	Antenatal Care System
SAPMS	Smart ASHA Pregnancy Monitoring System
POP- HT	Physician Optimised Postpartum Hypertension Treatment
SSL	Secure Sockets Layer
TLS	Transport Layer Security

Chapter 1 Introduction

1.1 Background

In recent times, smart mobile devices have become integral to people's everyday lives, leading to a rapid surge in their applications [1][2]. The eHealth pertains to providing healthcare services through internet or web-based systems and information technology [1]. Furthermore, smart devices have emerged as a crucial tool for enhancing health education and communication between patients and medical professionals [3]. The Global Observatory for eHealth, a division of the World Health Organization, characterizes mHealth as the utilization of mobile devices to enhance medical and public health practices [4].

In 2020, each day saw the loss of approximately 800 women's lives due to avoidable factors related to pregnancy and childbirth [5]. Enhancing maternal self-efficacy through prenatal education can help alleviate the stress and anxiety commonly felt during pregnancy [6][7]. Offering comprehensive and supportive prenatal education can empower women to effectively cope with these challenges [8]. For more than ten years, obstetric hospitals in Taiwan have extensively relied on paper-based maternity health records. In this system, each expectant mother receives a Maternal Health Booklet, a physical document outlining her maternity health information [9].

Many research studies also show that excessive pre-pregnancy weight or obesity, as well as excessive or insufficient weight gain during pregnancy, can have an impact on both the mother and the fetus, leading to complications such as hypertensive disorders of pregnancy and an increased risk during childbirth [10][11]. Healthcare providers should guide expectant mothers to maintain their weight within the optimal range, avoiding both overweight and underweight conditions. The Institute of Medicine (IOM) in the United States released new

guidelines on pregnancy weight gain in 2009. They recommend that women with a BMI (Body Mass Index) below 18.5 before pregnancy should gain 12.5-18.0 kilograms during pregnancy. For women with a normal BMI (18.5-24.9), the recommended weight gain is 11.5-16.0 kilograms. Those with a higher BMI (25.0-29.9) should gain 7.0-11.5 kilograms, and women with a very high BMI (>=30.0) should gain 5.0-9.0 kilograms during pregnancy [12].

Natural childbirth is widely regarded as the preferred method for pregnant women. Nevertheless, the primary concern revolves around pain, leading to a fear of delivery in 74% of pregnant women [13]. The loss of bodily control and fear of the unknown significantly influence how pregnant women perceive pain. Moreover, these factors also impact their overall pain perception [14]. If women receive education on prenatal pain management, which enhances their self-efficacy and diminishes the perception of childbirth pain as a negative event, they are more likely to cooperate with the labor process. Currently, prenatal education programs encompass teachings on alleviating and managing labor pain through non-pharmacological methods.

There is a growing focus on postnatal care, driven by increasing evidence highlighting the risk of recurrent pregnancy induced hypertension in future pregnancies [15]. Pregnancy-related hypertension disorders are common conditions that affect the well-being of both expectant mothers and their infants. HDP (Hypertension disorders of pregnancy) accounts for approximately 5-10% of pregnancies and is the most common complication of pregnancy [16]. In recent years, there has been a slow increase in its occurrence. It ranks as the third major cause of maternal mortality during the perinatal period, following only postpartum hemorrhage and infections. HDP can occur during the prenatal, intrapartum, and postpartum periods, with a higher occurrence in the late stages of pregnancy (last 10 weeks) [17] [18] [19]. Research findings indicate that 10% of maternal fatalities in the postpartum period are

linked to HDP [20]. Most maternal and neonatal deaths happen in the initial postpartum period [21].

1.2 Motivation

This study will digitalize prenatal and postnatal health education through a professional nursing team, allowing pregnant women to access and use the information at any time. We primarily aim to design a self-management system for pregnant women with high-risk pregnancies, supplemented by charts, allowing them to operate it at home. High-risk pregnancies include conditions such as hypertensive disorders of pregnancy and gestational diabetes.

At every antenatal check-up, healthcare providers such as obstetricians or nurse-midwives update the woman's health records, including information about the received antenatal care [22]. Each woman is then provided with a copy of her individual prenatal checkup records. Despite their utility, paper-based records suffer from various drawbacks, such as limited accessibility, inefficient record management, susceptibility to loss, and the potential for incomplete data.

There are many applications on the market related to personal weight and diet management [23] [24]. However, these apps are generally designed with a focus on controlling diet to achieve body shaping effects, which is slightly different from the principle for pregnant women who can only control their weight, not reduce it, during pregnancy. Additionally, in terms of daily diet recording features, although these apps provide a substantial food database for users to choose from, they often present the information purely in text form. This makes it difficult for non-nutritionist average users to accurately obtain the calorie content of the food they consume, increasing the hassle of recording.

In methods of reducing pain during childbirth, Lamaze breathing stands out as a widely

adopted strategy for pain relief in clinical settings [25]. The Lamaze breathing technique is recognized and accepted by the most obstetric healthcare professionals, being regarded as a safe and effective method.

Unfortunately, the postnatal period often receives inadequate attention in terms of providing high-quality services [26]. Inadequate care during this crucial time can result in severe health complications and, in some cases, even fatal outcomes [27]. Mothers to supervise their BP everyday and adopt healthy habits to promote their own well-being. This proactive approach can effectively prevent or minimize the risk of postpartum hypertension [28].

1.3 Approach

Electronic Maternity Records (EMRs) belong to the category of Electronic Health Records (EHRs) specifically designed for maternal care. Medical information is stored in collections of records and health-related data managed by different healthcare professionals or organizations. These collections consist of personalized records and are maintained within hospital systems [29]. As mobile environments and various eHealth technologies continue to expand, the possibilities for eHealth are growing [30] [31] [32] [33].

In this research, we designed and implemented a multi-platform personal perinatal care information system which contains an electronic maternity record. The proposed system has been given a name PregnantMomCare. This system is divided into four subsystems based on the period before and after childbirth and their functionality, and it can solve the problems mentioned earlier.

The initial component is the PrenatalCare system. It allows expectant mothers to effortlessly access their maternal health records, obtain information related to pregnancy and antenatal education, and monitor their baby's growth. This system offers comprehensive

antenatal care, supporting pregnant women in receiving enhanced prenatal services and in achieving optimal health throughout their pregnancy. It is designed to enable pregnant women to actively manage and oversee their own health.

Next is the MomweightCare system, a specialized diet and body weight management system tailored specifically for expectant mother and new mothers. Unlike generic applications focused on weight control and body sculpting, MomweightCare is uniquely crafted to cater to the distinct needs of women during pregnancy and post-childbirth, ensuring personalized support for their health and well-being.

Folowing that is the SPBIL App. We have integrated smart devices with Lamaze breathing techniques to create a breathing method application specifically for prenatal care. This application breaks free from the clinical passive, single-source medical information model. It allows women to practice and review breathing techniques at any time, enhancing their familiarity with these methods. This proficiency can be instrumental during childbirth, helping to alleviate labor pains.

Finally, there is the PostpartumCare System.This system enables these women to monitor their health with the guidance of healthcare professionals. The key features of this system include:

(1) Graphical Representation of Health Metrics.

(2) BP Trends Visualization.

(3) Live Exercise Instructional Videos.

(4) Medication Record Management.

(5) Interactive Intelligent chatroom.

(6) Up-to-Date Health Education Resources.

It provides graphical representations of daily changes in BP, pulse, and weight, showing recommended ranges for easy interpretation. Users can view their BP trends over a

customizable period (ranging from 7 to 90 days) through a statistical pie chart, allowing them to choose their preferred date range. Postnatal women have access to live exercise instructional videos tailored to their needs, promoting physical activity and overall well-being. Women who require hypertension medication can manage their medication records efficiently within the app. Users can engage in an interactive chat room where they can ask questions, with preset answers provided for common queries. The application offers access to current postnatal health education resources, available at any time, empowering users with valuable information for their well-being.

Chapter 2 Related works

2.1 Previous works

With the rapid development of information technology, new advancements have been brought to traditional healthcare methods. Since 1999, discussions and emphasis on eHealth issues have been growing. According to the definition given by Eysenbach [34], “eHealth is an emerging field that combines medical information, public health, and business, using the internet and related technologies to enhance the delivery of healthcare services and healthcare information. Broadly speaking, the characteristics of eHealth are not only technological development but also a mindset, approach, and commitment to using information and communication technology to improve local, regional, and global healthcare and to foster a global networked thinking.”

The User Interface (UI) refers to the communication medium between humans and computer systems. It serves as the "control interface" for users to interact with the system and the "communication interface" through which the computer system responds [35] [36]. The UI can be presented through simple commands, menu lists, or graphical elements (Graphical User Interface, GUI).

The prevailing trend in the healthcare sector involves connecting patients, physicians, and hospitals to ensure optimized care for all individuals. Emphasizing preventive care over curative medicine can lower costs, enhance treatment quality, and foster knowledge exchange with physicians. Numerous studies in the literature delve into the design and implementation of medical expert systems, detailing these approaches [37].

The integration of body weight loss and management into eHealth is prevalent, but most existing applications fall short in terms of user-friendliness and clarity in presenting their features and functions. At present, numerous mobile applications have been created to

support weight loss initiatives [38]. Howerer, there are limited applications designed to help pregnant women maintain their ideal body condition [39]. Additionally, it is crucial for pregnant women to maintain a balanced diet and engage in regular exercise [40].

In the year 2000, Lamaze International emphasized the use of 'self-aware controlled breathing' along with other comfort strategies such as massage to help women relax their bodies and minimize excessive medical interventions during childbirth [41]. Through Lamaze International, we can gain a clearer understanding that while the content of the Lamaze method has evolved since its inception, its essence remains unchanged, emphasizing self-aware controlled breathing to achieve body relaxation and alleviate the pain of childbirth. Furthermore, research indicates that expectant mothers consider it most helpful during childbirth when birthing partners and nurses can offer breathing relaxation techniques and provide emotional support as needed [42].

Previous studies indicate that consistently elevated BP six weeks after a hypertensive pregnancy is linked to a significant rise in BP over the subsequent 5 to 10 years [43]. A novel self-management intervention was developed from the TASMIN (Telemonitoring and Self-Management in Hypertension) self-management trials [44][45], for use by women, with medicated HDP, postpartum. This trial sought to assess the viability of implementing this intervention and conduct an initial evaluation of its effectiveness in controlling BP. Nevertheless, in the absence of intervention, BP instability persists in as many as 50% of women for several months following a hypertensive pregnancy [46].

2.2 Related research

Some studies have focused on websites or Apps related to pregnancy health management, covering both prenatal and postnatal periods, all designed for the well-being of pregnant women. We divided it into prenatal and postnatal systems for discussion.

Therefore, we found two similar studies in the prenatal care system, the data is as follows:

First, Tamar Krishnamurti *et al.*, developed and put into operation the MHP (MyHealthyPregnancy App) tailored for expectant mothers [45]. This system was to develop a personalized mobile app medical communication tool from a behavioral decision-making research approach to assess and communicate pregnancy risks associated with preterm birth. The preterm birth rate in the United States continues to rise. It aimed to design a prospective study to develop a user-friendly mobile application with the goal of reducing preterm birth rates in challenging patient populations. Sixteen participants were recruited from an outpatient clinic, each provided with a smartphone preloaded with the application. Participants were required to respond to daily inquiries assessing behaviors, emotions, and symptoms related to preterm birth risk. Additionally, monthly phone interviews were conducted to gather feedback on the App's usability.

Second, Nandakishor D Valakunde *et al.*, designed the SAPMS (Smart ASHA Pregnancy Monitoring System) [46]. This system was developed in India, where the Maternal Mortality Rate is significantly higher than in developed countries. The World Health Organization (WHO) recommends that pregnant women in developing countries should have at least four prenatal health check-ups in medical facilities to ensure safety and health. The purpose of the SAPMS is to digitize the work of healthcare personnel in underprivileged areas. The goal of this digitization effort is to decrease maternal mortality rates by empowering healthcare professionals to monitor the pregnancy status of women in their areas more effectively and efficiently, utilizing smartphones as a tool.

Next is the postnatal system. We also listed two studies in the postnatal system of our research, as explained below:

First, Kitt and colleagues introduced a study known as POP-HT (Physician-Optimized Postpartum Hypertension Treatment) [47]. This innovative study aimed to investigate

whether self-care of postpartum BP could result in substantial enhancements in BP regulation over the 6-9 months following childbirth, especially for women who had experienced hypertension during pregnancy. The POP-HT trial utilized a smartphone app to aid individuals in managing their BP after childbirth, with physicians monitoring medication adjustments as needed, marking a significant advancement in postpartum hypertension care.

Second, Cairns and colleagues conducted a investigation into mother's experiences with a postpartum hypertension treatment [48]. Their pilot RCT (randomized controlled trial), known as SNAP-HT (Self-Management of Postnatal Hypertension), targeted postnatal women with medicated pregnancy induced hypertension or pre-eclampsia. The study adopted a mixed methods approach, utilizing semi-structured interviews that integrated qualitative and scored (quantitative) components. Participants were randomly allocated to either the standard care group or the BP self-management group. The self-management intervention included daily BP monitoring at home and automated medication adjustments facilitated through telemonitoring. This method empowered women after childbirth, granting them a sense of control and reducing related anxiety.

2.3 Mobile Website Programming Language

In the entire system, we utilized HTML5, jQuery and PHP on the frontend to present the interface to users. Users input data through the program, which is then sent to the backend database. When users query data, it is retrieved from the database and transmitted back to them.

2.3.1 HTML5

HTML5 [49] is the latest revision of the Hypertext Markup Language (HTML) standard,

completed by the World Wide Web Consortium in October 2014. Broadly speaking, HTML5 comprises three components: HTML, Cascading Style Sheets (CSS), and JavaScript.

With the widespread availability of the internet and enhanced computer performance, people's online habits have shifted from using software to play multimedia or run games locally to streaming multimedia and playing web-based games online. To accommodate this trend, HTML5 introduces new functional elements such as <video> and <audio>... etc. Additionally, HTML5 has eliminated some outdated tags used purely for visual effects, replacing them with CSS. The development of applications on smart mobile devices using HTML5 has also had a significant impact. Applications developed with HTML5 have the following characteristics compared to native applications: (1) They can be used across different platforms with the same version, resulting in lower development time and costs; (2) When native applications encounter programming issues or require system updates, modifications and waiting for approval from various app stores are necessary before they can be downloaded and used. In contrast, web-based applications developed with HTML5 can be instantly updated with modifications; (3) These applications are not restricted by the executing device, can be quickly searched and accessed online without the need for downloading and installing steps, and can bypass hardware limitations, making them relatively easy to promote.

2.3.2 jQuery

jQuery [50] is open-source software, serving as a cross-browser JavaScript library, also known as a JavaScript framework. It allows developers to create complete web page effects with minimal JavaScript programming. This is the essence of jQuery's design philosophy: “Write Less, Do More.” Consequently, jQuery can quickly assist developers in performing the following tasks: (1) selecting page elements; (2) dynamically changing page styles; (3)

dynamically modifying page content; (4) controlling response events; (5) providing basic web page effects; (6) extending the JavaScript core.

jQuery Mobile is a JavaScript extension library based on jQuery and jQuery UI. It is composed of JavaScript, CSS, and related image files. Its goal is to support various mobile device browsers, and through a variety of extensions (Widgets), present content in a way that closely resembles native applications. This includes features like tool buttons and form controls. jQuery Mobile offers consistent visual design, support for most mobile devices on the market, a robust theming system, support for both mouse and touch events, and adaptability to any mobile device screen width.

2.3.3 PHP

PHP (Hypertext Preprocessor) [51], which can be combined with HTML5 as mentioned above, is a server-side web programming language. Due to its ease of learning and use, and its incorporation of the strengths of languages like C, Java, Perl, and others, PHP has become one of the primary languages for developing large-scale web applications.

