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PAPER

Mobile Application Prototype: AP3S to Prevent Stunted Babies

Emy Rianti[1](✉), Rr. Sri Endang Pujiastuti[2], Agus Triwinarto[3]

[1]Health Polytechnic of Jakarta I, South Jakarta, Indonesia

[2]Health Polytechnic of Semarang, Semarang City, Indonesia

[3]National Institute of Health Research and Development, South Jakarta, Indonesia

emy.rianti@poltekkesjakarta1.ac.id

ABSTRACT

Stunting in toddlers is a serious concern because it can have various short and long-term adverse effects. Therefore, it is necessary to design a mobile-based system to monitor the health of pregnant women early on so that stunted babies can be prevented. This study aims to develop a prototype of an application for early detection of stunting risk in Android-based antenatal care services. This application prototype is made in Indonesian and is called: "*Aplikasi Pendampingan Percepatan Penurunan Stunting (AP3S)*"/Stunting Reduction Acceleration Assistance Application. The methodology applied is the system development life cycle (SDLC), one of the primary methods for developing mobile applications in the health sector. As a result, a prototype application with a design and functionality that facilitates access for pregnant women can connect directly with health workers and monitor and consult further. As for health workers, AP3S can provide a comprehensive health analysis of antenatal care, including nutrition for pregnant women, fetal growth monitoring, and health education. AP3S has the advantage of being able to immediately display the risk of babies born stunted or babies with low birth weight so that preventive interventions can be carried out immediately. In conclusion, after conducting a literature study and prototype development, an efficient, easy-to-use, and safe application prototype was obtained to facilitate patient access to health services to prevent babies born with stunting.

KEYWORDS

antenatal care, mobile application, stunting

1 INTRODUCTION

According to World Health Organization (WHO) data in 2022, 22.3%, or 148.1 million children under five, were stunted, 6.8%, or 45.4 million, were underweight, and 5.6%, or 38.9 million, were overweight. Almost all affected children live in Asia (52% of the global total) and Africa (43%). Based on the World Health Assembly Nutrition (WHAN) target for 2025, it aims to reduce the proportion of stunting in children under five by 40%. More intensive efforts are needed to achieve

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the global target of reducing the number of stunted children to 89 million by 2030. With current progress, 39.6 million children will miss the 2030 target [1]. Indonesia is one of the middle-income countries in Asia that faces serious challenges related to nutritional health. According to the 2019 Global Nutrition Report, Indonesia has a significant prevalence of under-five nutrition problems, including stunting at 30.8%, wasting at 10.2%, and overweight at 8.0%. Among the three problems, stunting among children under five is the most severe issue in Indonesia, with the highest prevalence among countries with similar economies [2].

Based on data from the Indonesian Health Survey (IHS) 2023, the stunting prevalence is still at 21.5%, only 0.1% lower than in 2022 (21.6%). This figure is still considered high, considering that WHO targets the stunting rate to be no more than 20% [3]. Meanwhile, this figure still needs to be closer to the stunting reduction target set by the Indonesian government, which is 14% by 2024. Currently, Indonesia is ranked fifth in the world for the incidence of stunting in children under five years of age [4].

Stunting is a critical public health issue due to its far-reaching impact on individuals and society. Stunting is a chronic growth disorder caused by a lack of nutritional intake, especially in the first 1000 days of life [5]. Stunting is a condition of failure to grow in children caused by chronic malnutrition, infections, and environmental factors [6]. Nutrition plays a vital role in ensuring good health and encouraging optimal development of the human body, especially in children [7]. Children who suffer from malnutrition experience growth and developmental delays compared to their peers. The significant factors related to stunting in rural and urban areas are the complicated interaction between socioeconomic factors and access to health services [8].

One factor supporting stunting is limited health services, which include quality antenatal care, postnatal care, and early learning services [9]. The long-term impact of stunting on child growth and development is physical and mental health problems [10]. Stunting has a long-term effect on children's physical, cognitive, and social development. Stunting that is not handled correctly can continue into adulthood, which increases the risk of chronic diseases and decreases work productivity [9]. Therefore, stunting prevention efforts must be thoroughly carried out through health services, one of which is antenatal care (ANC). ANC is care provided professionally by health workers (obstetricians, general practitioners, nurses, and midwives) to pregnant women during pregnancy, starting from the first, second, and third trimesters [11].

The quality of ANC is essential to prevent stunting in babies born. Therefore, it is necessary to design a mobile-based system to monitor the health of pregnant women early on so that babies can be prevented from being stunted. Digital technology is an innovative solution to improve health services [12]. According to Bitar, antenatal care apps are challenging to develop [13]. Moniaga et al. argue that interactive multimedia can increase simplicity, user engagement, intuitiveness, and availability in processing data on stunting cases [14].

Research related to the use of health applications has been widely carried out in Indonesia; for example, a Baby Center application can be downloaded on mobile devices, providing information about care and nutrition for children. The National Population and Family Planning Agency in Indonesia made the "ELSIMIL" (*Elektronik Siap Nikah dan Hamil*/Electronics Ready for Marriage and Pregnancy) application, which can detect prospective brides who are at risk of having stunted children. In Egypt, the utilization of health services for children under the age of five is still low. With the "Sehhat Tefy app," the app was downloaded 1445 times in four months [15].

Likewise, research on Android-based applications to prevent stunting has been widely developed. One of them is "*Aplikasi Cegah Anak Lahir Stunting (ACALS)*," which used the 2016 Indonesian government program Maternal and Child Health Book (MCH) [6]. The MCH book is a tool for recording actions given to pregnant women by health workers in health facilities in Indonesia, including *Pusat Kesehatan Masyarakat* (*Puskesmas*)/Community Health Centers and their networks (auxiliary *Puskesmas*, mobile *Puskesmas*, and village midwives within the *Puskesmas* organization), clinics, doctor practices, midwife practices, and hospitals [16].

The "*Aplikasi Pendampingan Percepatan Penurunan Stunting (AP3S)*" prototype was designed differently from other previous applications. AP3S has gone through design improvements, including 1) two user authorities in one application, 2) adjusting to the latest government program, namely the MCH Book in 2023, which is guided by the number of ANC visits at least six times during pregnancy, namely: at least 1 ANC visit in the first trimester, with at least one examination by a doctor; at least 2 ANC visits in the second trimester; and at least 3 ANC visits in the third trimester, with at least one examination by a doctor, 3) monitor and evaluate the consumption of Blood Supplement Tablets for nine months, with minimum consumption of 90 tablets [16]. The AP3S prototype is an android-based technology solution developed with the aim of early detection of stunting risk in antenatal care services in health facilities in Indonesia.

