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Antenatal care management platform

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Abstract

Background Pregnancy is a process of developing a fetus in a woman's womb leading to anatomical and physiological changes. Currently, numerous health facilities offering antenatal services are yet to adopt health informatics. This led to several challenges, including unskilled, early and poor quality antenatal and delivery care, case traffic because many patients are admitted per day, and shy medical professional doctors, nurses, midwives and nursing aids. The main idea of this project was to design and develop a new system for managing maternal health in antenatal care.

Methods This web-based antenatal care management platform is designed using XAMPP, PHP, HTML and CSS. It involves designing the stoner interface and identifying the inputs, outputs, and processes of the designed system. The configuration involves the use of case diagrams, sequence diagrams and class diagram tools to achieve the physical consummation of the antenatal care management platform and positive living information system. The purpose of this work was to create a web-based platform for managing antenatal care.

Results The designed project was tested by using parameters such as WHO guidelines, security, user-friendliness and data storage. Three testing criteria, namely, unit testing, integration testing and system testing, were used to check the efficiency and effectiveness of the antenatal care management platform (ANCMP). The platform that was created met almost all of the criteria that were set out in the design.

Conclusion This project is objectively targeted to develop a web-based antenatal care management system to overcome the complications that occur during and following gestation.

It controls the overall conditioning of antenatal care, which includes the enrollment of expectant mothers, shadowing of the listed day and reminding them via email and effectively recording and saving all medical information about the mothers.

Keywords Antenatal care, Maternal health, mHealth, Free and open-source web server

Background

The term "pregnancy" refers to the period when a fetus develops inside a woman's womb or uterus. It typically takes 9 months from fertilization to birth, calculated from the last menstrual cycle to delivery. Some infants do, however, arrive early or late [1, 2]. WHO claims that using health informatics may significantly enhance the operational effectiveness of healthcare institutions. To improve collaboration between patients and different

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healthcare professionals, healthcare information is acquired, stored, retrieved, and utilized, which is referred to as health informatics [3]. Knowing what to look for throughout pregnancy can make it easier to keep an eye on both the mother's and the unborn child's health. The most typical symptoms of pregnancy are a missed period, headaches, weight gain, heartburn, pregnancy-induced hypertension, breast changes, vomiting, and others [4, 5]. Records are typically preserved in a conventional antenatal care management system for management ease, future reference, reclamation, and reproduction.

Taking proper care of pregnant women is critical for the health of both the mother and the unborn child since pregnancy is a crucial period to encourage healthy behaviors and parenting skills [6]. The ongoing care for reproductive, maternal, newborn, and child health must include antenatal care (ANC) [7]. Healthcare professionals teach women about safe pregnancy practices, dangerous complication symptoms, breastfeeding, and family planning during this time, as well as how to recognize and manage pregnancy-related disorders such as preeclampsia and eclampsia [8]. The likelihood that the woman and her family would use a trained attendant at delivery improves with effective control of ANC, which also promotes excellent health throughout the life cycle [9].

The WHO states that three components make up the quality of ANC: the first is assessment, which includes taking a patient's history, performing a physical examination, and ordering laboratory tests; the second is health creation, which includes nutrition counseling, birth planning, information about pregnancy, using posterior contraception and breastfeeding, and immunization; and the third is care provision, which includes tetanus toxoid vaccination, providing psychosocial support, and keeping records [10]. Health issues that develop before, after, or sporadically while pregnant are referred to as complications of pregnancy [11].

Pregnancy-related problems, such as infections, pre-eclampsia, and postpartum hemorrhage, are the main causes of death for women. Nearly 75% of all maternal fatalities are caused by these problems, the majority of which may be avoided [12]. The primary causes of mortality include chronic illnesses like HIV/AIDS and problems associated with pregnancy and delivery. Approximately 10.7 million women worldwide are estimated to have passed away from pregnancy-related causes. Hemorrhage, hypertensive disorders, and sepsis were among the direct obstetric causes of almost 73% of all maternal fatalities. Over 50% of maternal fatalities occur as a result of them globally [13]. High blood pressure, hypertension, anemia, urinary tract infection, premature delivery, and infection are a few of the problems [14].