Originally developed in 1994 by a programmer named Rasmus Lerdorf, PHP was created as a language to replace personal web pages developed with Perl scripts. Initially, it was a collection of CGI programs primarily used to display Rasmus Lerdorf's resume and track website traffic.

PHP has a wide range of applications, particularly in web development. Generally, PHP runs on web servers, generating web pages for users to browse by executing PHP code. It can run on most servers and operating systems, and using PHP is entirely free.

Chapter 3 System design

The purpose of this system is to create a health system tailored for expectant mothers, enabling them to self-care conveniently at home. Based on the literature, two key factors for developing a BP and pregnancy management system are discussed: usefulness and ease of use. The significance of this system is that users can conveniently and easily record with these tools and pregnancy management and access related pregnancy information without being restricted by time, location, or device. We would utilize the following methods for system design.

3.1 Agile Software Development

Basicly, the spirit of Agile development lies in shorter development cycles (based on iterative development methods) and incremental development and delivery. In other words, the results of the project, including the program, the details of the requirements, the design, etc., will be gradually completed as the project progresses, rather than having all the programs and requirements finalized at the beginning. The system adopts Rapid Application Development (RAD), primarily emphasizing shorter and iterative development cycles, as well as progressive development and delivery. This approach resembles iterative development, where programming commences without having gathered all the requirements in full detail. It makes software development faster and more adaptable to changing requirements.

The iterative development process means that the entire workflow, including requirements gathering, analysis, design, programming, and testing, is completed in a single cycle. In execution, the process is subdivided into iterations with minimal planning, meaning it is broken down into individual mini-projects. The execution process resembles a small-

scale waterfall project. Each iteration produces a result, and this cycle is repeated until a final product is created. The advantage of iterative development is that development work can begin before all requirements are fully collected. Through feedback, the requirements are refined, and a new iteration begins. As the project progresses, the requirements are gradually collected and the process is repeated until a system product that satisfies the requirements is completed [52].

Features of Agile Development：

(1) Personal and Interactive: People and interaction are more important than process and tools. It is very important to build a cooperative team with good interaction and communication.

(2) Working software: The working software available is heavily weighted towards detailed documentation. Files take effort to maintain, but quickly become obsolete.

(3) Customer Collaboration: Working with customers to get useful feedback is more important than contract negotiation.

(4) Responding to change: Responding quickly to change at any time is more important than following a plan.

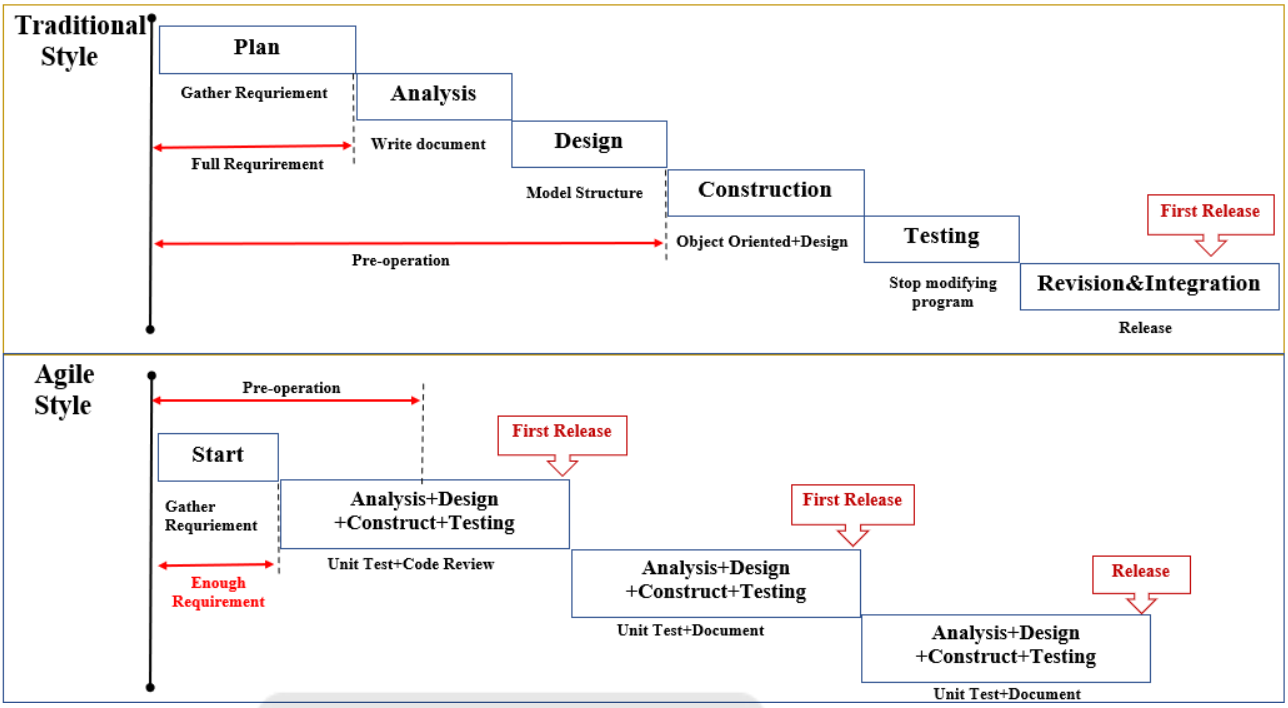

Figure 3.1 Traditional Style VS Agile Style [52]

3.2 Progressive Web App

PWA (Progressive Web App) is a concept initially introduced by Google. When users operate a specific application on their mobile phones, they typically need to download and install the App first. However, PWA eliminates this step, as it does not require app installation. Users can simply access it through a web browser with minimal configuration. Without a doubt, it offers users a superior web browsing experience. Compared to traditional apps, PWAs do not require installation, do not take up storage space on the mobile device, and do not need frequent updates. This allows users to directly run web applications on their mobile devices to manage women's pregnancy health, self-monitoring, and subsequent data organization and analysis.

PWA has the following three advantages:

(1) Linkable: It behaves like a native application but is still a website. You have the ability to follow links on the page, and you can also share the website with others by distributing

the URL.

(2) Progressive: Constructing the most streamlined framework on the most limiting platforms, starting with a design that includes only the essential content, and gradually expanding the design layout as limitations of the platform are progressively addressed, resulting in increasingly complete content.

(3) Responsive: Responsive web design is also applicable to Progressive Web Applications (PWAs) since they are primarily designed for mobile devices. With a plethora of devices equipped with browsers, ensuring that a website can be accessed across various screen widths, screen sizes, and pixel densities becomes particularly important.

Currently, common mobile device development methods can be broadly categorized into three types according to development: Native App, Web App, and Hybrid App. According to the types and characteristics, they are organized in Table 3.1.

Table 3.1 Comparison Table of Mobile Apps

	Native App	**Web App**	**Hybrid App**
Development	Java for **Android** Swift, Object-C for **iOS**	HTML5, CSS3, JavaScript, JavaScript Bridge	Depending on the requirements, decide whether the page development is native or web
Advantage	Fast execution speed	1. Cross-platform (Web, App in the same set) 2. Available Web standard technology development	Web App retains some of its cross-platform capabilities, leaving the high-computing demands to be handled by a Native program
Disadvantage	1. No cross-platform capability. 2. Must learn a proprietary language 3.High development cost	1. Limited API functionality 2. Slower than native (can't use without internet)	1.Complicated implementation structure 2. High threshold of integration technology

The subjects of this study are pregnant women during the prenatal and postnatal periods. To ensure the system's accessibility at any time and place, it must possess cross-platform capabilities to increase its universal applicability. Furthermore, they can utilize various devices equipped with web browsers, such as desktop computers, laptops, tablets, and smartphones, to access an online database, record, or retrieve individual health histories.

3.3 System Architecture

Figure 3.2 illustrates the architecture of the proposed system, showcasing the components of the PregnantMomCare System. Users utilize various devices (smartphones, tablets, computers) to send requests to this server system via the Internet. The system processes the requests, generates results, and responds back to the users based on the request content. Access and control over personal information were exclusively granted to the pregnant woman upon logging into the system. Conversely, an authorized Nurse-midwife possessed the ability to access and oversee the data of all users. Typically encompassing a web application server and a database, the system enabled a pregnant woman to begin utilizing its features once her pregnancy had been verified by an obstetrician.

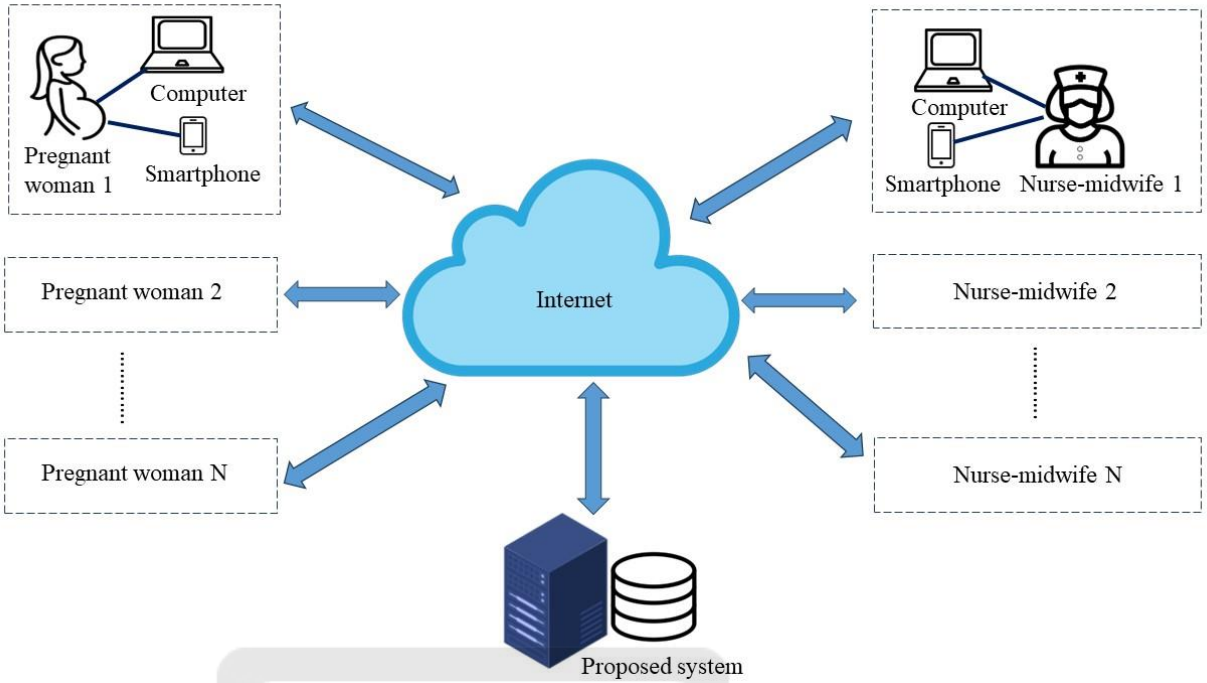

Figure 3.2 The architecture of proposed system

3.4 Use Case Diagram

Figure 3.3 displays the graphic representation of the PregnantMomCare System. Pregnant women need to log in to their accounts before using this system. After logging in, they can access the system through desktop computers or smart mobile devices equipped with browser software. First, there is PrenatalCare System. This system not only records detailed personal pregnancy and childbirth information but also provides functions such as Prenatal checkup record, Self-care Journal, and Health Education. The second one is MomweightCare System, which offers features like calorie estimation, weight curve, health Area, and a very practical tool - the SPBIL App. This App can be used for practicing Lamaze breathing, featuring instructional videos and self-practice capabilities. Finally, there is PostpartumCare System. Many people are unaware that postpartum care is equally important. Proper care can help prevent long-term complications.

Midwives had full access to the system's functions, enabling them to fetch and administer a range of data, such as personal details and self-care journals, for the expectant mother under their supervision. This capability significantly enhanced the midwives' ability to supervise the health status of these expectant mother.

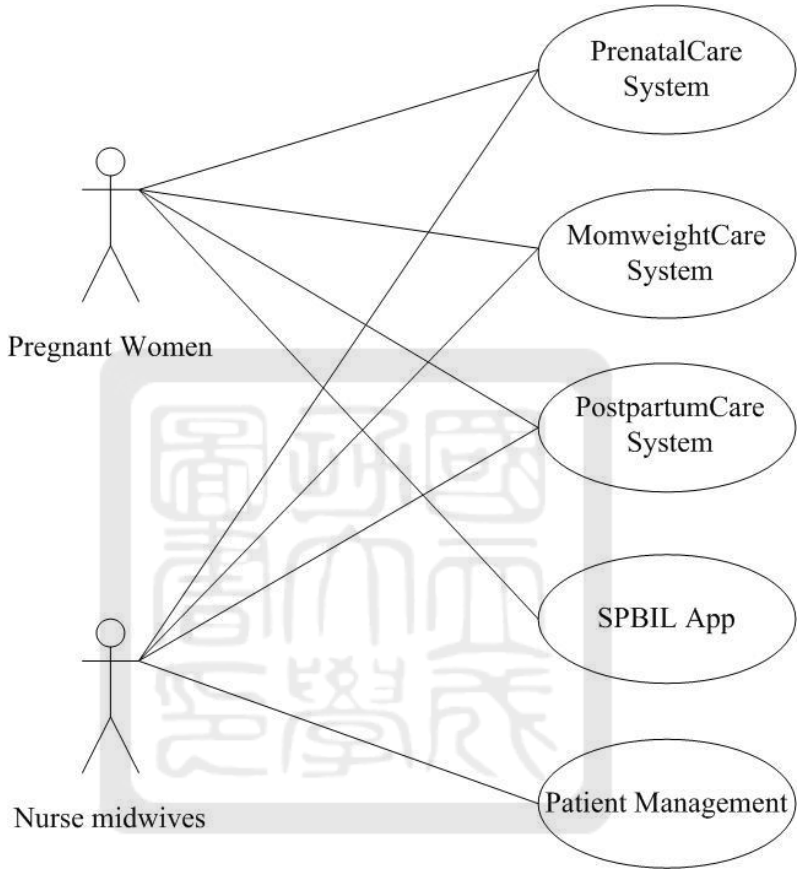

Figure 3.3 Use case diagram

3.5 System Exchange Process

This section introduces the architecture of the entire information exchange system. Users employ various types of devices (smartphones, tablets, computers) with web browsers to send web requests over the Internet to a web server. The web application server then executes tasks based on the request content, processes to generate result pages or request remote services, and responds to the user.

Figure 3.4 outlines the procedure for retrieving data from the database on the proposed server. Initially, an AJAX [53] request is made to gather data from PregnantMomCare. Afterward, the obtained data is transformed into JSON [54] format and sent to a cross-platform device. The application on the device then interprets the data format of JSON and displays it to the user.

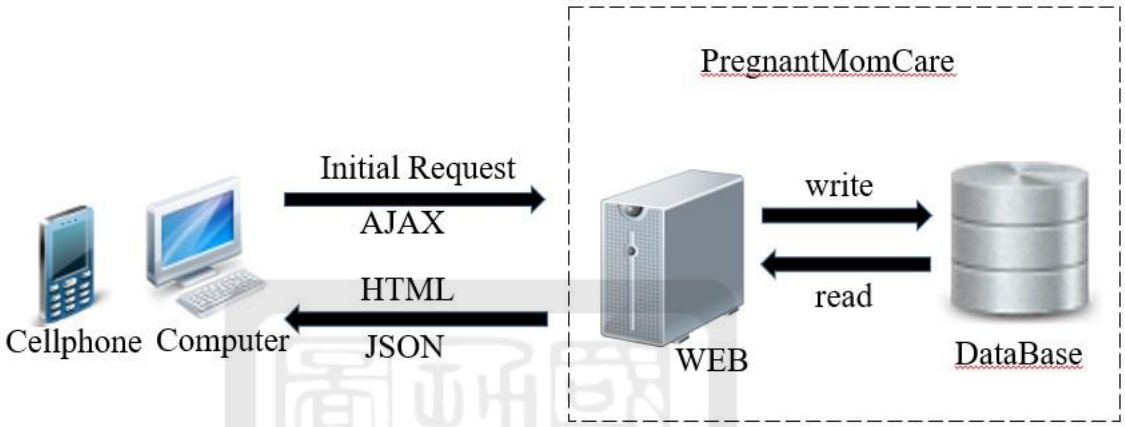

Figure 3.4 Data exchange process

3.6 PregnantMomCare System

PregnantMomCare system was structured into four main components, each corresponding to a specific stage of pregnancy which is presented in Figure 3.5. The first component, the PrenatalCare System. Mother-to-be can utilize various tools on the system, such as prenatal checkup records, self-care logs, and baby birth records, and health education. The second component, the MomweightCare System, included functionalities like estimating calorie intake from food, establishing a normal weight range curve, and providing dietary guidance. The third component was a tool for training Lamaze Breathing techniques. The ultimate component, the PostpartumCare System, facilitated autonomous health monitoring and recording, encompassing factors such as BP, pulse, weight, and medication. Moreover, the system included postpartum exercise videos and an intelligent chat room.