2 LITERATURE REVIEW

Rianti et al. designed two applications, "ACALS," for two users that aim to assist pregnant women and health workers in optimizing ANC visits at least four times during pregnancy. This application also monitors the compliance of pregnant women to drink blood supplement tablets according to the program, which is for three months of pregnancy. This application is intended to monitor and evaluate the health conditions of pregnant women to prevent babies from being born stunted [17].

Muflihatin et al. designed the "Early Detection of Stunting (EDOS)" application, which aims to detect early nutritional status and stunting in infants under five years of age, using anthropometric standards based on the Regulation of the Minister of Health of the Republic of Indonesia Number 2 of 2020 on toddlers [18].

Rinawan et al. developed an application called "Integrated Service Post (*Posyandu*)." This application was created to speed up reporting data from the CHW book into the Information System at *Posyandu* to build a "bridge" between the community and the national level [19].

Permana et al. argue that the "Nutrimo" application is easy to use and informative for parents in monitoring child nutrition and can help prevent stunting. This study aims to automatically monitor children's nutritional status to prevent stunting by facilitating parents' access to nutritional information. This application is expected to help parents get dietary recommendations based on their child's nutritional status to prevent stunting [20].

Hidayat et al. argue that the Android application "*Gizi Anak Stunting (GiAS)*" can compare macronutrients, zinc, and calcium in stunted and non-stunted children aged 12–24 months. This application has features that detect stunting, monitor toddler growth, recommend daily menus for toddlers, and provide nutritional adequacy figures [21].

Akber et al. argue that mobile health "Infant and Young Child Feeding (IYCF)" is efficacious in improving mothers' knowledge, attitudes, and practices about feeding children ≤24 months of age in rural Islamabad. The application aims to assist the government in developing and implementing proper nutrition practices for infants and young children. However, full implementation of the m-health app requires further research on the cost-effectiveness of the intervention in maternal and child health programs [22].

3 METHODOLOGY

3.1 Methodology development

The Android platform was chosen because it is the largest smartphone platform in the world [23]. The Android platform used in this AP3S prototype is the Android 10 software development kit (SDK). This AP3S prototype design is built using Indonesian and is a user-friendly system that ensures an application that is easy to understand. The mobile application development method is adapted from the system development life cycle (SDLC) principle, which consists of five stages: planning, analysis, design, implementation, and maintenance [24]. Studies prove the use of SDLC in mobile application development, and an integrative literature review found that SDLC is one of the main methods in mobile application development in healthcare [25]. SDLC is a complete process that requires structured and rational actions to create a software product. The stages of making the AP3S prototype can be seen in Figure 1.

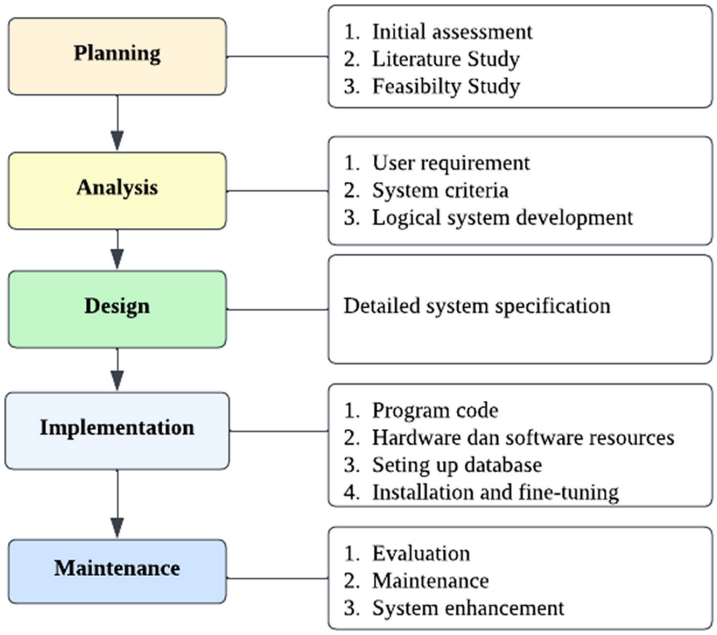

Fig. 1. AP3S prototype stage

AP3S methodology was created with an SDLC because it is very relevant in application development, so it can be ensured that AP3S is developed in a structured and beneficial way for pregnant women, effectively supporting the acceleration of stunting reduction.

The stages of the SDLC process in AP3S, especially about use cases, features, and usability of the application, include 1) the planning stage, which is carried out by defining the goals of AP3S development and identifying problems to be overcome, namely stunting. 2) The analysis stage, including the identification of problems related to stunting, the analysis of the need for more effective ANC services by health workers and pregnant women, so that it is decided that the initial use case and the main features support the goals of AP3S. User requirements: At this stage, the needs of pregnant women for ANC are collected and documented by focusing on user stories, use cases, and specific feature needs. Use cases describe pregnant women and health workers interacting with each other, such as pregnant women wanting to know the results of pregnancy tests, ANC status, and blood supplement tablet consumption status, and health workers providing data-based advice, and then pregnant women receive notifications. Features: Each use case is described in terms of application features, such as the feature of data input of pregnancy test results, ANC status, reminder notifications for the consumption schedule of blood booster tablets, ANC schedules, and education. 3) Design stage, including UI application architecture, namely layout such as placement of buttons, text, and image elements; visual elements, including colors, icons, and typography; menu-like interactivity; consistent design; and aesthetic design, which refers to the visual interface that healthcare workers and pregnant women will use to interact with AP3S, with a user-friendly design, especially for pregnant women with diverse cultural and educational backgrounds. The AP3S design is made to be tested and validated before further development. 4) The implementation stage involves applying code based on the agreed design and ensuring the feature works according to the set use case. The main features that have been determined for the development include backend development, which ensures data processing, such as the categories of all indicators in AP3S, and the cut-off value of the indicator runs smoothly. Meanwhile, the frontend development feature ensures the implementation of the user interface according to the prototype. 5) Maintenance stage: At this stage, AP3S will be tested to ensure functionality, safety, and usability by focusing on use cases to ensure that use cases can be carried out without errors, are easy to use by health workers and pregnant women with a low level of technological literacy. Then AP3S will be launched, additional features will be added based on user feedback, and maintenance will include updates and fixes.

3.2 Development tools

This section defined all the tools used to develop the prototype of the mobile:

Microsoft Word is a universal writing tool designed to suit all purposes of text production in all contexts and domains. MS Word is a text creation and layout program that can assume many functions of formatting text [26].

Adobe Illustrator is one of the vector-based editor applications that comes from Adobe Inc. Adobe Illustrator itself is software that can be used to create logos, illustrations, product packaging, typography, advertising designs, icons, etc. [27].