Both paper-based and computer options are available to assist users in keeping track of various elements of their health. However, the majority of these solutions are not intended for use in the general healthcare system for prenatal care. Pregnant women and healthcare professionals frequently communicate with one another using the paper hand-held record (PHR) [15]. The lady takes the card, which she keeps with her after each visit to either the community clinician or the sanitarium. This enhances communication between healthcare professionals, lowers anxiety, and encourages women's engagement in their treatment [16]. A provider's paper chart with a patient's medical history, diagnosis, prescriptions, vaccine dates, contraindications, test findings, and doctor's comments are all digitally represented in an electronic medical record (EMR) [14]. Since they enable communication and collaboration among members of a healthcare team for the best patient care, electronic medical records (EMRs) are more than just a relief for paper records [14]. The structured collection of cases and population health information that is electronically recorded in a digital format is known as an electronic health record (EHR), and these records may be transferred throughout various healthcare settings [17]. EHR systems are made to reliably retain data, capture a patient's status over time, and disseminate that data through other information networks and exchanges or enterprise-wide information systems that are networked [18]. EHRs are patient-centered, real-time records that replace the need to locate a patient's prior paper medical records by storing a patient's medical history, diagnoses, prescriptions, treatment plans, dates of immunizations, allergies, radiological pictures, and laboratory test results [19, 20].

The paper-based prenatal care system lacks accessibility, security, and ease of reading your record. If the paper becomes worn, it may also become misplaced. The thousands of cards in the poker area are not easy to obtain quickly [21]. The material may be difficult to obtain because it is written in free text. Only one sanitarium has access to the electronic paper-based prenatal care system. However, if the mother switches hospitals, she will undergo a fresh examination. Since the medical record is only available her mother cannot see the bits of advice given to her from anywhere.

Maternal mortality is defined as the death of a woman while she is pregnant or within 42 days of the pregnancy's termination due to any factor that is connected to or made worse by the pregnancy or its care [22]. It is the end consequence of pregnancy, birth, or care of the two problems. In Ethiopia, there are 401 maternal fatalities for every 100,000 live births [23, 24]. Hemorrhage (29.9%), obstructed labor (22.34%), pregnancy-induced hypertension (16.9%), anemia (10.39%), and malaria (4%), were the

primary reasons for maternal mortality. High mother and child morbidities and mortalities in Sub-Saharan Africa (SSA) are mostly caused by inadequate access to ANC, intrapartum, and postnatal care services [25, 26]. Acceptable antenatal care can minimize newborn and mother mortality rates.

At present, Ethiopia does not have an effective way to handle the data of pregnant women. The current manual system faces various challenges such as the arduous and costly journeys that pregnant women have to undertake to reach health centers, the high rate of infant mortality, inadequate training leading to poor health conditions for mothers and their children, lack of communication between women and healthcare providers, unexpected pregnancies and birth complications, substandard delivery services, and inadequate monitoring of absent mothers. Most often, healthcare institutions and individuals fall short of all three standards, which causes a high fatality rate. To enhance maternal health, barriers that prevent women from receiving high-quality care must be identified and eliminated on a social and healthcare system level. The main problem the existing are lack of communication, lack of accessibility, lack of communication, lack of proper counseling, poor client and health profession interaction, poor surveillance method.

Consequently, there is a need for a system that reliably and effectively records data, aids health professionals with potential tasks, reminds both health professionals and pregnant women about the scheduled visit, raises awareness of the importance of follow-up, and enables health professionals to survey pregnant women.

Method

The proposed design

The antenatal care management system's primary goals are to make it simple for users to enter data and store it in the database. Both healthcare professionals and expectant mothers themselves may access it whenever required because it displays essential information about the mother from prior visits. Therefore, the antenatal care management platform (ANCMP) proposed in this design research is a web-based system that routinely warns and notifies physicians, nurses, and midwives in case of crises and provides reminders to attend the hospital. Users of the portal can submit and change clinical data and test results in addition to browsing medical material.

The designed system consists of five clients/users, as indicated in Fig. 1. These are Admin, receptionist, doctors/midwife and laboratory technician/radiologist. Each of the users has exclusive roles. Administrators oversee the entire system, ensure that users are registered as doctors, laboratory technicians, and receptionists who work for the particular healthcare facility, and approve their

enrollment in the system. The receptionist, who plays two key functions, serves as the system's alternate client. The first step is helping patients who are not tech-savvy sign up for the web system. Additionally, receptionists look up instances that have previously registered in the system and contact the doctors in charge.