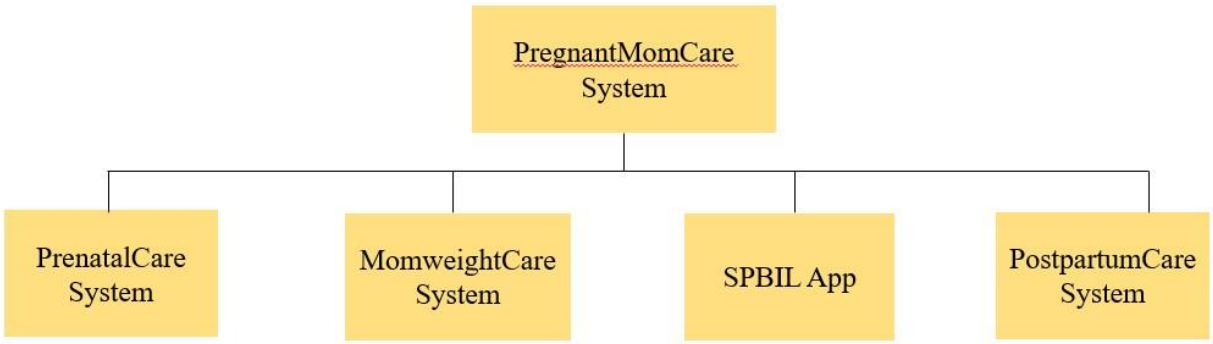

Figure 3.5 Components of PregnantMomCare System

3.6.1 PrenatalCare System

Pregnant women have the capability to input, retrieve, and modify their personal details, prenatal checkup records, self-care logs, and birth records. Midwives possess comprehensive system access, allowing them to both access and oversee all aspects of the pregnant women information. Furthermore, they can supplement or modify these expectant mothers' prenatal checkup records and access specific access logs to gain insights into patient behaviors, which is presented in Figure 3.6.

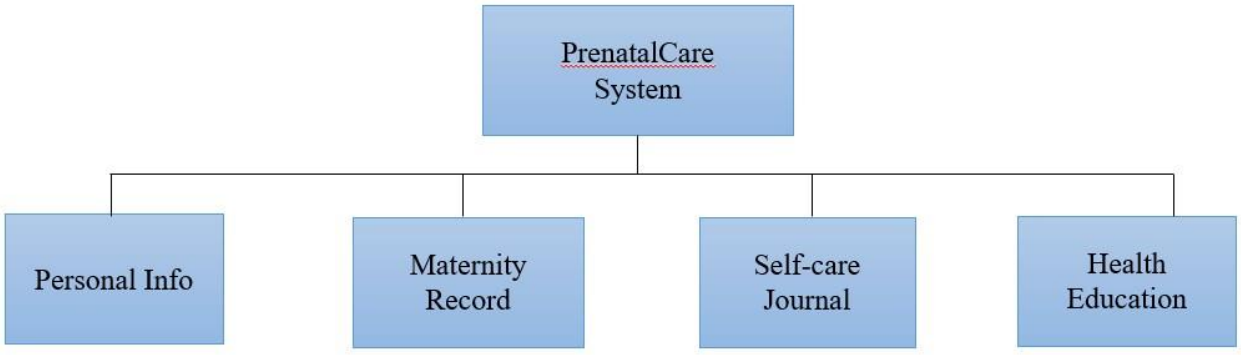

Figure 3.6 Features of PrenatalCare System

3.6.2 MomweightCare System

The MomweightCare System calculates total calorie requirements for pregnant women based on their area and unit calories. It presents visual graphs of weight fluctuations during pregnancy and childbirth, accompanied by the suggested range of weight gain for enhanced user comprehension. Additionally, it provides personalized advice on weight and diet management during pregnancy, as illustrated in Figure 3.7.

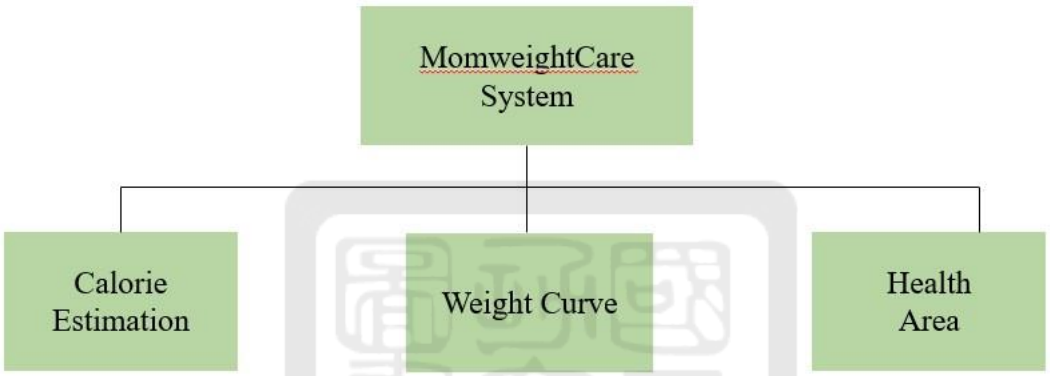

Figure 3.7 Features of MomweightCare System

3.6.3 SPBIL App

The SPBIL App starts with a written explanation of the Lamez breathing technique for pregnant women, followed by a video demonstration illustrating the correct way to perform it. Using the app along with a microphone, pregnant women can simulate the breath waveform in real-time to refine and correct your exercise technique, and ultimately, they can record each exercise, which is presented in Figure 3.8.

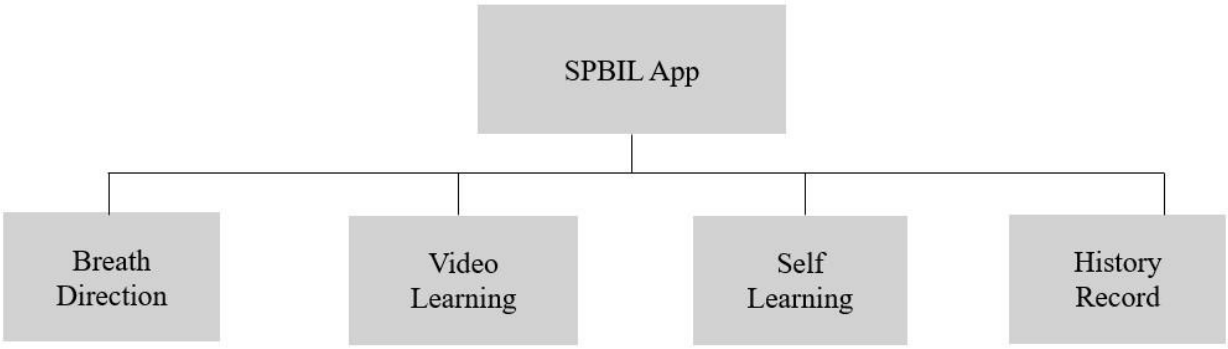

Figure 3.8 Features of SPBIL App

3.6.4 PostpartumCare System

The PostpartumCare System is presented in Figure 3.9. It showcases a visual representation of day-to day changes in BP, pulse, and weight, complete with recommended optimal ranges for these metrics, aiding user understanding. The system also provides a live instructional exercise video for postnatal women to follow, enhancing their fitness routines. Moreover, it incorporates a intelligent chatroom where postnatal women can pose questions, supported by automatic and intelligent response features.

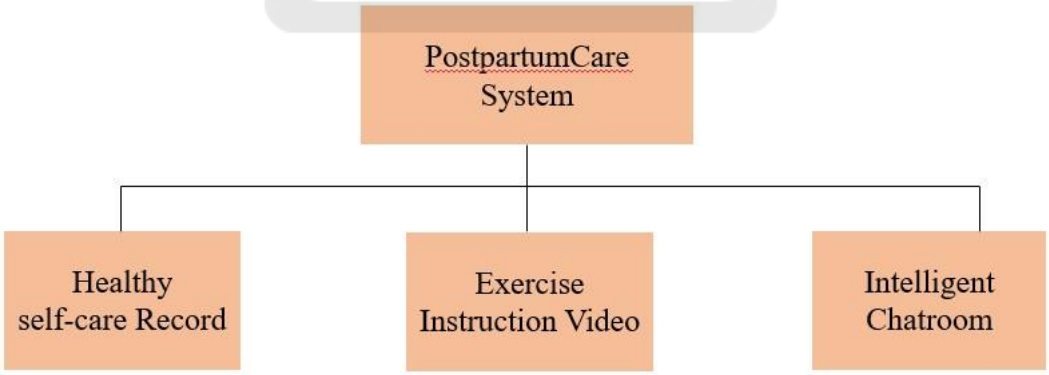

Figure 3.9 Features of PostpartumCare System

Chapter 4 Implementation

According to the system architecture proposed by this research method in this article, the system is implemented using the Apache Http Server software to set up a web server, and the database is built using the MySQL software, which is a relational database. Additionally, the system's communication between different layers is achieved through web programming in the front-end programming language PHP. Furthermore, to address cross-platform and cross-browser user interface execution issues, HTML5, CSS3 and jQuery Mobile were chosen for developing the user interface for presenting web pages [55].

Ensuring data security is of paramount importance in internet systems. To establish a secure encrypted connection between the server and the client, we implemented HTTPS. For secure data transfers, we utilized OpenSSL, an open-source implementation that supports SSL (Secure Sockets Layer) and TLS (Transport Layer Security) protocols.

4.1 PrenatalCare System

The web-based system's "Home" page, depicted in Figure 4.1, serves as the primary interface to present relevant antenatal health education topics to expectant mothers. Given the extensive range of antenatal care subjects, the system automatically curates appropriate topics based on a pregnant woman's Last Menstrual Period (LMP). Therefore, the pregnant woman is prompted to enter her LMP during her initial use of the system. Upon inputting her LMP, the system calculates her due date and provides information on fetal development.

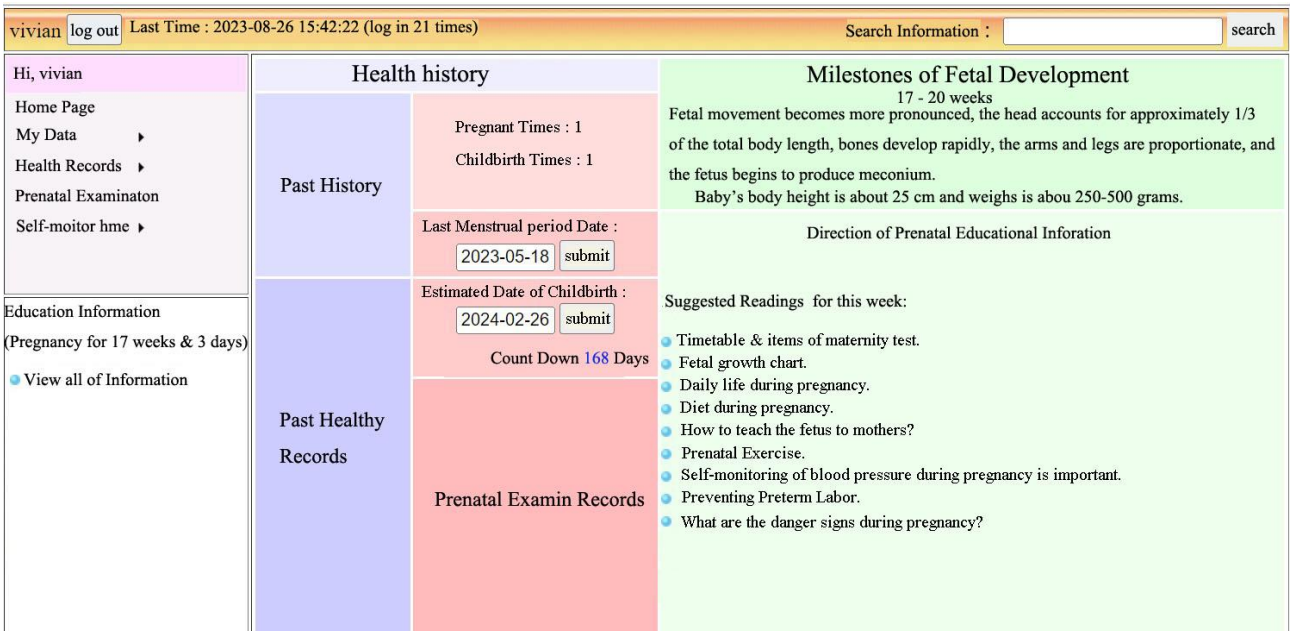

Figure 4.1 Home page of PrenatalCare System

This system provides four self-monitoring tools for recording pregnancy-related health information. These four tools are as follows: maternal weight record (as shown in Figure 4.2), BP tracking (as shown in Figure 4.3), fetal movement monitoring (as shown in Figure 4.4), and uterine contraction records (as shown in Figure 4.5).

Figure 4.2 shows the user interface of the weight tracker of our system. The weight tracker allows a user to record her weight change during pregnancy. Her weight gain record will be displayed as a table on the bottom of the screen.

Figure 4.2 Weight record interface

By using the blood pressure tracker, a user can save her blood pressure during her entire pregnancy as shown in Figure 4.3.

Figure 4.3 BP record interface

A kick counter is also implemented to track fetal movements in the system. The user interface of the kick counter is shown in Figure 4.4.

Figure 4.4 Fetal movement record interface

Figure 4.5 depicts the user interface of the contraction tracker. It allows a mother to observe and determine if a contraction is regular whenever one occurs.

Figure 4.5 Uterine contraction record interface

4.2 MomweightCare System

The System offers three key features: (1) Weight Curve: This module allows users to manage weight measurements and automatically assess whether the weight falls within the recommended pregnancy weight range according to medical guidelines. Through the presentation of a curve graph, users can swiftly understand their individual weight status. (2) Calorie Estimation: This module configures diverse food databases based on various dietary contexts and provides users with an auxiliary calorie estimation function. It enables users to quickly manage and record their meals. (3) Health Area: This module provides relevant educational information related to pregnancy, allowing users to engage in self-guided online learning at any time.

As shown in Figire 4.6, the weight curve chart is a graph with time and weight as coordinates. The X-axis ranges from the day of conception to a 12-month period, aiming to provide pregnant women with a visual representation of their weight changes during pregnancy. It helps them quickly understand their individual weight variations and whether

their weight aligns with or deviates from the recommended weight gain during pregnancy.

Figure 4.6 Weight Curve of Pregnancy

Figure 4.7 illustrates a user-friendly interface for recording the user's recent dietary intake. In the implementation of the dietary recording feature, the design is based on the concept of an online shopping cart interface. It utilizes images to display the food menu contents and allows users to drag and drop items into their meal cart. The quantities and calories in the meal cart are incremented using the same drag-and-drop method for identical items. Finally, all the entries are submitted and stored in the system at once.