Draw.io is an open-source application for creating diagram-based applications and the most widely used browser-based application by those proficient in diagram applications [28].

Figma is a cloud-based design application that creates application designs, develops prototypes, combines design components, and produces interactive design elements. It can also collaborate anywhere in real time [29].

4 RESULT

4.1 About prototype

The AP3S prototype was explicitly built for two user authorities, namely pregnant women and health workers, and was used for ANC services in health facilities in Indonesia. The prototype has login functionality, creates accounts, stores data locally, tracks app usage, and sends personalized reminders via push notifications. AP3S also has functions designed so pregnant women users can visualize data or medical records after examinations and identify potential risks of stunting in children early from the results of ANC examinations.

4.2 Planning

The prototype development process established the necessary features and functional and non-functional requirements. Core functionality included providing local (push) notifications, storing data locally, and tracking app usage. AP3S is designed to send personalized reminders via push notifications to pregnant women, especially reminders for daily blood supplement tablet consumption during pregnancy, push notifications for ANC compliance, and reminders for pregnant women's risk factors and steps to prevent stunting. In addition to pregnant women, AP3S also provides reminders to health workers to monitor the entire ANC process for pregnant women in their working area.

4.3 Analysis

In the stage of determining the structure of AP3S, variables are determined as indicators of determining risk factors. The design and structure of the AP3S prototype for health workers consists of 1) admin login, and 2) a list of pregnant women, 3) completeness of pregnant women's biodata, 4) filling in the results of ANC examinations, which consist of 10 indicators, namely, weighing weight and height, measuring blood pressure, measuring upper arm circumference, measuring the height of the fundus uteri, examining fetal presentation and heart rate, tetanus toxoid injection, laboratory and ultrasound examination results, 5) filling in the ANC history carried out in the first trimester (16 indicators), second trimester (13 indicators), and third trimester (16 indicators), namely, date of examination, place of examination, weight, height, upper arm circumference, blood pressure, fundus uteri height, fetal presentation, tetanus toxoid injection, counselling, doctor's screening, blood tablets, hemoglobin examination, blood type, proteinuria, blood sugar, and ultrasound examination, 6) completeness of the blood supplement tablets calendar filled in by pregnant women, 7) completeness of health education reading, 8) results of early risk of stunting in pregnant women, and 9) filling in baby characteristics after the baby is born. The design and structure of the prototype for pregnant women consists of 1) creating an account, 2) filling in biodata, 3) viewing ANC examination result data, 4) viewing ANC history result data (trimester I, II, and III), 5) filling in the daily blood supplement tablet calendar, 6) reading health education, and 7) viewing the results of early risk of babies born with stunting. The design and structure of the AP3S prototype can be seen in Figure 2.

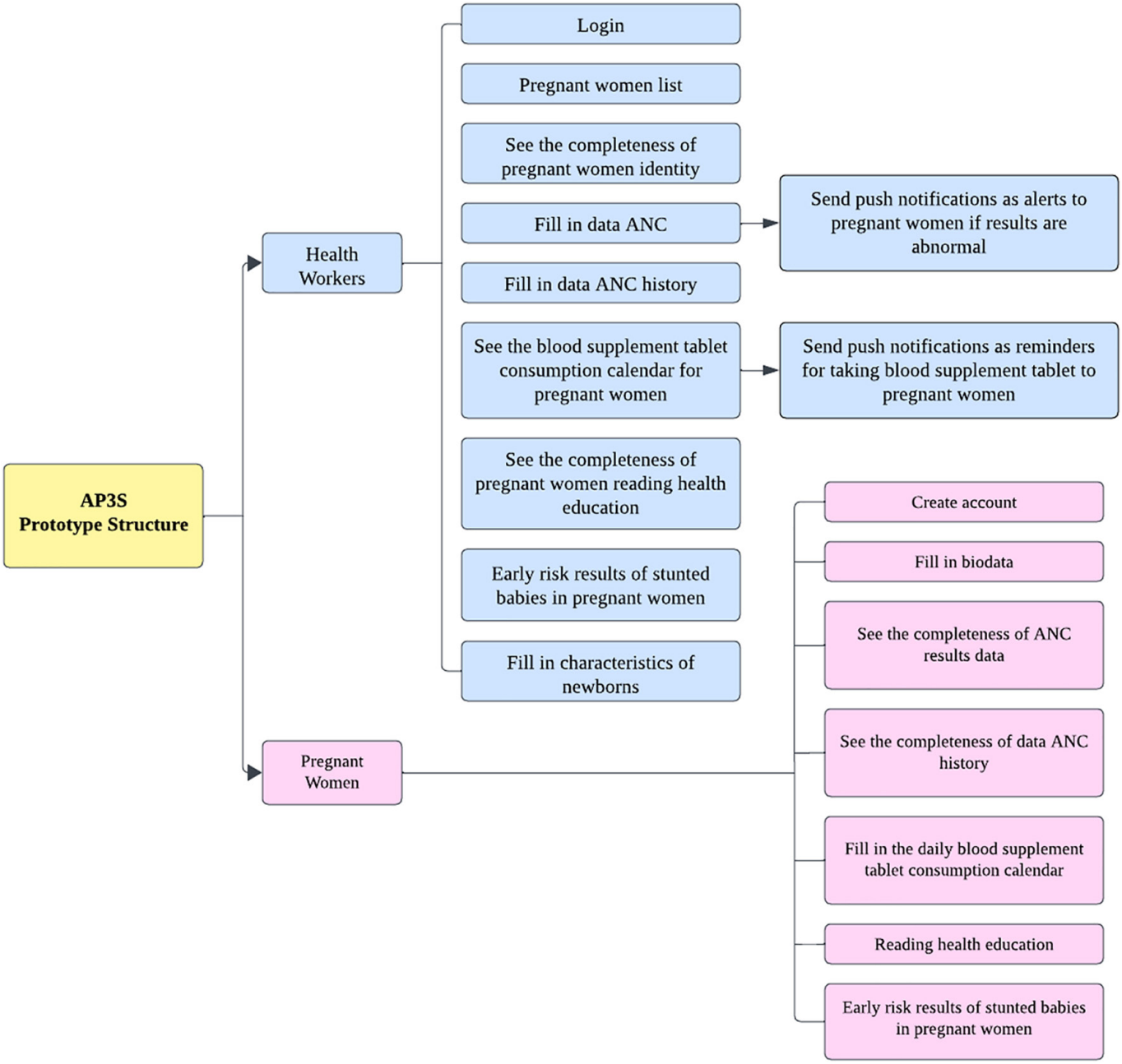

Fig. 2. AP3S design and structure

4.4 Design

Coding the system, namely compiling the selected programmer language, for example, web-based using HTML and PHP, creating and connecting the database with the system, creating system forms, and making manual books. Preventing stunting was developed to have a quality user interface (UI) component. UI is a general term that refers to software-based and physical systems that allow users to interact with technology, indicating that it is what users can access and see. UI design aims to ensure the best possible user experience in achieving user goals (user-oriented design). Researchers, designers, and IT experts conducted face-to-face meetings and

online discussions during the design phase from January 2024 to July 2024. The main goal was to integrate elements of an effective UI, including clarity to avoid confusion, familiarity with functionality, navigation methods, and responsiveness, including speed, aesthetics, and interface continuity, to help users understand usage patterns. After the requirements were finalized, the research team, with advice from IT experts, created a pregnant women user flow diagram to map and simulate the mobile application flow. The user flow diagram was drawn using Microsoft Word. Figure 3 presents a visualization of the activities carried out by pregnant women users, from logging in and filling in biodata to viewing notifications containing reminders for taking blood supplement tablets and reminders for the next ANC check-up visit.