A doctor is the third client. Unlike other clients, mothers have several unique needs that doctors must address. They are in charge of gathering information for an initial examination such as obstetric history, the status of the current pregnancy, general medical history, and general and genealogical exams. They are responsible for entering all data on the integrated antenatal card, except for those related to testing for syphilis, blood groups, infections, proteins, and hemoglobin. The database used to track trends in patients' well-being trends is updated with recorded data. The technology automatically delivers advice through email addresses when doctors submit counseling and advice to the database. More crucially, the system keeps track of the mother's appointment date and notifies her when there is just one day remaining.

A laboratory technician/radiologist is the fourth client. They perform infection testing, protein tests, syphilis tests, blood group tests, and hemoglobin tests upon doctors' orders. They also go through imaging tests, if any. Patient clients are all pregnant women who begin follow-up using this platform. They are qualified to view all of their documented histories on the system after they have enrolled. The platform for managing prenatal care added to the body of knowledge concerning the creation of digital health applications. The fully working system serves as a knowledge base for researchers conducting research in related subjects.

Materials used

The physical realization of the antenatal care management platform and verification that the information system complies with quality requirements are accomplished using several types of technologies. The materials and parameters utilized to build the prototype are shown in Table 1.

System implementation

The major goal of this project was to create a platform for managing antenatal care to enhance the Ethiopian antenatal care management system. After design and development were complete, the ACNMP was put into various production settings to see if the anticipated design requirements were reached. Various methods and instruments were employed, as indicated in Table 2, to determine if the goals had been achieved. To achieve the design goals for ANCMP, many users have to engage with the system using various computers and cell phones. Figures 2, 3, 4, 5, 6 and 7 show screenshots of webpages that were taken when the created ANCMP was being implemented.