Figure 4.7 Diet Management

Figure 4.8 demonstrates the food calorie estimation feature. The user first drags and drops the food items to be estimated into the food list, then clicks the estimation button to enter the area-based calorie estimation page. Next, they select a standard item for comparison, take photos of both the standard item and the item to be estimated, and upload them simultaneously. When the photos successfully display on the screen, the user can use the mouse or touchscreen to click the option buttons for the standard item and the estimated item, respectively. This action delineates their respective rectangular areas on the screen. After completing this process, the system calculates and submits, providing the actual quantity and calories of the estimated item.

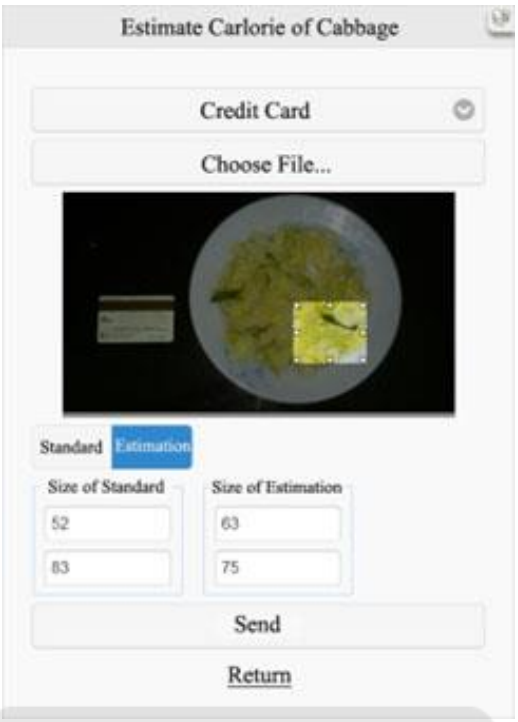

Figure 4.8 Food calories estimation by area

Figure 4.9 demonstrates the real-time communication functionality integrated into the system. When a user accesses this feature for the first time, they can easily connect with our official account by clicking the 'join' button. This feature is intended to facilitate users in contacting our expert nursing team whenever they face problems or have inquiries.

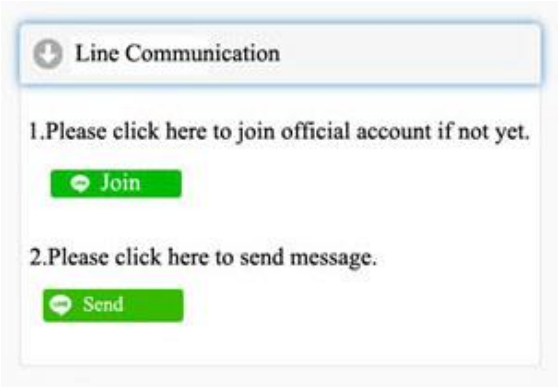

Figure 4.9 Real-time Communication

4.3 SPBIL App

This study utilized Arduino-related components to achieve its goals, including the use of a microphone module as shown in Figure 4.10 and an Arduino motherboard as shown in Figure 4.11. By combining the Arduino programming software and Processor drawing software, the sound signals detected by the Voice Sensor were received through the Arduino motherboard. Then, Processor obtained the signals from Arduino and plotted them into a graph. The purpose of this setup was to observe the waveform characteristic changes of subjects' inhalation and exhalation.

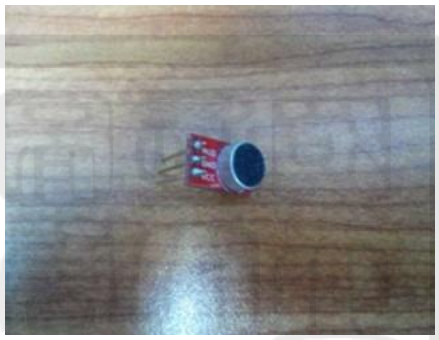

Figure 4.10 Microphone module

Figure 4.11 is the Arduino mainboard, whose task is to receive breathing signals and then transmit these signals via Bluetooth.

Figure 4.11 Arduino motherboard

This App acquires signal data from a sensor composed of Arduino components through wireless transmission. It simultaneously pairs with a processor and graphic software to display breathing patterns and rhythms on the screen. The microphone in the receiving end of the sensor captures the user's breathing sounds and transmits the respiratory signals to a smartphone or tablet. The App then converts these respiratory signals into waveform graphs for real-time feedback. The real-time feedback is presented in waveform format, with inhalation represented as peaks and exhalation as valleys, as shown in Figure 4.12. To facilitate user interpretation, this App eliminates noise caused by variations in volume and presents the data using square waves.

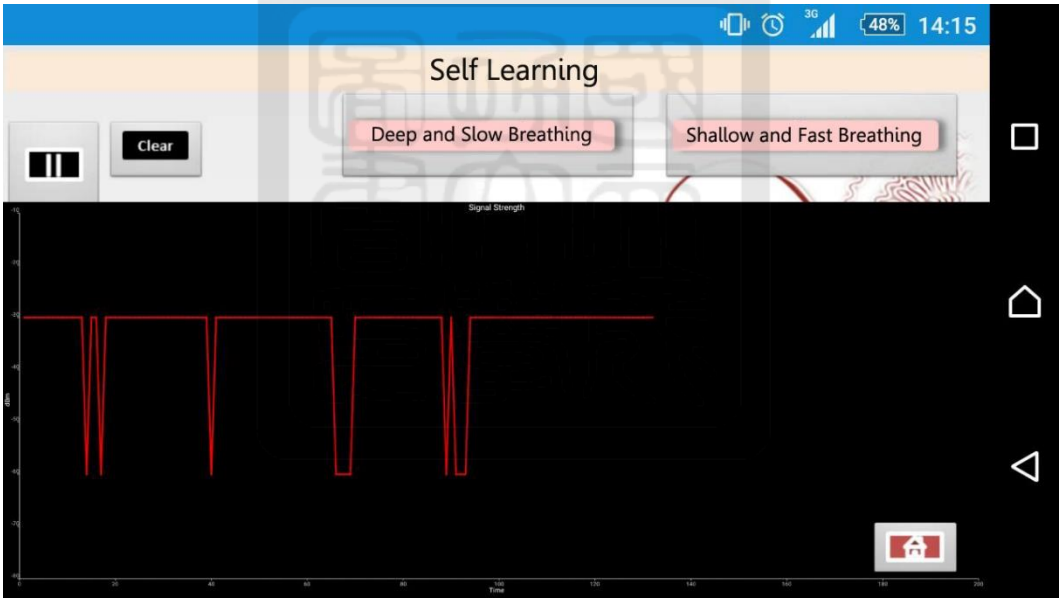

Figure 4.12 Realtime screen of SPBIL App

Based on the two breathing modes available in the App, “deep and slow breathing” and “shallow and fast breathing,” combined with real-time feedback in the form of a breathing curve graph, women can practice self-control of their breathing techniques. This allows them to observe their own breathing patterns, strengthen their self-control, and enhance their training in breathing adjustment. Women can use the “play,” “pause,” and “clear” buttons to

control the presentation of the breathing waveform graph. This enables women to practice self-control and adjustment of their breathing using their mobile phones in their daily prenatal life, increasing their learning efficiency. In the subsequent labor process, they can further familiarize and master this App, thereby alleviating pain during childbirth and enhancing their self-efficacy in the delivery process.

4.4 PostpartumCare System

The primary functions of this system can be outlined as follows, as depicted in Figure 4.13. On the left, the initial feature focuses on BP and pulse management, while in the upper right corner, a statistical chart illustrating BP is displayed. On the right side, the first one is weight management. In the middle, there are two functions for medication management and medication records. On the left, the third one is video demonstrations of postpartum exercises by real individuals. On the right, the third one is dietary recommendations, and in the bottom right corner, the second-to-last one is some postpartum health education. The last one in the bottom right corner is an intelligent chatroom. Next, we will describe how to use these functions.

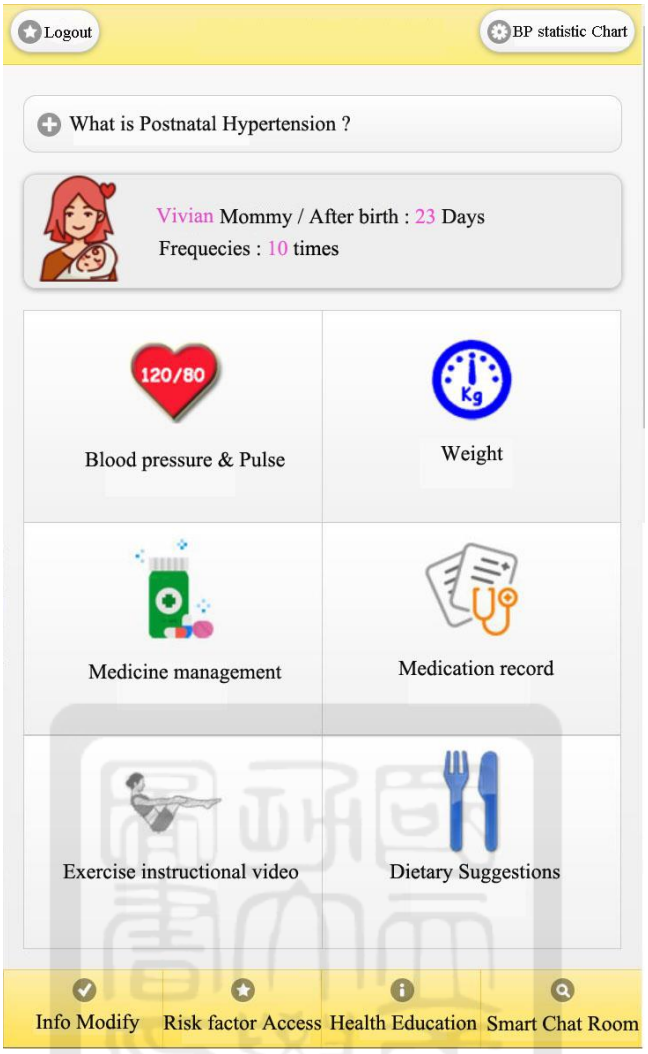

Figure 4.13 Main page of PostpartumCare System

In the section dedicated to recording BP and pulse data, postpartum women are required to input the data, SBP (systolic blood pressure) and DBP (diastolic blood pressure) readings, as well as pulse measurements., as demonstrated in Figure 4.14. On the system's right-hand side, a line graph is displayed, with each entry being represented as a point on the graph. The red line represents the upper limits for SBP (140) and DBP (90), allowing users to quickly identify if their readings surpass these levels. Moreover, a separate graph records pulse data, with a red line indicating the upper limit (100) and lower limit (60). Users can easily discern whether their pulse measurements fall below or exceed these specified boundaries.

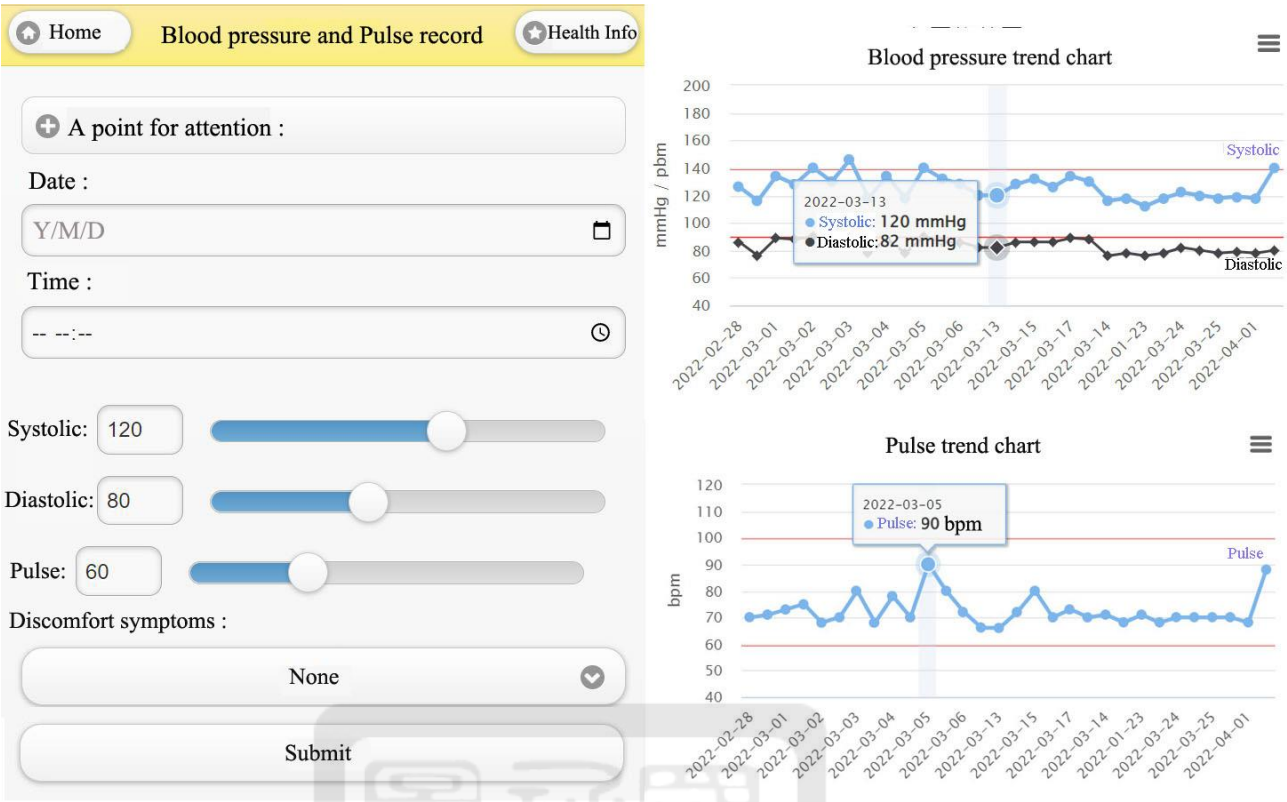

Figure 4.14 BP and pulse record

Within the BP pie chart [56], postpartum women can pick their preferred timeframe, ranging from 7-90 days or a tailored date range, as illustrated in Figure 4.15. Different colors represent various statistics: green indicates good readings, yellow denotes normal levels, and red signifies high BP. It is advisable for postnatal women to schedule regular follow-up visits, typically occurring six weeks after natural childbirth and between 10 to 12 days and up to six weeks after a cesarean section delivery. The collected BP data can be shared with healthcare providers for postpartum BP evaluation, facilitating necessary medication adjustments if needed.

Figure 4.15 BP statistical pie chart

In the weight tracking section of the self-recording system, postnatal women are prompted to input their everyday weight accessments., as depicted in Figure 4.16. BMI is just a reference for assessing the weight changes at that time. Generally, postpartum women strive to return to their pre-pregnancy weight as much as possible after childbirth.

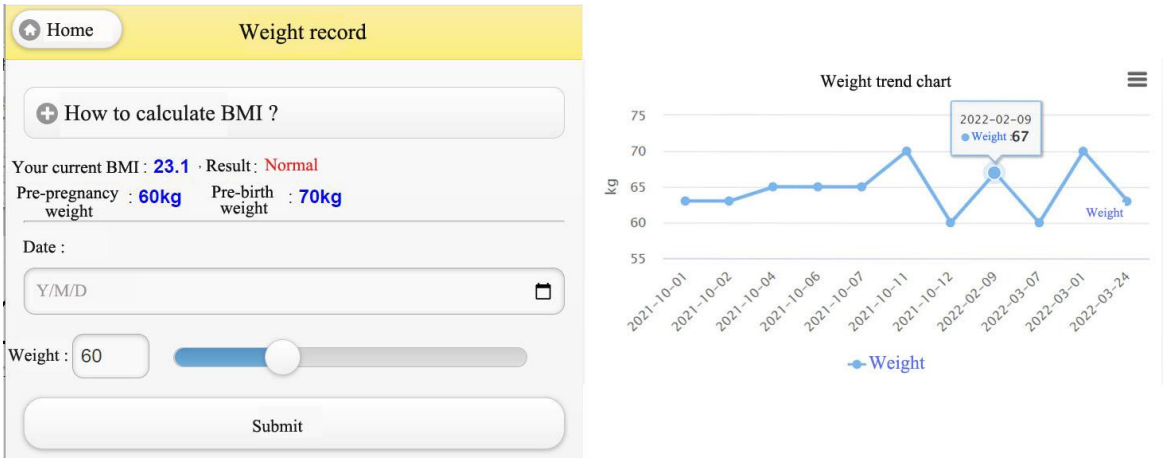

Figure 4.16 Weight record

Medication record management, as depicted in Figure 4.17, comprises two key components. On the left side, users can manage their medications, with the system already incorporating some antihypertensive drugs; however, users also have the option to input their own if needed. Users can access the medication record on the right-hand side, enabling them to document details when taking medications., including the medication's name, date of usage, and time of administration. Furthermore, the system includes a calendar feature designed to function as a medication reminder. At the bottom, users can access a comprehensive record detailing each medication.