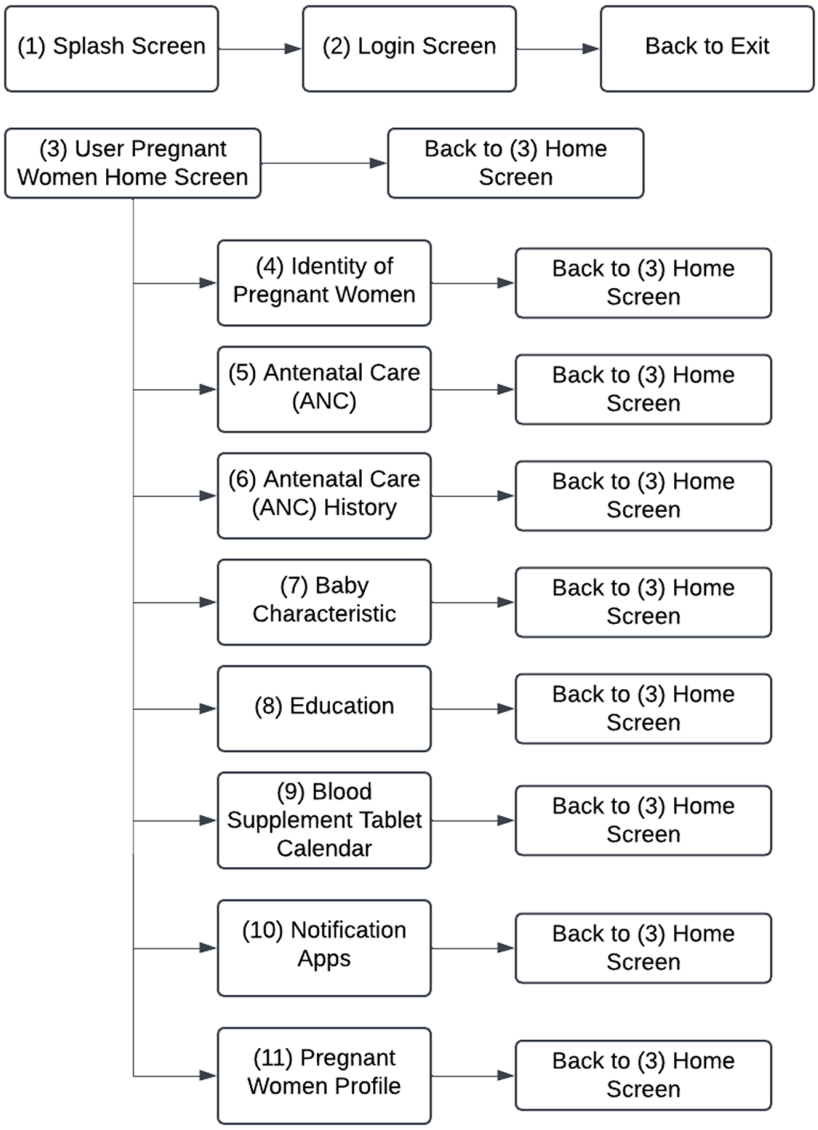

Fig. 3. User flow diagram of pregnant women

In addition, the research team also created a user flow diagram for health workers to map and simulate the flow of the mobile application. Figure 4 presents a visualization of the flow of activities carried out by health worker users, from logging in

and listing pregnant women to viewing notifications containing a list of pregnant women who have not taken blood supplement tablets and a list of pregnant women who have not made ANC visits.