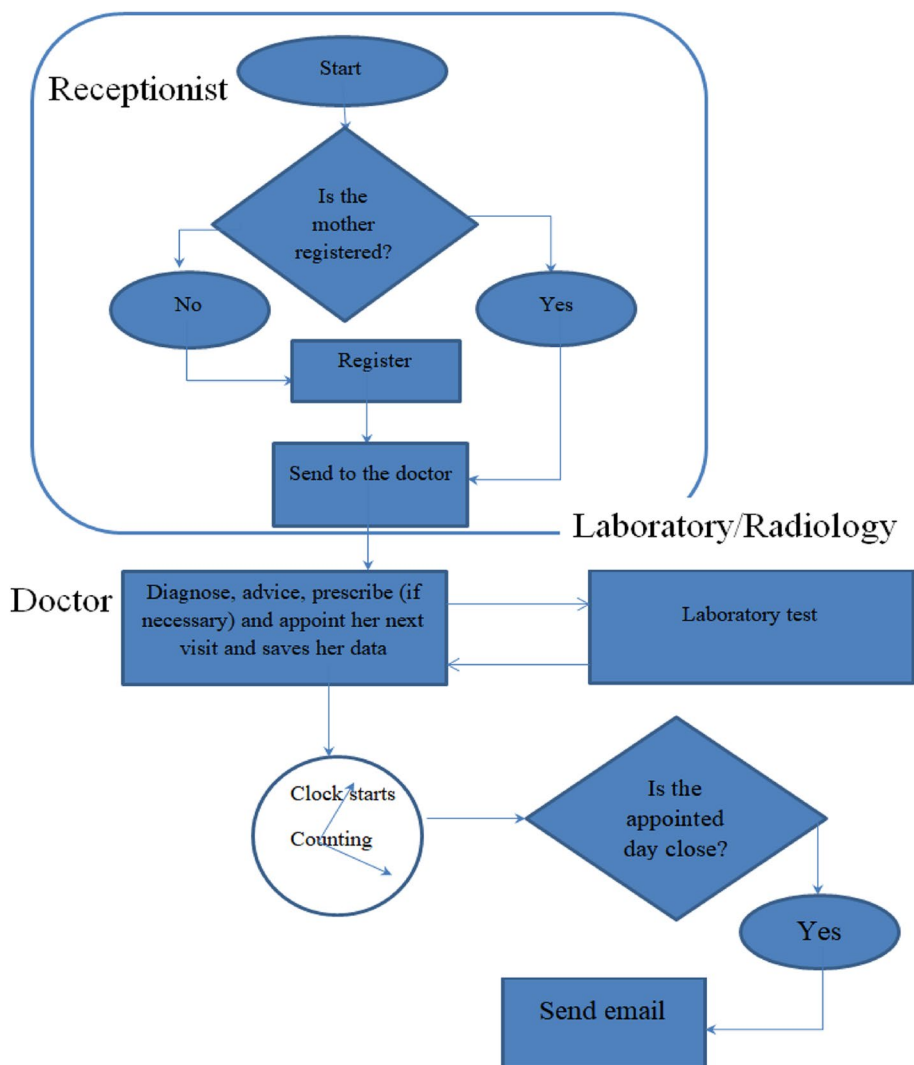


Fig. 1 Flow diagram of the proposed design

Table 1 List of materials and specifications used to construct ANCMP

S. No	Items	Specification
1	XAMPP	<ul style="list-style-type: none"> • The term stands for Cross-platform Apache, MYSQL PHP Perl. • It is free and easy to use and easily available for Windows, Linux and Mac OS. • It is beginner’s friendly solution package for full-stack web development.
2	PHP	<ul style="list-style-type: none"> • The term stands for hypertext pre-processor. • It is integrated with several popular databases like MySQL, Informix and Microsoft SQL server. • It is also Simple Efficient, Secure, Flexible, Familiar
3	HTML	<ul style="list-style-type: none"> • The term stands for Hyper Text Markup Language which is used for the creation of webpages. • It has a series of elements that tell the browser how to display the content
4	CSS	<ul style="list-style-type: none"> • The term stands for cascading style sheet. • It is ruling-based language and layout of control multiple pages at once • It describes how HTML elements are displayed on the screen, paper, or other media.
5	Bootstrap	<ul style="list-style-type: none"> • Is a front-end framework used for designing an interface for the user, • Gives the ability to create responsive designs for both mobile and desktop screen sizes.

Table 2 A summary of methods and techniques used to achieve the objectives

Tools	Techniques/Method	Objectives
✓ Literature review	<ul style="list-style-type: none"> ✓ Reviewing and reading secondary data, about existing antenatal ✓ Data collection and analysis 	✓ To determine requirements for the proposed antenatal care management platform
✓ Using software like MS Visio	<ul style="list-style-type: none"> ✓ Using data flow diagrams, ✓ Modeling and drawing 	✓ To design the antenatal care management platform specifications
✓ Using soft wares like Android Studio, IDEs, Android emulator, Firefox	<ul style="list-style-type: none"> ✓ Prototyping using XAMPP, PHP, HTML, CSS, and Java. 	✓ To implement, test, and validate the antenatal care management information system