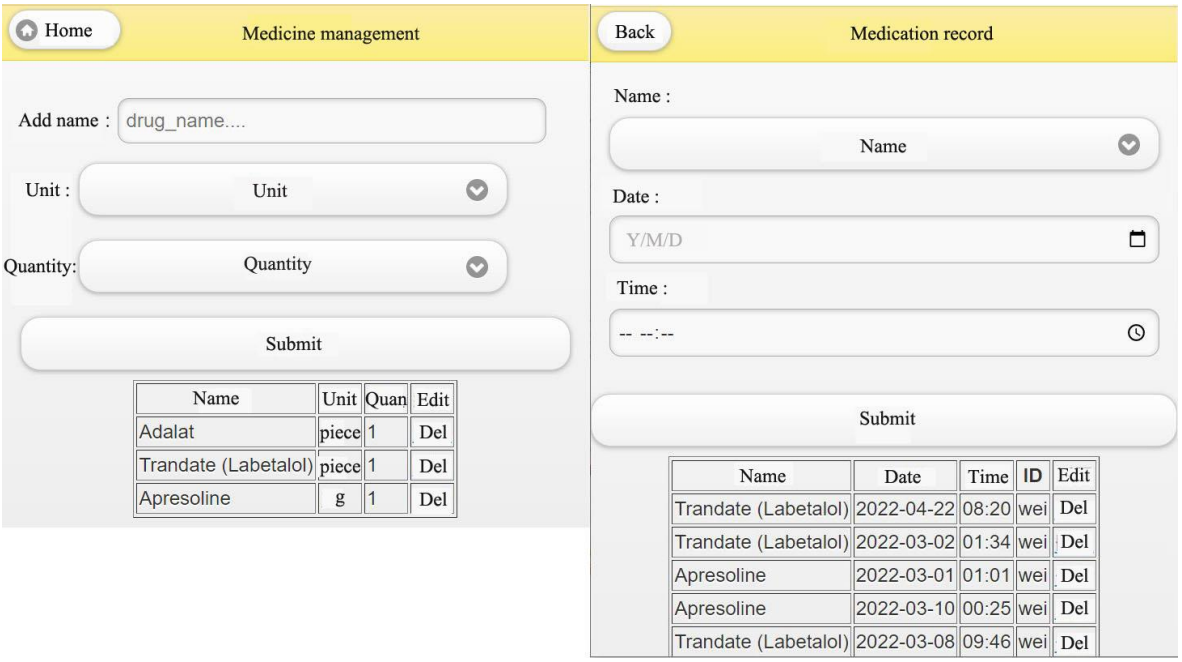

Figure 4.17 Medication record

Figure 4.18 showcases an instructional exercise video [57]. As seen in the figure, the right side offers an overview of postnatal exercises tailored for different stages. These exercises are designed for women after childbirth, beginning from day one after delivery up to the fifteenth day, with additional exercises becoming accessible afterward. Users can follow live demonstration videos, complete with voice instructions, ensuring proper and effective execution of each exercise. The program begins with simple and user-friendly exercises, featuring only one exercise type in the initial session. Each day, a new exercise is introduced. On the left side, users can track their exercise duration. They can select the exercise corresponding to the video, specify the date and time, and initiate the exercise by clicking the play button. After completing the exercise session, users can click the end button to note down the duration. This process creates a comprehensive exercise log.

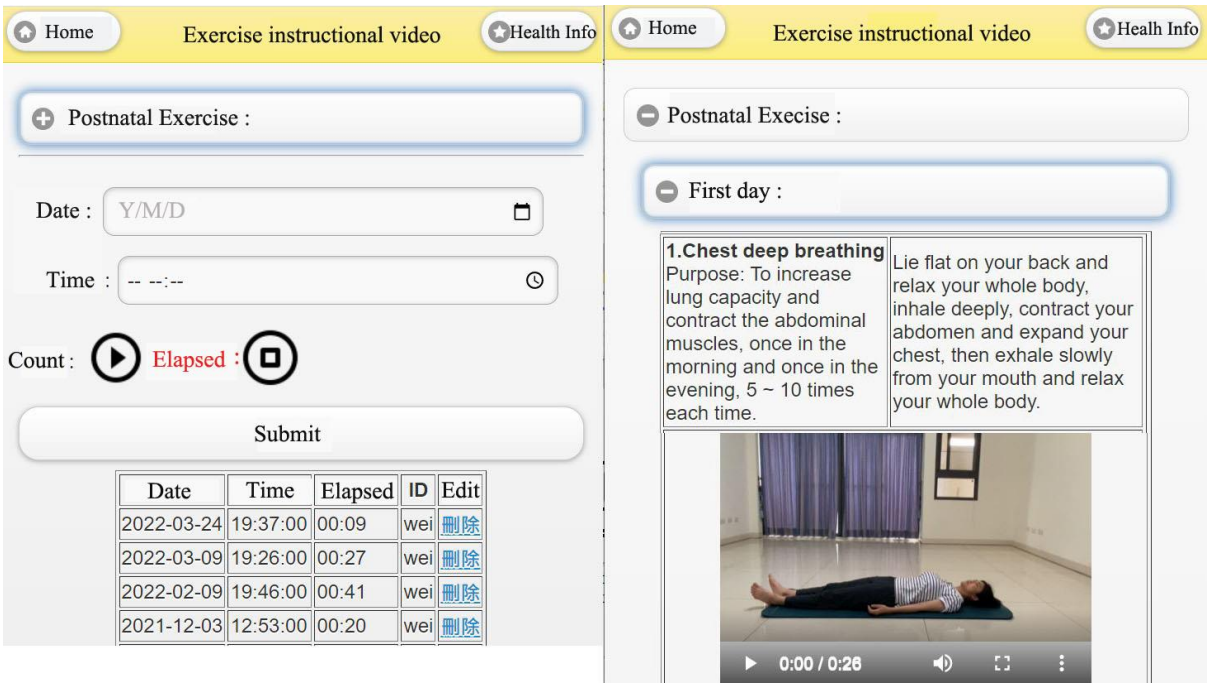

Figure 4.18 Instructional exercise video

The intelligent chatroom, depicted in Figure 4.19, is an integral feature of the system. It is designed as an intelligent platform where a comprehensive database compiles common inquiries from postnatal women. These inquiries encompass various topics, including questions like, “Is it safe to shower and wash my hair after giving birth?”, “When can I expect my period to return after delivery?”, “What is the appropriate time to resume sexual activity safely after childbirth?”, “What are the commonly used contraceptive methods?”, and more. To enhance accessibility, numerous keywords are associated with these questions, enabling the system to intelligently link them to their respective answers.

When a user submits a question containing specific keywords, the system promptly generates a relevant response. In cases where the system is unable to answer a query, it initiates a standard response: “I'm sorry, but I can't answer this question right away. We will have someone contact you shortly.” Following this, a midwife, overseeing the system's backend, reviews and formulates an appropriate response. This response is then conveyed directly to the user through a manual process.

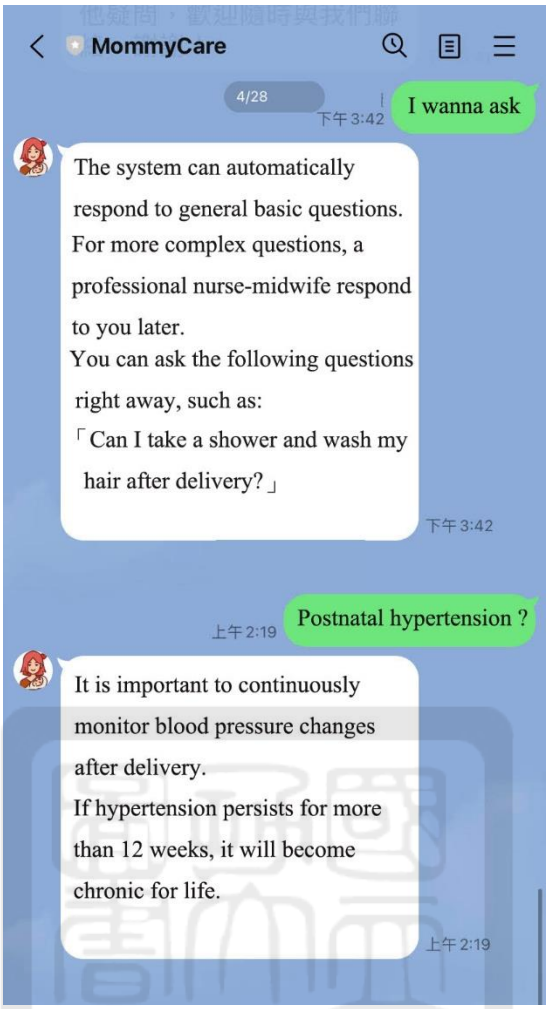

Figure 4.19 Intelligent chatroom

Finally, postnatal health education information serves as a vital resource of professional knowledge for postnatal women, as depicted in Figure 4.20. This information is both vital and useful for postnatal education, offering great benefits to new mothers.

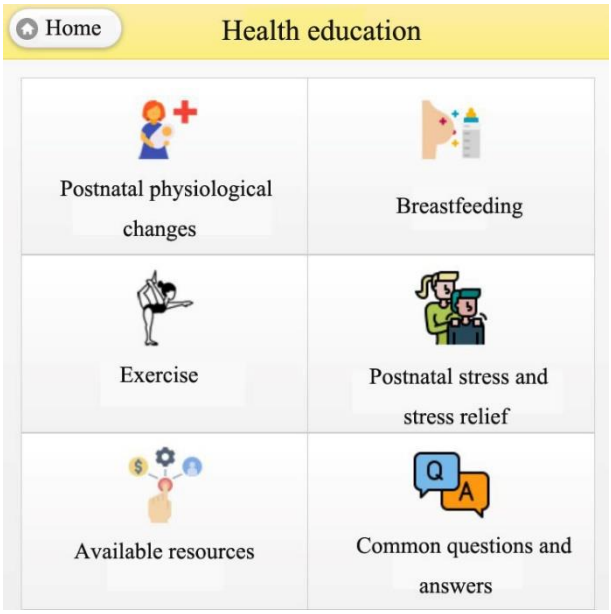

Figure 4.20 Health education information

4.5 Evaluation

We gradually completed these four systems separately, and after the system construction was finished, we looked for suitable users to arrange for testing. The study recruited mothers through convenient sampling from the obstetric outpatient department at a medical center. We conducted a survey to evaluate their satisfaction with the proposed system, resulting in a total of four satisfaction questionnaires for the systems.

It employed the Likert scale [58] to gauge user satisfaction with the proposed system. Each item used a 5-point scale. It represented by the values 1 to 5, respectively.

The PrenatalCare System recruited users for a total of 68 participants. User participation in the PrenatalCare System's demographic analysis includes age, BMI, education level, and number of pregnancies as shown in Table 4.1. After a period of usage, we conducted a satisfaction survey to gauge their experiences. The results are summarized in Table 4.2.

Table 4.1 Participants' demographics of PrenatalCare System(n=68)

Variable	n=68 n(%)
Age	
20~29	15(22.1%)
30~39	31(45.6%)
40~49	22(32.3%)
BMI	
<18.5	3(4.4%)
18.5~23	49(72.1%)
>=24	16(23.5%)
Education	
High school	4(5.9%)
College	53(77.9%)
>=Master's degree	11(16.2%)
Number of pregnancies	
First	37(54.4%)
Second	27(39.7%)
Third	3(4.4%)
>=Third	1(1.5%)

The results show an overall satisfaction rating of 3.82 out of 5. Regarding the design and helpfulness of the application, 72% of women expressed satisfaction (total average). Looking at the main functions, the most popular one is the fourth item, the weight gain journal (3.87 ± 0.67), followed by the fifth item (3.82 ± 0.62), the BP journal, and the third one is the fetal movement journal (3.78 ± 0.69). The results are presented in Table 4.2.

Table 4.2 After-use with PrenatalCare System(n=68)

項目	Mean ± SD	非常滿意 n (%)	滿意 n (%)	普通 n (%)	不滿意 n (%)	非常不滿意 n (%)
總平均	**3.82 ± .62**	**9(13.2%)**	**40(58.8%)**	**19 (27.9%)**	**0**	**0**
1.您對整個系統的感受如何?	3.93 ± .61	9 (13.3%)	46 (67.6%)	12 (17.6%)	1 (1.5%)	0
2.這系統對您的懷孕是否有幫助?	3.94 ± .69	11 (16.2%)	44 (64.7%)	12 (17.6%)	0	1 (1.5%)
3.您覺得上傳寶寶超音波的功能如何?	3.68 ± .66	6 (8.8%)	35 (51.5%)	26 (38.2%)	1 (1.5%)	0
4.您覺得體重紀錄的功能如何?	3.87 ± .67	10(14.7%)	40(58.8%)	17(25.0%)	1(1.5%)	0
5.您覺得血壓測量紀錄的功能如何?	3.82 ± .62	7(10.3%)	43(63.2%)	17(25.0%)	1(1.5%)	0
6.您覺得胎動測量紀錄的功能如何?	3.78 ± .69	9(13.2%)	36 (52.9%)	22(32.4%)	1(1.5%)	0
7.您覺得宮縮紀錄的功能如何?	3.74 ± .66	8(11.8%)	34(50.0%)	26(38.2%)	0	0

Pregnant women typically begin consulting obstetricians in the first trimester following confirmation of their pregnancy. Typically, a pregnant woman schedules more than six doctor's appointments throughout her pregnancy. Originally, it was reasonable to expect that each user would regularly update their information. However, as shown in Table 4.3, numerous users logged in between 6 to 10 times. Among them, a total of 52 users logged in more than six times, indicating that 76% of the users frequently utilized the system.

Table 4.3 User log in frequency with PrenatalCare System

Login frequency	1-5	6-10	11-15	16-20	>21
Number of users	16	32	10	8	2

MomweightCare System were recruited 52 pregnant women for our study. User participation in the MomweightCare System's demographic analysis includes age, BMI, education level, and number of pregnancies as shown in Table 4.4.

Table 4.4 Participants' demographics of MomweightCare System(n=52)

Variable	n=52 n(%)
Age	
20~29	9(17.3%)
30~39	23(44.2%)
40~49	20(38.5%)
BMI	
<18.5	4(7.7%)
18.5~23	37(71.2%)
>=24	11(21.1%)
Education	
High school	0
College	44(84.6%)
>=Master's degree	8(15.4%)
Number of pregnancies	
First	29(55.8%)
Second	22(42.3%)
Third	1(1.9%)
>=Third	0

The results show an overall satisfaction rating of 4.03 out of 5. Regarding the design and helpfulness of the application, 84.7% of women expressed satisfaction (total average). Looking at the main functions, the most popular one is the fourth item, recommended weight curve during pregnancy (4.44 ± 0.61), followed by in the sixth item (4.08 ± 0.48), my favorite food function, and the third one is the diet management (4.04 ± 0.59). The results are presented in Table 4.5.