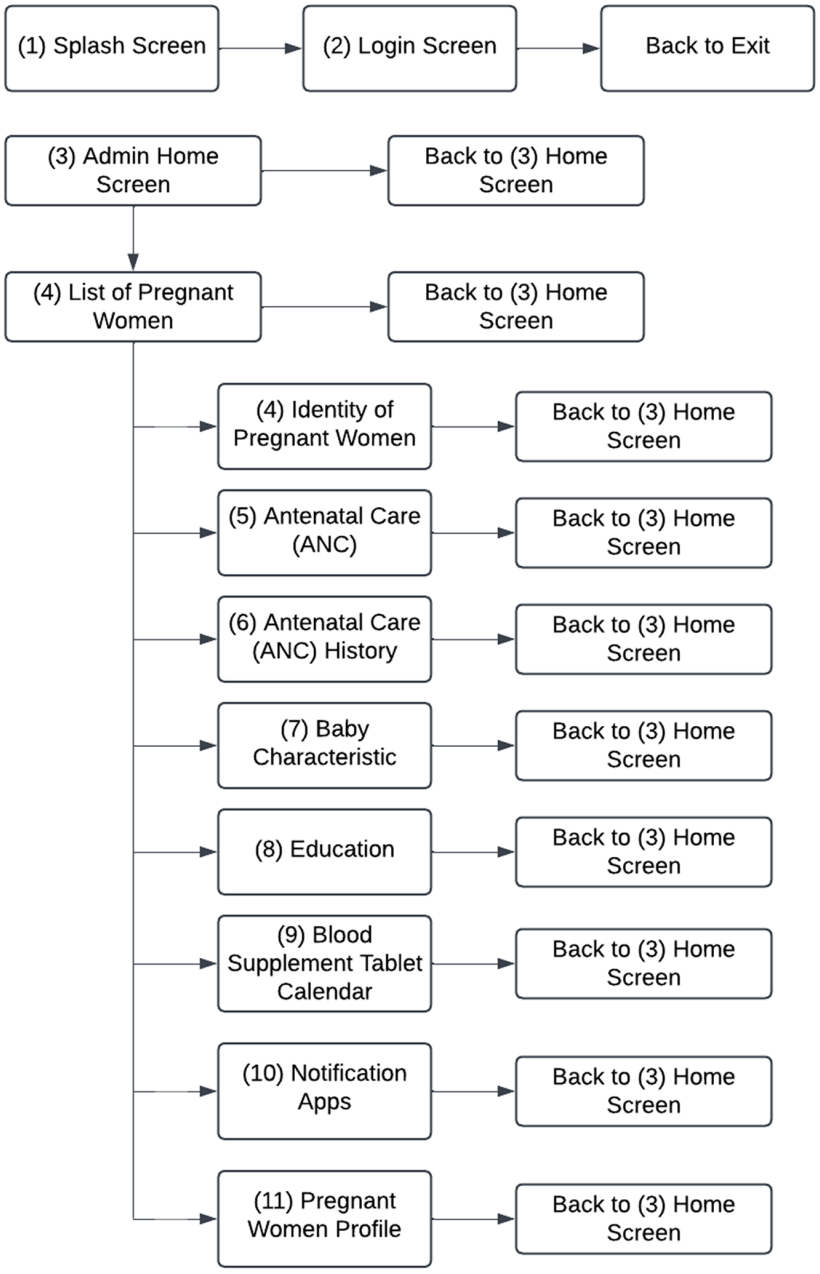

Fig. 4. User flow diagram of health workers

4.5 Implementation

Prototypes of mobile applications for the Android platform began to be developed in 2024. At this stage, the program is coded. The app's coding was done using Android Studio by the mobile app developer with guidance from an IT expert. To meet the specifications set by the research team, AP3S was built using the

Java programming language, and Google powered its application programming interface (API). The mobile app database was developed using MySQL MariaDB Server. The software program for the Android operating system comes in the android application package (APK) file format. The completed APK file is then used in the next stage of testing.

The design implementation consists of low-fidelity wireframes and high-fidelity wireframes. Wireframes, which are concise graphical depictions of the layout of a mobile app UI, were developed at the initial design stage. The research team created low-fidelity wireframes using Microsoft Word as simple sketches for the initial AP3S UI design, as shown in Figures 5–7. Figure 5 is a wireframe for pregnant women. Figure 6 is the first-page wireframe for health workers. Figure 7 in the second-page wireframe for health workers.