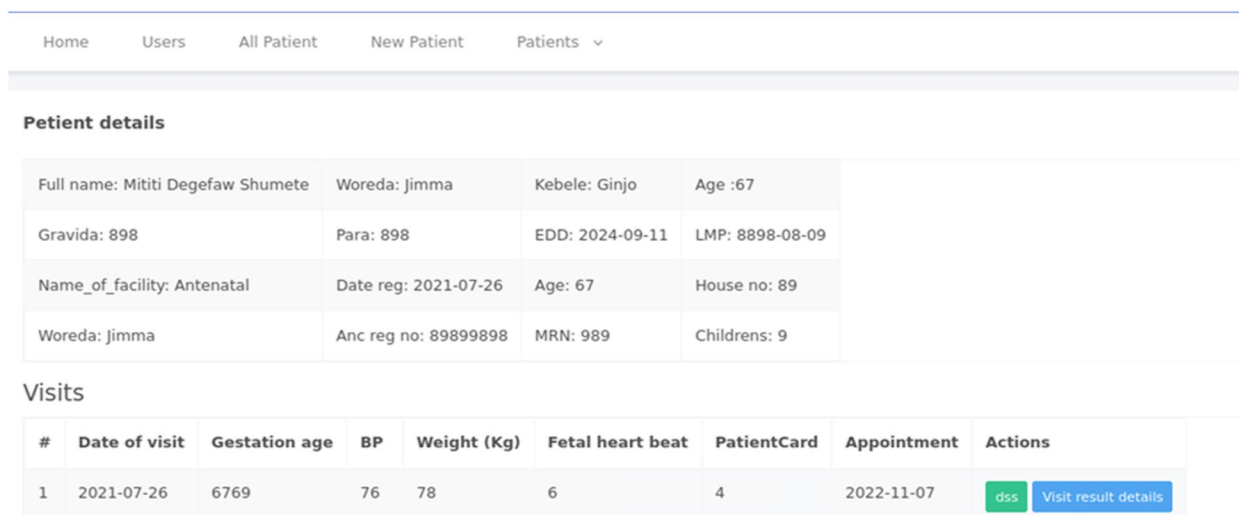


Fig. 2 The 1st visit of ANCMP on the web

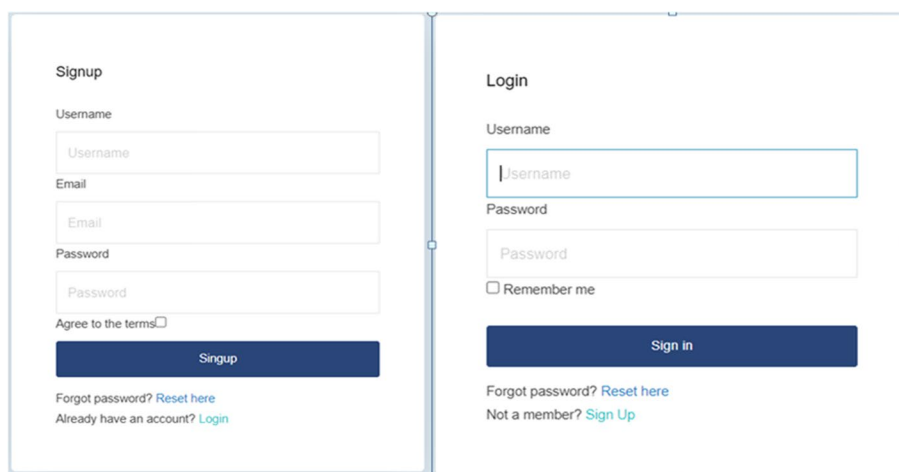


Fig. 3 The signup and login pages of ANCMP

#	Full name	Username	Email	Phone number	Roles	Actions
1	Mignot Yizengaw		miggnot@gmail.com	09876766766	["ROLE_USER"]	Edit Roles Profile
2	Hawi Wondimu	hawi	hawiwondimu@gmail.com	0987654667	["ROLE_USER","ROLE_DOCTOR"]	Edit Roles Profile
3	one admin ma	admin	admin@admin.com	090000000	["ROLE_ADMIN","ROLE_USER"]	Edit Roles Profile
4	Fuad Hassen Defo	Fuad	fuahas1@gmail.com	0973027884	["ROLE_USER","ROLE_DOCTOR","ROLE_PHARMACIST"]	Edit Roles Profile
5	Elias Fariq	Fariq	elarsi677@gmail.com	09328327444	["ROLE_USER","ROLE_LAB_TECHNITIAN"]	Edit Roles Profile

Fig. 4 ANCMP Patient management information

Doctor Name	Schedule Date	Schedule Day	Start Time	End Time	Consulting Time	Status	Action
Sarahsdoctor	2021-12-10	Sunday	06:34	23:34	65 Minute	Active	[Yellow] [Red]
Dr. Peter Parker	2021-11-30	Wednesday	04:00	22:30	50 Minute	Active	[Yellow] [Red]
Dr. Peter Parker	2021-11-30	Friday	09:00	14:00	60 Minute	Active	[Yellow] [Red]

Fig. 5 ANCMP schedule management information

WHO requirement

According to World Health Organization (WHO) recommendations, the frequency of contact and the kind of care provided are indicators of the quality of ANC. Every

expectant mother requires a minimum of 4 prenatal care visits and must undergo all required tests. By comparing the number of ANCMP visits developed based on the design and advice of the WHO and the Ethiopian