Table 4.5 After-use with MomweightCare System(n=52)

項目	Mean ± SD	非常滿意 n (%)	滿意 n (%)	普通 n (%)	不滿意 n (%)	非常不滿意 n (%)
總平均	**4.03 ± .59**	**11 (21.2%)**	**33(63.5%)**	**8 (15.4%)**	**0**	**0**
1.您對整個系統的感受如何?	4.08 ± .48	8 (15.4%)	40 (76.9%)	4 (7.7%)	0	0
2. 您覺得整個系統的資訊是容易理解的嗎?	4.1 ± .53	10 (19.2%)	37 (71.2%)	5 (9.6%)	0	0
3. 您可以很容易地操作此系統嗎?	3.94 ± .61	8 (15.4%)	33(63.5%)	11(21.2%)	0	0
4. 您覺得體重建議曲線的功能如何?	4.44 ± .61	26 (50%)	23 (44.2%)	3 (5.8%)	0	0
5.您覺得飲食管理系統的功能如何?	4.04 ± .59	10 (19.2%)	34 (65.4%)	8 (15.4%)	0	0
6.您覺得「我的最愛食物」的功能如何?	4.08 ± .48	8 (15.4%)	40 (76.9%)	4 (7.7%)	0	0
7.您覺得食物熱量估算的功能如何?	3.58 ± .80	6 (11.5%)	22 (42.3%)	20 (38.5%)	4 (7.7%)	0

Among the 52 women studied, 15% were in the 1st trimester, 46% were in the 2nd trimester, 27% were in the 3rd trimester, and 12% were in the postpartum phase (< 1 year).

Based on their login records, most pregnant women used the system continuously for about 1 to 2 months. Tables 4.6 to 4.9 represent the 1st trimester, 2nd trimester, 3rd trimester, and postpartum phases, respectively. Table 4.6 indicates that 75% of the respondents expressed satisfaction (either satisfied or strongly satisfied) with the overall system. In Table 4.7 this satisfaction level increased to 91.6%, and in Table 4.8 and 4.9, it reached 100% for both cases, indicating a high level of contentment among the participants.

Table 4.6 After-use with MomweightCare System (1st trimester n=8)

項目	Mean ± SD	非常滿意 n (%)	滿意 n (%)	普通 n (%)	不滿意 n (%)	非常不滿意 n (%)
1.您對整個系統的感受如何?	4(0.76)	2 (25%)	4 (50%)	2 (25%)	0	0
2. 您覺得整個系統的資訊是容易理解的嗎?	4.13(0.35)	1 (12.5%)	7 (87.5%)	0	0	0
3. 您可以很容易地操作此系統嗎?	4.13(0.35)	1 (12.5%)	7 (87.5%)	0	0	0
4. 您覺得體重建議曲線的功能如何?	4.50(0.76)	5 (62.5%)	2 (25%)	1 (12.5%)	0	0
5.您覺得飲食管理系統的功能如何?	4.38(0.52)	3 (37.5%)	5(62.5%)	0	0	0
6.您覺得「我的最愛食物」的功能如何?	4.13(0.35)	1 (12.5%)	7 (87.5%)	0	0	0
7.您覺得食物熱量估算的功能如何?	3.88(0.99)	3 (37.5%)	1 (12.5%)	4 (50%)	0	0

Table 4.7 represents the second stage of pregnancy, and its satisfaction level has increased to 91.6% compared to the first stage.

Table 4.7 After-use with MomweightCare System (2nd trimester n=24)

項目	Mean ± SD	非常滿意 n (%)	滿意 n (%)	普通 n (%)	不滿意 n (%)	非常不滿意 n (%)
1.您對整個系統的感受如何?	4 (0.42)	2 (8.3%)	20 (83.3%)	2(8.3%)	0	0
2. 您覺得整個系統的資訊是容易理解的嗎?	4. (0.51)	3 (12.5%)	18 (75%)	3 (12.5%)	0	0
3. 您可以很容易地操作此系統嗎?	3.63(0.65)	2 (8.3%)	11(45.8%)	11(45.8%)	0	0
4. 您覺得體重建議曲線的功能如何?	4.21(0.59)	7 (29.2%)	15 (62.5%)	2 (8.3%)	0	0
5.您覺得飲食管理系統的功能如何?	3.79(0.51)	1 (4.2%)	17 (70.8%)	6 (25%)	0	0
6.您覺得「我的最愛食物」的功能如何?	3.96(0.36)	1 (4.2%)	21 (87.5%)	2 (8.3%)	0	0
7.您覺得食物熱量估算的功能如何?	3.29(0.62)	0	9 (37.5%)	13 (54.2%)	2 (8.3%)	0

Table 4.8 represents the third stage of pregnancy, and its satisfaction level has increased to 100%, higher than all others.

Table 4.8 After-use with MomweightCare System (3rd trimester n=14)

項目	Mean ± SD	非常滿意 n (%)	滿意 n (%)	普通 n (%)	不滿意 n (%)	非常不滿意 n (%)
1.您對整個系統的感受如何?	4.21 (0.43)	3(21.4%)	11 (78.6%)	0	0	0
2. 您覺得整個系統的資訊是容易理解的嗎?	4.14(0.66)	4(28.6%)	8 (80%)	2 (20%)	0	0
3. 您可以很容易地操作此系統嗎?	4.21 (0.43)	3(21.4%)	11 (78.6%)	0	0	0
4. 您覺得體重建議曲線的功能如何?	4.71(0.47)	10 (71.4%)	4 (28.6%)	0	0	0
5.您覺得飲食管理系統的功能如何?	4.29 (0.47)	4(28.6%)	10 (71.4%)	0	0	0
6.您覺得「我的最愛食物」的功能如何?	4.29 (0.47)	4(28.6%)	10 (71.4%)	0	0	0
7.您覺得食物熱量估算的功能如何?	3.86(0.54)	1(7.1%)	10 (71.4%)	3 (21.4%)	0	0

Table 4.9 represents the postpartum of pregnancy, and its satisfaction level has increased to 100%, higher than all others.

Table 4.9 After-use with MomweightCare System (postpartum <1year n=6)

項目	Mean ± SD	非常滿意 n (%)	滿意 n (%)	普通 n (%)	不滿意 n (%)	非常不滿意 n (%)
1.您對整個系統的感受如何?	4.17(0.41)	1 (16.7%)	5 (83.3%)	0	0	0
2. 您覺得整個系統的資訊是容易理解的嗎?	4.33(0.52)	2 (33.3%)	4 (66.7%)	0	0	0
3. 您可以很容易地操作此系統嗎?	4.33(0.52)	2 (33.3%)	04 (66.7%)	0	0	0

Table 4.9 (Continued) After-use with MomweightCare System (postpartum <1year n=6)

項目	Mean ± SD	非常滿意 n (%)	滿意 n (%)	普通 n (%)	不滿意 n (%)	非常不滿意 n (%)
4. 您覺得體重建議曲線的功能如何?	4.67(0.52)	4 (66.7%)	2 (33.3%)	0	0	0
5.您覺得飲食管理系統的功能如何?	4 (0.89)	2 (33.3%)	2 (33.3%)	2 (33.3%)	0	0
6.您覺得「我的最愛食物」的功能如何?	4 (0.89)	2 (33.3%)	2 (33.3%)	2 (33.3%)	0	0
7.您覺得食物熱量估算的功能如何?	3.67(1.37)	2 (33.3%)	2 (33.3%)	0	2 (33.3%)	0

SPBIL App were recruited 23 pregnant women for our study. User participation in the SPBIL App's demographic analysis includes age, BMI, education level, and number of pregnancies as shown in Table 4.10. The average usage of the SPBIL App is 12.83 times, with a minimum of 3 times and a maximum of 23 times.

Table 4.10 Participants' demographics of SPBIL App(n=23)

Variable	n=23 n(%)
Age	
20~29	11(47.8%)
30~39	8(34.8%)
40~49	4(17.4%)
BMI	
<18.5	1(4.3%)
18.5~23	16(69.6%)
>=24	6(26.1%)
Education	
High school	1(4.3%)

Table 4.10 (Continued) Participants' demographics of SPBIL App(n=23)

Variable	n=23 n(%)
Education	
College	18(78.3%)
>=Master's degree	4(17.4%)
Number of pregnancies	
First	11(47.8%)
Second	11(47.8%)
Third	1(4.3%)
>=Third	0

The results show an overall satisfaction rating of 3.93 out of 5. Regarding the design and helpfulness of the application, 78.3% of women expressed satisfaction (total average), with 69.5% indicating satisfaction with its use and assistance during pregnancy and childbirth (ninth item). The most satisfying aspects were the practicality of the fifth item, healthy educational (4.22 ± 0.60), followed by the utility of the application's image tutorials in the sixth item (4.17 ± 0.72). The first item, ease of reading various information displayed by the application (4.04 ± 0.64), and the fourth item, comfort in navigating the application interface (4.04 ± 0.64), tied for third place. The results are presented in Table 4.11.

The users' least favorite aspect is the practicality of the seventh application for self-practice breathing. However, 78.3% (n=18) of women indicated that they would use this application again if they become pregnant next time, and 87.0% (n=20) of women expressed their willingness to recommend it to other pregnant women for use.

Table 4.11 After-use with SPBIL App(n=23)

項目	Mean ± SD	非常滿意 n (%)	滿意 n (%)	普通 n (%)	不滿意 n (%)	非常不滿意 n (%)
總平均	**3.93 ± .64**	**5 (21.7%)**	**13(56.6%)**	**4 (17.4%)**	**1(4.3%)**	**0**
1.此應用程式所顯示的各項資訊容易閱讀	4.04 ± .64	5 (21.7%)	13 (56.6%)	4 (17.4%)	1 (4.3%)	0
2. 此應用程式所顯示的各項資訊完整	3.96 ± .64	4 (17.4%)	14 (60.9%)	5 (21.7%)	0	0
3.此應用程式的操作及使用方式流暢	3.91 ± .79	4 (17.4%)	15 (65.2%)	2(8.7%)	2(8.7%)	0
4.此應用程式介面設計閱覽舒適	4.04 ± .64	5 (21.7%)	14 (60.9%)	4 (17.4%)	0	0
5.此應用程式衛教資訊實用性	4.22 ± .60	7 (30.4%)	14 (60.9%)	2 (8.7%)	0	0
6.此應用程式影像教學實用性	4.17 ± .72	8 (34.8%)	11(47.8%)	4 (17.4%)	0	0
7.此應用程式自我練習呼吸波形實用性	3.57± 1.08	4 (17.4%)	10 (43.5%)	5 (21.7%)	3 (13.0%)	1(4.3%)
8.此應用程式紀錄使用日期、次數實用性	3.65 ± 1.03	4 (17.4%)	11(47.8%)	5 (21.7%)	2 (8.7%)	1(4.3%)
9.此應用程式整體的使用滿意度	3.83 ± .89	5 (21.7%)	11(47.8%)	5 (21.7%)	2 (8.7%)	0
10.整體而言，此應用程式對於您在孕產期間照護幫助性	3.87 ± .82	5 (21.7%)	11(47.8%)	6 (26.1%)	1(4.3%)	0
	YES/RECOMMEND			**NO/ NO RECOMMEND**		
11.若您下次懷孕是否願意再次使用本應用程式?	18 (78.3%)			6 (21.7%)		
12. 若您的朋友懷孕，是否會推薦使用?	20 (87.0%)			3 (13.0%)		

PostpartumCare System were recruited 39 pregnant women for our study. User participation in the PostpartumCare System's demographic analysis includes age, BMI, education level, and number of pregnancies as shown in Table 4.12.

Table 4.12 Participants' demographics of PostpartumCare System(n=39)

Variable	n=39 n(%)
Age	
20~29	2(5.1%)
30~39	15(38.5%)
40~49	22(56.4%)
BMI	
<18.5	4(10.3%)
18.5~23	25(64.1%)
>=24	10(25.6%)
Education	
High school	0
College	29(74.4%)
>=Master's degree	10(25.6%)
Number of pregnancies	
First	22(56.4%)
Second	16(41.0%)
Third	1(2.6%)
>=Third	0

The results show an overall satisfaction rating of 4.23 out of 5. Regarding the design and helpfulness of the application, 92.2% of women expressed satisfaction (total average). Looking at the main functions, the most popular one is the sixth item, function of BP chart statistic (4.36 ± 0.50), followed by in the sixth item (4.27 ± 0.65), function of BP&pulse, and the third one is the function of weight record (4.27 ± 0.47). The results are presented in Table 4.13.

The users' least favorite aspect is the practicality of the eleventh item for intelligent chatroom. However, 94.9% (n=37) of women indicated that they would use this application again if they become pregnant next time, and 97.4% (n=38) of women expressed their willingness to recommend it to other pregnant women for use.

Table 4.13 After-use with PostpartumCare System(n=39)

項目	Mean ± SD	非常滿意 n (%)	滿意 n (%)	普通 n (%)	不滿意 n (%)	非常不滿意 n (%)
總平均	**4.23 ± .61**	**18 (46.1%)**	**18 (46.1%)**	**3 (7.6%)**	**0**	**0**
1.您對整個系統的感受如何?	4.45 ± .69	20 (51.3%)	17 (43.6%)	2 (5.1%)	0	0
2.這個系統對您的產後健康是否有幫助?	4.09 ± .70	18 (46.2%)	18 (46.2%)	3 (7.6%)	0	0
3.您覺得整個系統的資訊是容易理解的嗎?	4.27 ± .65	22 (56.4%)	15 (38.5%)	2 (5.1%)	0	0
4. 您覺得這個系統是容易使用的嗎?	4.18 ± .60	19 (48.7%)	16 (41.0%)	4 (10.3%)	0	0
5. 您覺得「血壓及脈搏」的紀錄功能如何?	4.27 ± .65	22 (56.4%)	14 (36.0%)	3 (7.6%)	0	0
6. 您覺得「血壓統計圖」的功能如何?	4.36 ± .50	22 (56.4%)	17 (43.6%)	0	0	0
7. 您覺得「體重」的紀錄功能如何?	4.27 ± .47	16 (41.0%)	22 (56.4%)	1 (2.6%)	0	0
8. 您覺得「產後運動教學」的功能如何?	4.18 ± .60	17 (43.6%)	16 (41.0%)	6 (15.4%)	0	0

Table 4.13 (Continued) After-use with PostpartumCare System(n=39)

項目	Mean ± SD	非常滿意 n (%)	滿意 n (%)	普通 n (%)	不滿意 n (%)	非常不滿意 n (%)
9. 您覺得「用藥紀錄」的功能如何?	4.18 ±.60	12 (30.8%)	25 (64.1%)	2 (5.1%)	0	0
10. 您覺得「危險因素評估表」的功能如何?	4.18 ± .60	16 (41.0%)	22 (56.4%)	1 (2.6%)	0	0
11. 您覺得「智慧聊天室」的功能如何?	4.09 ± .70	17 (43.6%)	19 (48.7%)	3 (7.6%)	0	0
12. 您覺得「衛教資訊」的內容如何?	4.18 ±.60	19 (48.7%)	19 (48.7%)	1 (2.6%)	0	0
	YES/RECOMMEND			**NO/ NO RECOMMEND**		
13.若您下次懷孕是否願意再次使用本應用程式?	37 (94.9%)			2 (5.1%)		
14. 若您的朋友懷孕，是否會推薦使用?	38 (97.4%)			1 (2.6%)		

4.6 Discussion

Because this study combines both prenatal and postnatal systems, we selected two studies each for prenatal and postnatal to make comparisons.

Table 4.14 compares three prenatal systems. On the left is the system developed and put into operation by Tamar Krishnamurti et al., known as the MHP (MyHealthyPregnancy App), which is tailored for expectant mothers [45]. In the middle is the SAPMS (Smart ASHA Pregnancy Monitoring System) designed by Nandakishor D Valakunde et al. [46]. Our system is on the far right. We propose eight essential features for a prenatal system. In the

first three features, either it's just a web interface or it's not multi-platform. Only our prenatal system can achieve both. One of the features, “Specialized BP Monitor,” refers to the ability to directly transmit BP measurements into the system using a dedicated BP monitor. However, none of the three systems have this functionality. In conclusion, our proposed prenatal system possesses seven out of the eight features, indicated by asterisks.