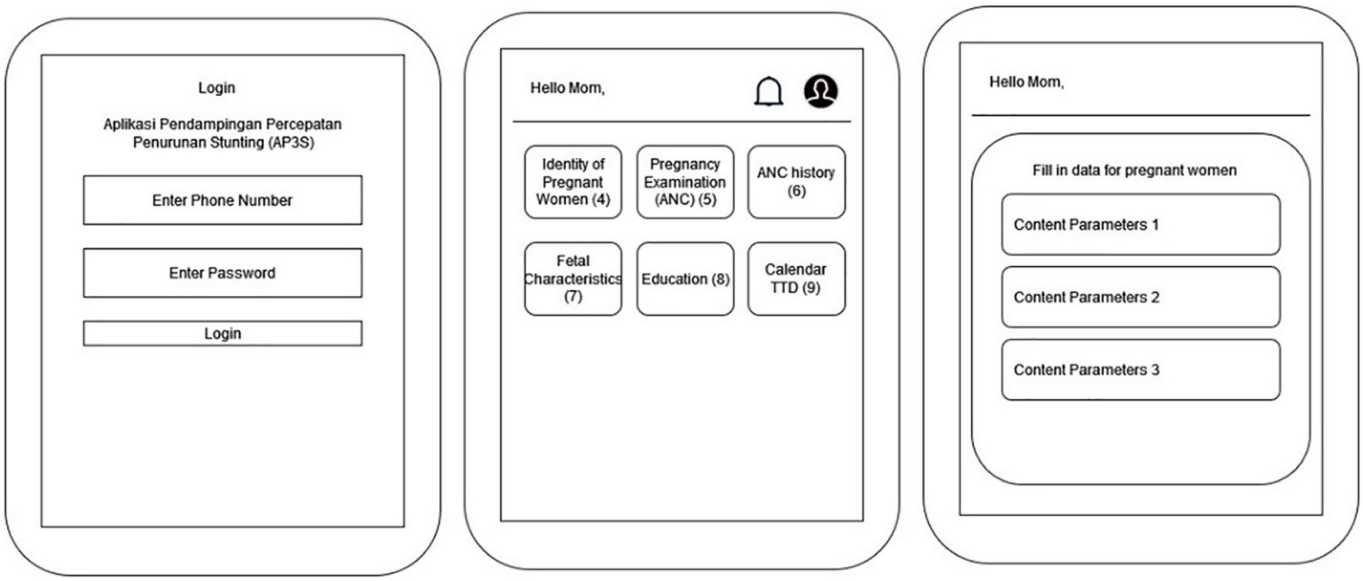

Fig. 5. Wireframe for pregnant women

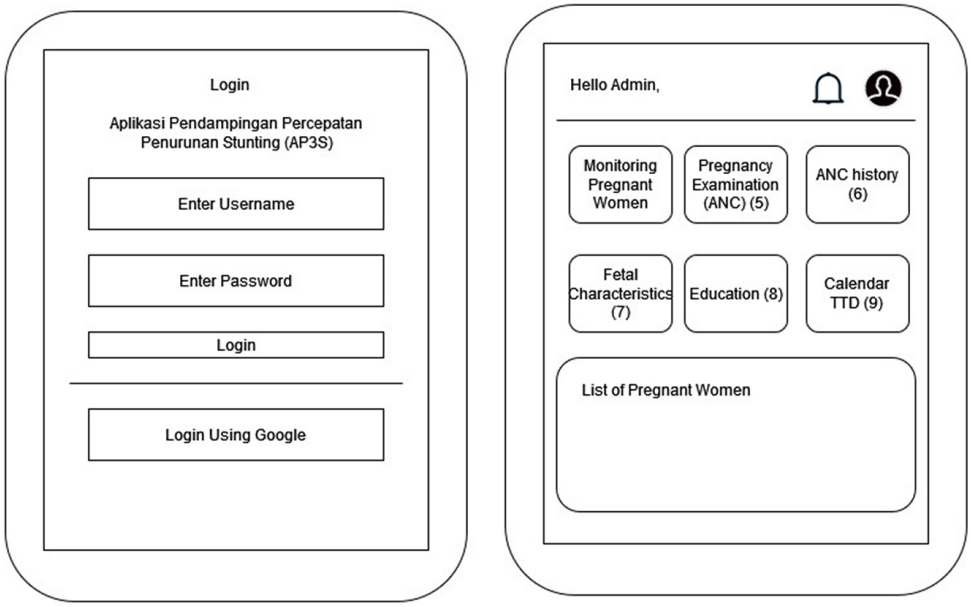

Fig. 6. First page wireframe for health workers

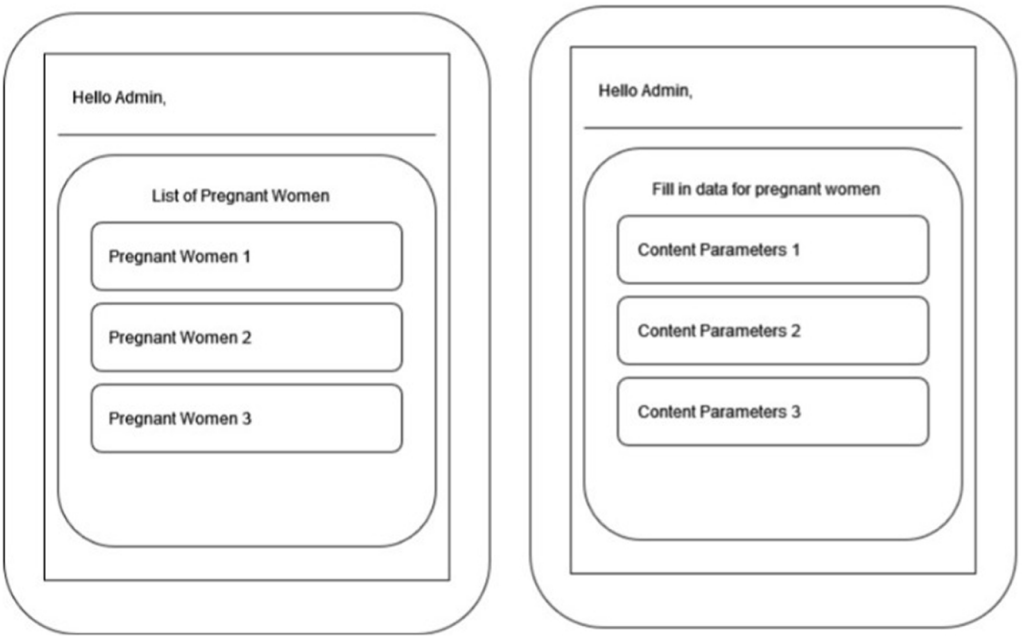

Fig. 7. Second-page wireframe for health workers

Furthermore, the researcher and design team developed high-fidelity wireframes (clickable mock models) to simulate navigation between screens using Adobe Illustrator. The initial design display on pregnant women users is shown in Figure 8. On this page, Pregnant women create an account. When the application is first run, pregnant women must create an account by filling in the phone number column, filling in the password column, filling in the confirm password column, and then submitting.

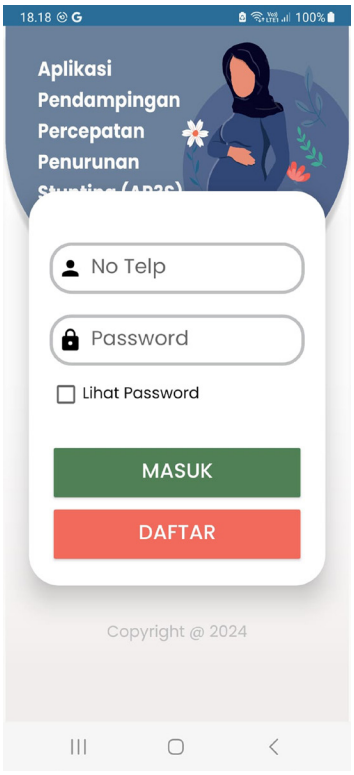

Fig. 8. Pregnant mother user login page (in Indonesian)

After the pregnant woman has successfully logged in, the display will look like in Figure 9. Pregnant women can complete their data on this page and fill in the daily blood tablet consumption calendar. Then, a local notification (push) will appear on the device screen at programmed intervals, as in Figure 10. Push notifications are instant and easy to follow up on, and this notification will remain in the user's Android notification until the user has finished following up on the notification. This local notification serves as a reminder and increases pregnant women's awareness of consuming and filling out the blood supplement tablet calendar.

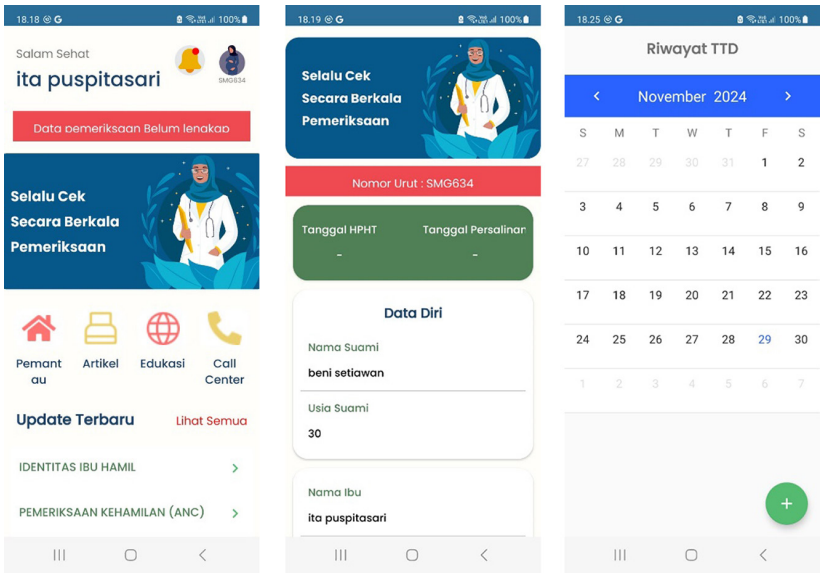

Fig. 9. Pregnant mother user home page

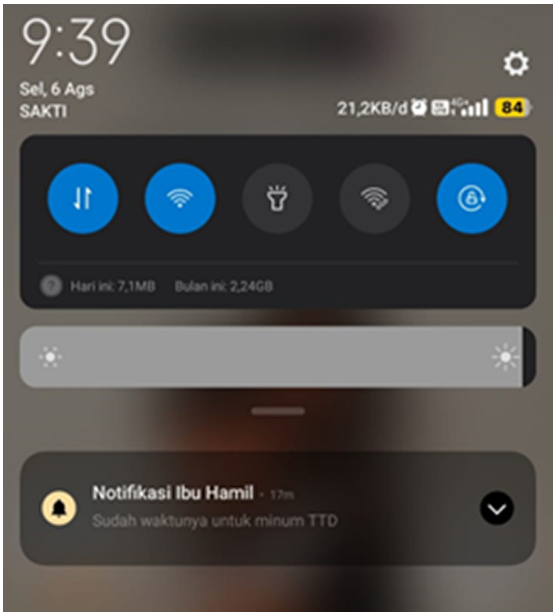

Fig. 10. Local notification

Display for health worker users. Log in using your ID and password, then enter the home page, as shown in Figure 11. Health workers can see data on pregnant women who have conducted examinations on this page.