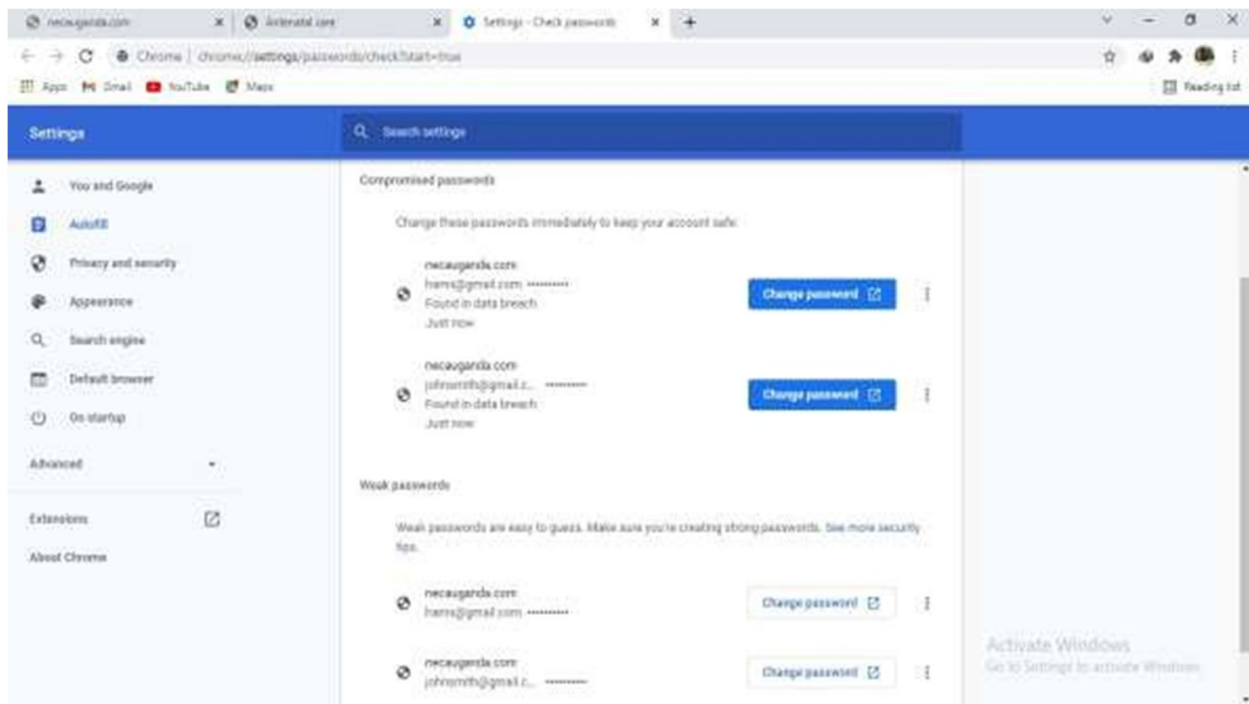


Fig. 6 ANCMP password recoveries

username	first_name	email	password
sss	Abebe	abekebe@gmail.com	\$2y\$13\$bsU0UjbfOVRk.V1Sse7uo.2xac7EMjdQk1sLS00MLZxrAji3UMONW
Fariq	NULL	elarsi677@gmail.com	\$2y\$13\$JQiJnG3JeJqjBk9K3Sjqu.DFLyBZEJf8VjjxcvUahAOKILecZ/fNO
Fuad	Fuad	fuhasi1@gmail.com	\$2y\$13\$Fue9Z2QCQ/EifzcmQK54W0Clue02JISLIgh5XFJsFsJCa5F/PtQbs

Fig. 7 Encrypted password

Ministry of Health, the effectiveness of WHO recommendations has been evaluated. Figure 2 depicts the levy person Mititi’s first ANCMP appointment, together with all the essential data and upcoming testing.

Login page

To utilize the system, users must be able to easily sign up and log in using an interactive platform. The developed website’s interaction (both on the login and signup pages) was compared to the most widely used social media platforms at the time. Both signing up and logging in using an email address and password are simple processes. Figure 3 shows the registration pages, which allow new users to access the system, and the login pages, which allow logged-in users to use the system. Only users who have been authenticated and have the right credentials are

logged in. The user has successfully logged in if the credentials are accurate. If users fail to input login details the system produces an error of either the wrong username or the wrong password.