Table 4.14 Comparison of prenatal health management studies

	MHP App [44]	SAPMS System [45]	Proposed System
*Web Interface	No	Yes	Yes
*Mobile App	Yes	Yes	Yes
*Multi-platform	No	No (Android)	Yes
*Maternity Records	No	Yes	Yes
*Antenatal Health Education	Yes	No	Yes
Specialized BP Monitor	No	No	No
*Self-care Function	Yes	Yes	Yes
*Reminders or Alerts	Yes	Yes	Yes

Table 4.15 compares three postnatal systems. On the left is a study introduced by Kitt and colleagues known as POP-HT (Physician-Optimized Postpartum Hypertension Treatment) [47]. In the middle is an investigation conducted by Cairns and colleagues into mothers' experiences with a postpartum hypertension treatment [48]. Our system is positioned on the extreme right. We have identified and incorporated eight key features essential for a postnatal system. In the first three features, it's either lacking a web interface

or incapable of being multi-platform. Only our postnatal system can achieve both. One of the features, “Specialized BP Monitor,” is present in the first system, POP-HT, which can directly transmit BP records into the system. Additionally, our system incorporates an intelligent chatroom where expectant mothers can ask questions and receive prompt answers, enriching their overall experience and providing valuable support throughout their maternity journey. In conclusion, our proposed postnatal system possesses six out of the eight features, indicated by asterisks.

Table 4.15 Comparison of postnatal health management studies

	POP- HT Trial [46]	Mixed-methods Study [47]	Proposed System
*Web Interface	No	No	Yes
*Mobile App	Yes	No	Yes
*Multi-platform	No	No	Yes
*Postnatal Health Education	Yes	Yes	Yes
Specialized BP Monitor	Yes	No	No
*Self-care with Function	Yes	Yes	Yes
*Intelligent chatroom	No	No	Yes
Trial period > 1 year	No	No	No

In the post-development phase of the PrenatalCare System, we encountered a significant challenge: the system was exclusively designed for Android, lacking an iOS version. Initially, we prioritized Android due to its larger market share, neglecting the prevalent iPhone use among pregnant women. To address this, we pursued a cross-platform approach, ultimately utilizing HTML5 and jQuery to create a web version compatible with both Android and iOS

platforms. Subsequently, we faced two additional challenges. The first was the decreasing frequency of logins by pregnant women. Although initial engagement was high, it gradually declined, leading to reduced system usage. Enhancing the system's appeal to ensure consistent use by pregnant women is a key area for improvement. The second challenge involved the manual entry of crucial data like blood pressure and weight, which users found burdensome and led to decreased system utilization. This issue was also observed in the PostpartumCare System.

Moreover, in our MomweightCare System, the manual calorie measurement process was time-consuming, diminishing user interest. To mitigate this, we implemented a diet recording method based on favorite foods and frequency, allowing for faster dietary logging. The initial manual calorie calculation is required, but subsequent entries do not need recalibration. The most significant user dissatisfaction stemmed from the complex process of estimating food calorie content, involving photographing the food and adding items for calorie calculation. Simplifying this process could greatly enhance the system.

Additionally, during the development of the SPBIL App, we observed weaker inhalation signals compared to exhalation, presenting a challenge in graph representation. We adapted by using the exhalation waveforms as a reference and interpreting weaker signals between exhalations as inhalations. This approach enabled accurate graph plotting, with minor adjustments for individual respiratory variations. However, the lowest satisfaction point was the real-time feedback on the breathing curve during self-practice, primarily due to response time lags. Addressing this delay could improve user engagement and satisfaction.

In the PostpartumCare System's development, we initially incorporated newborn care functions after examining other postpartum care systems. However, we later decided that pregnant women should focus solely on their own care, leading to the removal of these functions and the creation of the system's initial version.

User satisfaction with the systems was generally high. The PrenatalCare system, being the first, achieved an average satisfaction score of 3.82, followed by the MomweightCare system at 4.03. The SPBIL App received a rating of 3.93, while the PostpartumCare System scored an impressive 4.23. The collective average satisfaction score for all systems was 4.00, reflecting strong user satisfaction.

Our system boasts five key advantages over other research projects:

(1) No installation required.

(2) Space-saving design.

(3) Ease of updates and maintenance.

(4) Centralized data management.

(5) Capability for push notifications.

Users can access it directly in the browser, a significant advantage considering the reluctance to install new apps due to security concerns and storage limitations. Server-based updates eliminate the need for manual user updates. Centralized data management enhances protection and backup. Incorporating intelligent chat room technology, like LINE, enables real-time inquiries and important message dissemination, facilitating proactive user engagement by healthcare professionals.

Chapter 5 Conclusion

5.1 Conclusion

Initially, the PrenatalCare System offers an extensive Maternity Record, providing mothers with in-depth insights. It features a Self-care Journal for personalized care and Health Education resources to enrich the pregnancy experience with knowledge. Subsequently, our MomweightCare System enhances maternal health monitoring. This includes calorie estimation, weight curve analysis, and a specialized Health Area for effortless tracking. We also introduce the SPBIL App, a novel tool offering Lamaze breathing techniques through instructional videos and self-practice options.

Previously, there were few apps designed for women with postnatal hypertension. Our system offers humanized care, focusing on analyzing daily changes in postnatal hypertension. This allows doctors to review and adjust blood pressure changes more accurately and swiftly, ensuring timely medication adjustments during postnatal visits. During the postnatal recovery period, the system aims to restore blood pressure to a normal range as quickly as possible. This reduces the likelihood of women with postpartum hypertension developing chronic hypertension and the need for lifelong medication to control their blood pressure.

Our primary goal in this study is to ensure that pregnant women can complete childbirth smoothly and safely, and return home in good health.

5.2 Future work

In time to come, the planned system can be smoothly incorporated into a hospital's Electronic Health Record (EHR) system, improving the prevention of pregnancy complications. Additionally, incorporating features for weight management and enriching the system with detailed nutritional information can promote a balanced diet among pregnant

women.

In addition, due to the constraints of the development timeline, this study proceeded to develop four different systems at different points in time and conducted relevant research with users. If these four systems are integrated, and the same group of users is engaged from the prenatal to the postnatal period, followed by a satisfaction survey, perhaps it could provide greater assistance to these pregnant women. It could also reveal the level of satisfaction pregnant women have with these four systems individually. This information could then be used to identify areas for improvement in the entire system.

Also, we originally aimed to provide care systems for high-risk pregnancies, such as hypertension disorders of pregnancy or gestational diabetes. Among them, the incidence of hypertension disorders of pregnancy is relatively high, and it is one of the main factors causing maternal mortality. Therefore, we first started research on hypertension disorders of pregnancy and will later extend our focus to gestational diabetes.

References

[1] F. Fatehi, R. Wootton, Telemedicine, “telehealth or e-health? A bibliometric analysis of the trends in the use of these terms”, *J. Telemed. Telecare*. vol.18, pp. 460–464,2012. doi:10.1258/jtt.2012.GTH108.

[2] World Health Organization (WHO), “Global diffusion of eHealth: Making universal health coverage achievable,” 2016, Available: http://who.int/goe/publications/global_diffusion/en/.

[3] R. Fletcher, G. Vimpani, G. Russell, and D. Keatinge, “The evaluation of tailored and web-based information for new fathers,” *Child: Care, Health and Development*, vol. 34, no. 4. pp. 439–446, 2008, doi: 10.1111/j.1365-2214.2008.00811.x.

[4] S. P. Rowland, J. E. Fitzgerald, T. Holme, J. Powell, and A. McGregor, “What is the clinical value of mHealth for patients?,” *npj Digit. Med*., vol. 3, no. 1, pp. 1–6, 2020, doi: 10.1038/s41746-019-0206-x.

[5] WHO, UNICEF UNFPA, and WORLD BANK GROUP and UNDESA/Population Division, “Trends in maternal mortality 2000 to 2020: estimates, ” 2023.

[6] Salomonsson B, Gullberg MT, Alehagen S, Wijma K. “Self-efficacy beliefs and fear of childbirth in nulliparous women,” *J Psychosom Obstet Gyneco*,34(3),116-121, 2013.

[7] Sercekus P, Baskale H. “Effects of antenatal education on fear of childbirth, maternal self-efficacy and parental attachment,” *Midwifery*, 34,166-172, 2016.

[8] G. Latendresse, “The Interaction Between Chronic Stress and Pregnancy: Preterm Birth from A Biobehavioral Perspective,” *J. Midwifery Women’s Heal.*, vol. 54, no. 1, pp. 8–17, 2009, doi: 10.1016/j.jmwh.2008.08.001.

[9] Health Promotion Administration, Ministry of Health and Welfare (Taiwan), Maternal Health Booklet, July. 2020.

[10] M.Hong et al., “Weight gain rate in the second and third trimesters and fetal growth in women with gestational diabetes mellitus: a retrospective cohort study,” *BMC Pregnancy Childbirth*, vol. 22, no. 1, pp. 1–10, 2022, doi: 10.1186/s12884-022-04762-4.

[11] J Han, G Ohaegbulam, F Yan, M Lindsay, FH Geary and R Lee, “Gestational Weight Gain in Patients With Obesity and Diabetes A Comparison of 2009 Institute of Medicine Versus 2019 JAMA Recommendations [A270],” *Obstetrics & Gynecology*, Volume 139, Supplement 1, pp. 78S-78S(1), 2022, doi: 10.1097/01.AOG.0000825640.83284.87.

[12] Institute of Medicine (US), National Research Council (US) Committee to Reexamine IOM Pregnancy Weight Guidelines, Weight Gain During Pregnancy: Reexamining the Guidelines - PubMed - NCBI, 2009. Available: https://www.ncbi.nlm.nih.gov/pubmed/20669500. Accessed Oct 5, 2020.

[13] Fenwick, J., Gamble, J., Nathan, E., Bayes, S., & Hauck, Y., "Pre-and postpartum levels of childbirth fear and the relationship to birth out come in a cohort of Australian women," *Journal of Clinical Nursing*,18(5), 667-677, 2009.

[14] Y.Deng et al., “A comparison of maternal fear of childbirth, labor pain intensity and intrapartum analgesic consumption between primiparas and multiparas: A cross-sectional study,” *Int. J. Nurs. Sci.*, vol. 8, no. 4, pp. 380–387, 2021, doi: 10.1016/j.ijnss.2021.09.003.

[15] D. Bick, S. A. Silverio, A. Bye, and Y. S. Chang, “Postnatal care following hypertensive disorders of pregnancy: a qualitative study of views and experiences of primary and secondary care clinicians,” *BMJ Open*, vol. 10, no. 1, 2020, doi: 10.1136/bmjopen-2019-034382.

[16] J. A.Hutcheon, S.Lisonkova, andK. S.Joseph, “Epidemiology of pre-eclampsia and the other hypertensive disorders of pregnancy,” *Best Pract. Res. Clin. Obstet. Gynaecol.*, vol. 25, no. 4, pp. 391–403, 2011, doi: 10.1016/j.bpobgyn.2011.01.006.

[17] Brown MA, Magee LA, Kenny LC, et al. “Hypertensive disorders of pregnancy: ISSHP classification, diagnosis, and management recommendations for international practice, ” *Hypertension*, 72(1),24-43, 2018, doi:10.1161/HYPERTENSIONAHA.117.10803.

[18] M. D. Lindheimer, S. J. Taler, and F. G. Cunningham, “Hypertension in pregnancy,” *J. Am. Soc. Hypertens*., vol. 4, no. 2, pp. 68–78, 2010, doi: 10.1016/j.jash.2010.03.002.

[19] Cunningham, e.a., “Pregnancy hypertension,” In Willams obstetrics, 23 Edition. p.706-756, 2010.

[20] L.Magee and P.vonDadelszen, “Prevention and treatment of postpartum hypertension,” *Cochrane Database Syst. Rev*., vol. 2013, no. 4, 2013, doi: 10.1002/14651858.CD004351.pub3.

[21] A. B. Geremew, M. M. Boke, and A. E. Yismaw, “The Effect of Antenatal Care Service Utilization on Postnatal Care Service Utilization: A Systematic Review and Meta-analysis Study,” *J. Pregnancy*, vol. 2020, 2020, doi: 10.1155/2020/7363242.

[22] M. M. Islam andM. S. Masud, “Determinants of frequency and contents of antenatal care visits in Bangladesh: Assessing the extent of compliance with the WHO recommendations,” *PLoS One*, vol. 13, no. 9, pp. 1–22, 2018, doi: 10.1371/journal.pone.0204752.

[23] J. Rivera *et al.*, “Mobile apps for weight management: A scoping review,” *JMIR mHealth uHealth*, vol. 4, no. 3, pp. 1–9, 2016, doi: 10.2196/mhealth.5115.

[24] S. L. Holzmann and C. Holzapfel, “A scientific overview of smartphone applications and electronic devices for weight management in adults,” *J. Pers. Med.*, vol. 9, no. 2,

2019, doi: 10.3390/jpm9020031.

[25] A. Jhala, “A Study to Assess the Effectiveness of Lamaze Breathing on Labor Pain and Anxiety Towards Labor Outcome among Primigravida Mothers During Labor in Community Health Center, Kolar Road, Bhopal (M.P.),” *Indian J. Obstet. Gynecol.*, vol. 5, no. 1, pp. 19–22, 2017, doi: 10.21088/ijog.2321.1636.5117.2.

[26] Cheng C-Y, Fowles ER, Walker LO. “Postpartum Maternal Health Care in the United States: A Critical Review,” *J Perinat Educ*,15(3),34-42, 2006. doi:10.1624/105812406x119002.

[27] World Health Organization (WHO), “Postnatal care of the mother and newborn 2013,” *World Heal. Organ.*, pp. 1–72, 2013, [Online]. Available: http://apps.who.int/iris/bitstream/10665/97603/1/9789241506649_eng.pdf.

[28] Ann C. Celi, Ellen W. Seely, Penny Wang, Ann M. Thomas & Louise E. Wilkins-Haug. “Caring for Women After Hypertensive Pregnancies and Beyond: Implementation and Integration of a Postpartum Transition Clinic,” *Maternal and Child Health Journal*, vol. 23, pp. 1459-1466, 2019.

[29] J.Vora, P.Devmurari, S.Tanwar, S.Tyagi, N.Kumar, andM. S.Obaidat, “Blind signatures based secured E-healthcare system,” *CITS 2018 - 2018 Int. Conf. Comput. Inf. Telecommun. Syst.*, no. Cc, pp. 1–5, 2018, doi: 10.1109/CITS.2018.8440186.

[30] Z. Jin and Y. Chen, “Telemedicine in the cloud era: Prospects and challenges,” *IEEE Pervasive Comput*., vol. 14, no. 1, pp. 54–61, 2015, doi: 10.1109/MPRV.2015.19.

[31] R. Kraft *et al.*, “ESano - An eHealth Platform for Internet- and Mobile-based Interventions,” *Proc. Annu. Int. Conf. IEEE Eng. Med. Biol. Soc. EMBS*, pp. 1997–2002, 2021, doi: 10.1109/EMBC46164.2021.9629534.

[32] F. Bert et al., “Pregnancy e-health: A multicenter Italian cross-sectional study on internet use and decision-making among pregnant women,” *J. Epidemiol. Community*

Health, vol. 67, no. 12, pp. 1013–1018, 2013, doi: 10.1136/jech-2013-202584.

[33] A. Munandar, A. Setyanto, S. Raharjo, and G. Wicahyono, "Pregnancy mapping and monitoring web based geographic's information system," *2019 4th Int. Conf. Inf. Technol. Inf. Syst. Electr. Eng. ICITISEE 2019*, vol. 6, pp. 490–494, 2019, doi: 10.1109/ICITISEE48480.2019.9003916.

[34] G. Eysenbach, "What is E-health?," *Journal of Medical Internet Research*, vol. 3, 2001. Available at http://www.jmir.org/2001/2/e20. Accessed June 25, 2020.