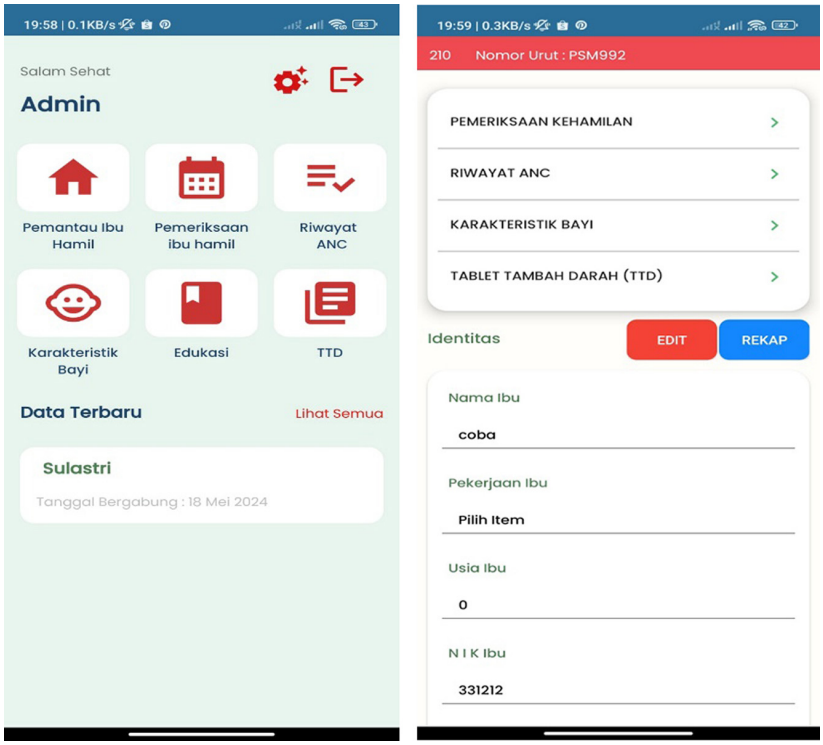

Fig. 11. Health worker user home page

On the data entry page, health workers can fill in according to the findings of the ANC examination results, which consist of indicators: weighing weight and height, measuring blood pressure, measuring upper arm circumference, measuring the size of the uterine fundus, checking presentation and fetal heart rate, tetanus toxoid injection, and laboratory examination results and ultrasound, as shown in Figure 12.

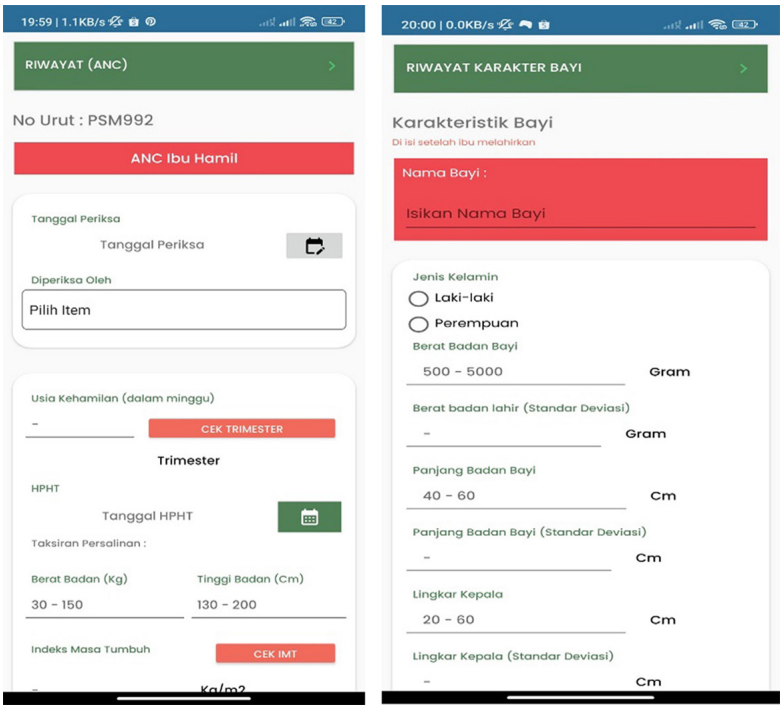

Fig. 12. Health worker data entry page

On the blood supplement tablet consumption monitoring page, health workers can monitor the consumption of blood supplement tablets filled in by pregnant women, as shown in Figure 13. Suppose it is found that pregnant women have not consumed or have not filled in the blood supplement tablet consumption calendar. In that case, health workers can send push notifications for additional reminders that the pregnant woman user will directly receive.

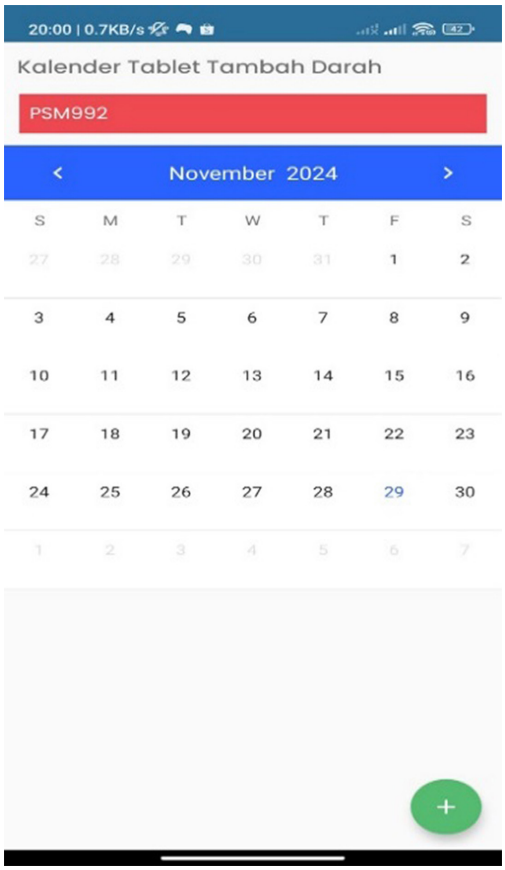

Fig. 13. Monitoring of blood supplement tablet consumption by health workers

4.6 Maintenance

Usage is the last stage in the SDLC. Here, the new system will be used in the actual environment, and maintenance will be carried out to adapt to changes or developments continuously. The activities undertaken are using the new system, evaluating the new system, maintaining the system by fixing errors, keeping the system updated, and developing the system.