Patient management information

Pregnant women should seek information early in their pregnancies to obtain the required guidance from their doctor. Since the platform was created to provide counseling services to the mother, she may go into her user account and view both her medical record and the advice that has been offered to her. Therefore, there will not be a knowledge gap when she applies the counsel that is offered to her. Patients and physicians may access the database on the server that contained data from the patients. The recording and storage of

specific patient management data, including name, email, address, contacts, email verification status, and activities. For this particular case, in place of patients' data, the team members' information was recorded, and they accessed the data using their username and password that they had created while signing up as shown in Fig. 4

Scheduling and reminding

The doctor will schedule her for the next appointment date to provide her second antenatal care service after the first visit of antenatal care. If the appointment day is approaching, the created platform keeps track of the dates and emails the mother. Figure 5 demonstrates how the ANCMP schedule and reminder information management system sets the date in a surprisingly quick amount of time using our team member's name and password. The name of the physician, scheduled day and date, start and finish times, consulting time, status, and action are all included.

Security

To provide additional security for everyone who uses the system and to need admin clearance for staff signup, the system must decode the password that is kept on a platform to prevent the data from being altered. By establishing the user password and comparing the password that was input and the password that was saved, the password was encrypted. The password reset form is shown in Fig. 6 and assists users in recovering forgotten passwords when they enter the incorrect password. The pop-up alerts the user to check their password; after doing so, the user may view their current password and modify it as necessary. Figure 7 shows password encryption where the applied password was 123456 by the use of the function called crypt.

Testing and result

Testing involves evaluating the system's quality and making corrections after pointing out errors or faults. To determine if the system met user needs and expectations, ANCMP was put to the test. The usefulness and efficiency of the ANCMP architecture were examined using three testing criteria: unit testing, integration testing, and system testing.

Integration testing

All modules have undergone thorough testing to ensure their reliability, validity, and quality assurance. To assess their performance, the design criteria that were subjected to unit testing and are given in Table 3 were examined as a whole.

System testing

The whole system functionality was tested. The designers acknowledge that all the modules were tested on various devices using various inputs and the system showed consistency in giving the outputs as it had been required to do.

Unit testing

For unit testing, several items of ANCMP were tested against the inputs into the system to validate and verify their functionality. Table 3 demonstrates the units/items, testing method, expected results and actual result of the developed ANCMP.

Discussion

A vital moment to improve health behaviors and parenting skills may be during pregnancy. Therefore, crucial to look after pregnant women for the sake of both the mother and the unborn child. Maternal mortality is the phrase used to describe the death of a woman while she is pregnant or within 42 days after the pregnancy's termination from any cause related to or made worse by the

Table 3 Unit testing results

Item/Unit	Test description	Expected results	Actual results
• Username/ Email	<ul style="list-style-type: none"> ✓ leave it blank ✓ type a wrong user name ✓ type the correct username 	<ul style="list-style-type: none"> ✓ An error message that informs the user that username/ email can't be blank ✓ The error message tells the user that the user name/email is incorrect ✓ No error is expected 	<ul style="list-style-type: none"> ✓ Error message; user name/email cannot be blank ✓ Error message; incorrect user name/email ✓ No error
• Password	<ul style="list-style-type: none"> ✓ leave it blank ✓ type the wrong password ✓ type correct password 	<ul style="list-style-type: none"> ✓ an error message that tells a user that the password cannot be blank ✓ an error message tells the user that the password is incorrect ✓ No error 	<ul style="list-style-type: none"> ✓ Error message; the password cannot be blank ✓ Error message; incorrect password ✓ No error
• Login button	<ul style="list-style-type: none"> ✓ click on button 	<ul style="list-style-type: none"> ✓ if the password and email are correct, the user successfully logs in to ANCMP 	<ul style="list-style-type: none"> ✓ User logs in successfully

pregnancy or its care. It continues to be the most common and dangerous issue because of a pregnancy or birth difficulty, or because there isn't a good ANC management strategy in place. The purpose of this work was to create a web-based platform for managing antenatal care. It has features of a web-based platform that efficiently records ANC data, a system that reminds pregnant women about each visit's appointment and delivers counseling services via the platform for pregnant women. The design involves developing web-based digitalized antenatal care in the health care center. The system will register and record data of expectant mothers digitally, remind and schedule an appointment and help health professionals monitor and manage the health of expectant mothers by providing quality antenatal care for safe delivery of the mother.