[35] M. Schrepp and J. Thomaschewski, "Design and Validation of a Framework for the Creation of User Experience Questionnaires," *Int. J. Interact. Multimed. Artif. Intell*., vol. 5, no. 7, pp. 88–95, 2019, doi: 10.9781/ijimai.2019.06.006.

[36] I. Kurniawan, "The Effect Of The Information System Quality, Service Quality, And User Satisfaction On Academic Information System User Loyalty," *Lume*, vol. 10, no. 05, p. 5, 2021, [Online]. Available: www.ijstr.org.

[37] S. A. Onashoga, A. S. Sodiya, T. O. Omilani, and H. O. Ajisegiri, "A mobile phone-based antenatal care support system," *Proc. - ICSEng 2011 Int. Conf. Syst. Eng.*, pp. 410–415, 2011, doi: 10.1109/ICSEng.2011.81.

[38] J. Tang, C. Abraham, E. Stamp, C. Greaves, "How can weight-loss app designers' best engage and support users? A qualitative investigation," *Br. J. Health Psychol*, 20,151–171, 2015. doi:10.1111/bjhp.12114.

[39] K. S. Gibson, T.P. Waters, P.M. Catalano, "Maternal weight gain in women who develop gestational diabetes mellitus, " *Obstet. Gynecol*, 119(3), 560–565, 2012. doi:10.1097/AOG.0b013e31824758e0.

[40] A. Rhodes, A. D. Smith, P. Chadwick, H. Croker, and C. H. Llewellyn, "Exclusively digital health interventions targeting diet, physical activity, and weight gain in pregnant women: Systematic review and meta-analysis," *JMIR mHealth uHealth*, vol.

8, no. 7, 2020, doi: 10.2196/18255.

[41] Lothian, J. A., “Lamaze Breathing What Every Pregnant Woman Needs to Know,” *The Journal of Perinatal Education*, 20(2),118-120, 2011, doi:10.1891/1058-1243.20.2.118.

[42] C. Wu et al., “The combined effects of Lamaze breathing training and nursing intervention on the delivery in primipara A PRISMA systematic review meta-analysis,” *Med. (United States)*, vol. 100, no. 4, pp. 1–8, 2021, doi: 10.1097/MD.0000000000023920.

[43] Lazdam M, de la Horra A, Diesch J, Kenworthy Y, Davis E, Lewandowski AJ, Szmigielski C, Shore A, Mackillop L, Kharbanda R, et al, “Unique blood pressure characteristics in mother and offspring after early onset preeclampsia,” *Hypertension*, 2012;60:1338–1345. doi: 10.1161/HYPERTENSIONAHA.112.198366.

[44] McManus RJ, Mant J, Bray EP, Holder R, Jones MI, Greenfield S, Kaambwa B, Banting M, Bryan S, Little P, Williams B, Hobbs FD, “Telemonitoring and self-management in the control of hypertension (TASMINH2): a randomised controlled trial,” *Lancet*, 2010;376:163–172.
doi: 10.1016/S0140-6736(10)60964-6.

[45] McManus RJ, Mant J, Haque MS, et al, “Effect of self-monitoring and medication self-titration on systolic blood pressure in hypertensive patients at high risk of cardiovascular disease: the TASMIN-SR randomized clinical trial, ” *JAMA*. 2014;312:799–808.
doi: 10.1001/jama.2014.10057.

[46] National Institute for Clinical Excellence (NICE), “Clinical Guideline 107 (CG107),” 2011. https://www.nice.org.uk/guidance/cg107.

[45] T. Krishnamurti, A. L. Davis, G. Wong-Parodi, B. Fischhoff, Y. Sadovsky, and H. N.

Simhan, “Development and testing of the myhealthypregnancy app: A behavioral decision research-based tool for assessing and communicating pregnancy risk,” *JMIR mHealth uHealth*, vol. 5, no. 4, pp. 1–11, 2017, doi: 10.2196/mhealth.7036.

[46] N. D. Valakunde *et al.*, “Smart ASHA pregnancy monitoring system,” *2017 Int. Conf. Big Data, IoT Data Sci. BID 2017*, vol. 2018-Janua, pp. 185–192, 2018, doi:10.1109/BID.2017.8336596.

[47] J. Kitt *et al.*, “Postpartum blood pressure self-management following hypertensive pregnancy: Protocol of the Physician Optimised Postpartum Hypertension Treatment (POP-HT) trial,” *BMJ Open*, vol. 12, no. 2, 2022, doi: 10.1136/bmjopen-2021-051180.

[48] A. E. Cairns, K. L. Tucker, C. Crawford, R. J. McManus, and J. Powell, “Implementing self-management: A mixed methods study of women’s experiences of a postpartum hypertension intervention (SNAP-HT),” *Trials*, vol. 21, no. 1, pp. 1–13, 2020, doi: 10.1186/s13063-020-04394-z.

[49] HTML5, Available at https://html.spec.whatwg.org/, Accessed Nov 4, 2020.

[50] jQuery, Available at https://jquery.com/, Accessed Nov 4, 2020.

[51] PHP, Available at https://www.php.net/, Accessed Nov 4, 2020.

[52] M. Lindvall et al., “Agile software development in large organizations,” *Computer (Long. Beach. Calif).*, vol. 37, no. 12, pp. 26–34, 2004, doi: 10.1109/MC.2004.231.

[53] S. I. Adam and S. Andolo, “A New PHP Web Application Development Framework Based on MVC Architectural Pattern and Ajax Technology,” *2019 1st Int. Conf. Cybern. Intell. Syst. ICORIS 2019*, vol. 1, no. August, pp. 45–50, 2019, doi: 10.1109/ICORIS.2019.8874912.

[54] Douglas Crockford, "Introducing JSON," Available at http://www.json.org/, Accessed Nov 4, 2020.

[55] jQuery Mobile, Available at https://jquerymobile.com/, Accessed Nov 4, 2020.

[56] Highcharts, Available at https://www.highcharts.com/, Accessed Nov 4, 2020.

[57] Mei-ling Gao, e.a., “Practical Obstetric & Gynecologic Nursing,” Farseeing Publishing Co., 9 Edition. p.482-484, 2021.

[58] T.W.M., The Research Methods Knowledge Base, 2nd ed., http://www.socialresearchmethods.net/kb/scallik.php, Accessed Nov 12, 2021.

附錄 A 產前自我照護資訊管理系統評估調查問卷

產前自我照護資訊管理系統評估調查問卷

敬愛的女士您好：

這是一份學術研究問卷，目的在瞭解您對使用產前自我照護資訊管理系統的看法，您的意見對本研究有相當的價值，期望這研究能提供給本系統使用者一個更完善的 e 化環境，讓之後的使用者在使用時更便利，以提升本系統的使用效率。

本研究僅供學術之用，所有資料內容不會對外公開，請您安心填寫。謝謝您的支持。

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身體健康、工作愉快

成功大學

工科所博士生　張仲瑋 先生

工科系教授　侯廷偉 博士

敬上

A.個人基本資料

A1.年齡：□未滿 20 歲 □20～29 歲 □30～39 歲 □40～49 歲 □50 歲以上

A2.學歷：□高中（職）以下（含）□專科 □學士 □碩士 □博士

A3.懷孕次數: □第一胎 □第二胎 □第三胎 □三胎以上

A4.目前懷孕月數: □1~3 個月 □3~6 個月 □6 個月以上

A5.孕前身高: _____ 公分

A6.孕前體重: _____ 公斤

B. 系統使用後的使用者意見表

B1.您對於系統整體使用狀況?

□非常滿意 □滿意 □普通 □不滿意 □非常不滿意

B2.您覺得系統對您懷孕期間是否有幫助?

□非常滿意 □滿意 □普通 □不滿意 □非常不滿意

B3.您覺得寶寶超音波照片的上傳功能如何?

□非常滿意 □滿意 □普通 □不滿意 □非常不滿意

B4.您覺得體重管理的功能如何?

□非常滿意 □滿意 □普通 □不滿意 □非常不滿意

B5.您覺得血壓管理的功能如何?

□非常滿意 □滿意 □普通□不滿意 □非常不滿意

B6. 您覺得胎動紀錄的功能如何?

□非常滿意 □滿意 □普通 □不滿意 □非常不滿意

B7. 您覺得宮縮紀錄的功能如何?

□非常滿意 □滿意 □普通 □不滿意 □非常不滿意

B8.(若下次懷孕)是否會再次使用本系統?

□會 □不會

B9.若您的親朋好友懷孕，是否會推薦使用本系統?

□會 □不會

附錄 B 孕產期體重及飲食管理系統評估調查問卷

孕產期體重及飲食管理系統評估調查問卷

敬愛的女士您好：

這是一份學術研究問卷，目的在瞭解您對使用孕產期體重及飲食管理系統的看法，您的意見對本研究有相當的價值，期望這研究能提供給本系統使用者一個更完善的 e 化環境，讓之後的使用者在使用時更便利，以提升本系統的使用效率。

本研究僅供學術之用，所有資料內容不會對外公開，請您安心填寫。謝謝您的支持。

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工科所博士生　張仲瑋 先生

工科系教授　侯廷偉 博士

敬上

A.個人基本資料

A1.年齡：□未滿 20 歲 □20～29 歲 □30～39 歲 □40～49 歲 □50 歲以上

A2.學歷：□高中（職）以下（含）□專科 □學士 □碩士 □博士

A3.懷孕次數: □第一胎 □第二胎 □第三胎 □三胎以上

A4.目前懷孕月數: □1~3 個月 □3~6 個月 □6 個月以上 □產後

A5.孕前身高: _____ 公分

A6.孕前體重: _____ 公斤

B. 系統使用後的使用者意見表

B1.您對於系統整體使用狀況?

□非常滿意 □滿意 □普通 □不滿意 □非常不滿意

B2 您覺得系統所顯示的各項資訊容易閱讀?

□非常滿意 □滿意 □普通 □不滿意 □非常不滿意

B3.您對系統的操作及使用方式感到容易使用?

□非常滿意 □滿意 □普通 □不滿意 □非常不滿意

B4.您對系統孕期體重建議成長曲線感到實用?

□非常滿意 □滿意 □普通□不滿意 □非常不滿意

B5.您對系統飲食管理功能感到實用?

□非常滿意 □滿意 □普通□不滿意 □非常不滿意

B6. 您對系統我的最愛食物功能感到實用?

□非常滿意 □滿意 □普通 □不滿意 □非常不滿意

B7. 您對系統圖片式輔助食物熱量估測功能感到實用?

□非常滿意 □滿意 □普通 □不滿意 □非常不滿意

B8.(若下次懷孕)是否會再次使用本系統?

□會 □不會

B9.若您的親朋好友懷孕，是否會推薦使用本系統?

□會 □不會

附錄 C 拉梅茲呼吸方法應用程式評估調查問卷

拉梅茲呼吸方法應用程式評估調查問卷

敬愛的女士您好：

這是一份學術研究問卷，目的在瞭解您對拉梅茲呼吸方法應用程式的看法，您的意見對本研究有相當的價值，期望這研究能提供給本系統使用者一個更完善的ｅ化環境，讓之後的使用者在使用時更便利，以提升本系統的使用效率。

本研究僅供學術之用，所有資料內容不會對外公開，請您安心填寫。謝謝您的支持。

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敬上

A.個人基本資料

A1.年齡：□未滿 20 歲 □20～29 歲 □30～39 歲 □40～49 歲 □50 歲以上

A2.學歷：□高中（職）以下（含）□專科 □學士 □碩士 □博士

A3.懷孕次數: □第一胎 □第二胎 □第三胎 □三胎以上

A4.目前懷孕月數: □1~3 個月 □3~6 個月 □6 個月以上

A5.孕前身高: _____ 公分

A6.孕前體重: _____ 公斤

B. 系統使用後的使用者意見表

B1.您覺得此應用程式所顯示的各項資訊容易閱讀?

□非常滿意 □滿意 □普通 □不滿意 □非常不滿意

B2.您覺得此應用程式所顯示的各項資訊完整?

□非常滿意 □滿意 □普通 □不滿意 □非常不滿意

B3.您覺得此應用程式的操作及使用方式流暢?

□非常滿意 □滿意 □普通 □不滿意 □非常不滿意

B4. 您覺得此應用程式介面設計閱覽舒適?

□非常滿意 □滿意 □普通 □不滿意 □非常不滿意

B5. 您覺得此應用程式衛教資訊實用性?

□非常滿意 □滿意 □普通□不滿意 □非常不滿意

B6. 您覺得此應用程式影像教學實用性?

□非常滿意 □滿意 □普通 □不滿意 □非常不滿意

B7. 您覺得此應用程式自我練習呼吸波形實用性?

□非常滿意 □滿意 □普通 □不滿意 □非常不滿意

B8 您覺得此應用程式紀錄使用日期、次數實用性?

□非常滿意 □滿意 □普通 □不滿意 □非常不滿意

B9. 您覺得此應用程式整體的使用滿意度?

□非常滿意 □滿意 □普通 □不滿意 □非常不滿意

B10.整體而言，此應用程式對於您在孕產期間照護的幫助?

□非常滿意 □滿意 □普通 □不滿意 □非常不滿意

B11.(若下次懷孕)是否會再次使用本系統?

□會 □不會

B12.若您的親朋好友懷孕，是否會推薦使用本系統?

□會 □不會

附錄 D 產後高血壓健康管理系統評估調查問卷

產後高血壓健康管理系統評估調查問卷

敬愛的女士您好：

這是一份學術研究問卷，目的在瞭解您對使用產後高血壓健康管理系統的看法，您的意見對本研究有相當的價值，期望這研究能提供給本系統使用者一個更完善的 e 化環境，讓之後的使用者在使用時更便利，以提升本系統的使用效率。

本研究僅供學術之用，所有資料內容不會對外公開，請您安心填寫。謝謝您的支持。

敬祝

身體健康、工作愉快

成功大學

工科所博士生　張仲瑋 先生

工科系教授　侯廷偉 博士

敬上

A.個人基本資料

A1.年齡：□未滿 20 歲 □20～29 歲 □30～39 歲 □40～49 歲 □50 歲以上

A2.學歷：□高中（職）以下（含）□專科 □學士 □碩士 □博士

A3.懷孕次數: □第一胎 □第二胎 □第三胎 □三胎以上

A4.孕前身高: _____ 公分

A5.孕前體重: _____ 公斤

B.系統使用後的使用者意見表

B1.您對於系統整體使用狀況?

□非常滿意 □滿意 □普通 □不滿意 □非常不滿意

B2.您覺得系統對您產後健康管理有幫助?

□非常滿意 □滿意 □普通 □不滿意 □非常不滿意

B3 您覺得系統所顯示的各項資訊容易閱讀?

□非常滿意 □滿意 □普通 □不滿意 □非常不滿意

B4.您對系統的操作及使用方式感到容易使用?

□非常滿意 □滿意 □普通 □不滿意 □非常不滿意

B5.您對血壓脈搏管理功能感到實用?

□非常滿意 □滿意 □普通□不滿意 □非常不滿意

B6.您對血壓圖表分析功能感到實用?

□非常滿意 □滿意 □普通 □不滿意 □非常不滿意

B7.您對體重紀錄功能感到實用?

□非常滿意 □滿意 □普通 □不滿意 □非常不滿意

B8.您對產後運動功能感到實用?

□非常滿意 □滿意 □普通 □不滿意 □非常不滿意

B9.您對用藥管理功能感到實用?

□非常滿意 □滿意 □普通 □不滿意 □非常不滿意

B10.您對危險因子評估功能感到實用?

□非常滿意 □滿意 □普通 □不滿意 □非常不滿意

B11.您對 LINE 智慧聊天室感到實用?

□非常滿意 □滿意 □普通 □不滿意 □非常不滿意

B12.您對衛教指南建議資訊感到實用?

□非常滿意 □滿意 □普通 □不滿意 □非常不滿意

B13.(若下次產後)是否會再次使用本系統?

□會 □不會

B14.是否會推薦您的親朋好友懷孕使用本系統?

□會 □不會