This platform was designed to educate the mothers and give them needed advice without going to a hospital or health center. However, the history of the mothers is registered on the website on their 1st visit. They can access their history and obtain different advice about where they are. They will be alarmed when their date of appointment is nearer. When the mother goes to the hospital for her 1st ANC visit, she will be asked for her background history and diagnosed physically by observation and by lab tests. These histories and lab test results will be saved on the server. After the 1st visit, the second, third and fourth visits will show the previous visit history. After the diagnosis, the doctor or the physician will give her the next date of appointment. Then the server will count down and when the date of her appointment gets closer, the mother will be alarmed by email notifications. Every mother that is registered on this website will have their username and password so that nobody except the mother sees her history.

For the construction of the ANCMPP platform XAMPP, PHP, HTML and CSS were used. Before using these platform design plans, steps were followed. Among many text editors that are used for writing these codes, the Atom code editor was selected and used for writing the code. Then the front page of every page that is seen on the web is designed and written in HTML. However, it is not attractive on its own, so CSS is used to make it more attractive. Then, to connect the code to the server, XAMPP was used as a server and created a database table on XAMPP. Here PHP is used to connect the created database and the pages that had been HTML. The developed ANC management system achieves all the design criteria of the WHO and the Minister of Health requirements. The data must be kept from being altered or destroyed in an unauthorized manner. The patient should be registered, and her patient record should be seen by logging in to her account. The patient should be reminded of the date of appointment for the registered

mother by sending an email. It should be user-friendly and easy to use, and it should save the medical and diagnosis history of the mother.

The designed system allows users to enter data easily and save it to the database. It will also allow users to browse medical content, and upload and modify clinical data and laboratory results. It will show necessary data of the mother from previous visits so that both healthcare providers and pregnant women themselves can access it whenever needed. The system notifies the mother of the next scheduled visit by sending an email. The ANCMPP enables users to create, update, search, and delete antenatal-related records. In addition, the user can book an appointment with available doctors in the system by exporting the records to other file types such as PDF and HTML. For the proper functioning of ANCMPP, the user needs a reliable internet connection since it is a web-based application. Therefore, ANCMPP helps the antenatal care management system manage records while protecting the principles of information security, that is, data confidentiality, integrity, and availability. The system deployment contributes to the development of a pathway to adaptive and intertwined guidelines in digital systems to improve the quality, coverage and responsibility of health systems including high-risk pregnant women, to reduce barriers to accessing care and reach out to women not accessing care.

Conclusion and future work

Antenatal care is generally thought to be an effective method of improving pregnancy outcomes and its quality depends on the number of visits and the quality of the content. The designed system (ANCMPP) provides an information management system in antenatal care. It is secure, user-friendly which makes it a proper solution to the manual systems used in managing records within antenatal care. Its user interface makes it easier to access all the information without necessarily moving from one page to another, therefore, the user does not have more challenges in accessing the content, creating, streamlining and retrieving records. The designed system allows users to enter data easily and save it to the database. It will also allow users to browse medical content and upload and modify clinical data and laboratory results. It will show necessary data of the mother from previous visits so that both healthcare providers and pregnant women themselves can access it.

The designed antenatal care management platform effectively solves the problems related to the sustainability of quality service delivery to pregnant mothers. However, to make the system more effective, additional features such as "Free Online antenatal" education service and SMS features even reach further to the rural

areas where there is not sufficient internet access and the government provides subsidized or free web hosting to each hospital for the ANCMP web application.

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Authors' contributions

AAD and DD are the overall coordinators of this study, and they conceptualized, designed, and implemented it in collaboration with the main investigators' AA, BM, FH, GD, HW and MY. All authors contributed to the preliminary study, design, prototyping, and testing. The article was drafted by AAD, taking into account the comments and suggestions of the co-authors. All coauthors had the opportunity to comment on the manuscript. The author read and approved the final manuscript.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

This research has been approved by Jimma University's institutional review board (IRB: 36/2019) and the study was conducted following the Declaration of Helsinki (as revised in 2013). All methods were carried out under relevant guidelines and regulations. In addition, in this experiment involving human participants, informed consent was obtained from all subjects. In this experiment involving human participants, informed consent was obtained from all subjects.

Consent for publication

Participants provided written, informed statement for publication of their data.

Competing interests

The authors declare no competing interests.

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