4.7 Application output

The application output is in the form of scoring from the results of the examination and filling out the application, which can provide a prediction of the risk of giving birth to a baby born stunted (body length <48 cm) and/or with low birth weight (birth weight <2500 grams) as shown in Figure 14.

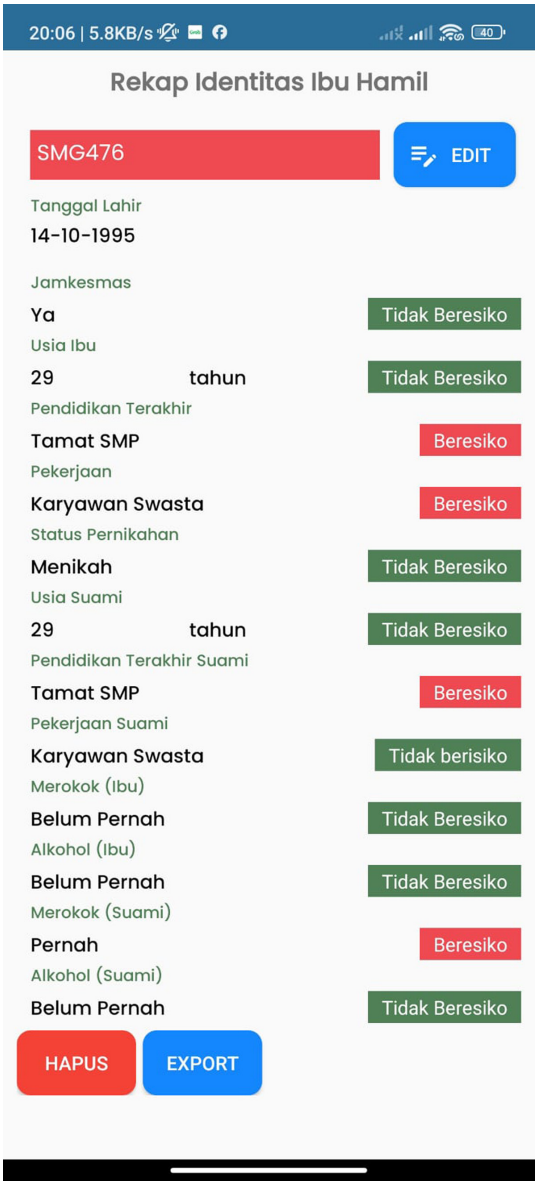

Fig. 14. List of early stunting risk prediction results

5 DISCUSSIONS

The purpose of developing the AP3S prototype is to prevent the birth of babies with stunting. This is in line with similar application prototype development research conducted by Rianti et al., which resulted in the ACALS application being one of the options for online maternal and child health services in the millennial era, which aims to prevent malnutrition in children and complications in pregnant women and is expected to reduce stunting in Indonesia [17]. Each stage of the design thinking process contains specific steps to design an application with the primary function of early detection of the risk of a child being born stunted. Pregnant women and health workers developed the app to provide a comprehensive health analysis of antenatal care, including maternal nutrition, fetal growth monitoring, and health education for pregnant women. Therefore, this prototype application was built

based on design thinking, novelty, and development, which proved suitable for early detection of stunting risk from pregnancy [18].

Pregnant women can connect directly with health workers so they can constantly be monitored and consult further with them. This application also helps pregnant women and their families (husbands and parents) monitor the health of pregnant women and take quick and appropriate action to avoid giving birth to children at risk of stunting. In addition, the development of this prototype is designed to be actionable by using push notifications that allow for behavioral improvements. Compared to other types of notifications, such as email, push notifications are instant and actionable, where giving a push notification will take the consumer directly to the mobile app. Notifications will also remain on the list until activated, ensuring they can genuinely act as reminders and prompts for further action [30].

Using web and mobile applications designed for child growth measurement and monitoring can provide valuable guidance for parents and health workers [31]. Therefore, there is an urgent need for an automated tool to detect malnutrition in children, enabling early intervention and improving health service outcomes [7]. It is also hoped that the application produced in this project can serve as a role model for future application function designers. This application can address the government's and society's nutritional health problems, especially stunting. While true, the research is still at the technical level of prototyping. However, from a general point of view, the prevention of stunting needs to be carried out thoroughly from the moment in the womb to postpartum. So, mothers need to do ANC because ANC is one of the early treatments that prevent stunting in newborns.

The advantage of AP3S is that it can immediately display the risk of a baby being born short or giving birth to a baby with low birth weight by calculating the total score from the examination results and filling out the application cut-off from the median value. If the score value is less than the median, it is considered that there is a risk of a baby being born stunting and a baby born with low birth weight. This risk can be recognized early by the mother, family, and health workers so that preventive interventions can be immediately carried out.

6 CONCLUSION

After conducting a literature study and developing the application, it can be concluded that it runs as expected and can be easily used by mothers and health workers to prevent the birth of stunted babies and/or babies with low birth weight.

The results of this study can significantly enrich the literature and develop new theories related to technology-based stunting prevention. AP3S is a technological innovation that will help address maternal and child health issues by enhancing the theoretical basis and impacting stunting prevention. The AP3S prototype can test the theory's validity in stunting prevention through interventions in maternal health services.

In terms of practice, AP3S can be used by health workers and pregnant women to accelerate stunting reduction through ANC assistance, monitoring the consumption of blood-boosting tablets, education, and data-based interventions. AP3S can help automate processes that were previously done manually, such as tracking the number of blood booster tablets consumed and the number of ANC visits of pregnant women in each trimester, to be faster and more accurate. AP3S can be a roadmap for developing other applications in the health sector, especially health services related to stunting in Indonesia.

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8 AUTHORS

Emy Rianti is an Associate Professor at Health Polytechnic of Jakarta I, Jakarta, Indonesia. She received her bachelor's degree in Nursing and the Nursing Profession from the Faculty of Nursing Science, University of Indonesia. She received masters' in Epidemiology from the Faculty of Public Health, University of Indonesia. She received her Ph.D. in Religion and Health from Jakarta State Islamic University, Indonesia. Her research interests include public health, especially maternal and child health, including stunting and low birth weight babies (E-mail: emy.rianti@poltekkesjakarta1.ac.id).

Rr. Sri Endang Pujiastuti is an associate professor at the Health Polytechnic of Semarang, Indonesia. She received her bachelor's degree in Public Health from the Faculty of Public Health at Diponegoro University, Semarang, Indonesia. Received her Master of Nursing degree from the Nursing Faculty of Prince of Songkla, Thailand. Received her Ph.D. in education from Semarang State University, Indonesia. Her research interests include public health, especially maternal and child health (E-mail: roropujiastuti@poltekkes.ac.id).

Agus Triwinarto is a Health Policy Analyst, working for the Ministry of Health, Indonesia. He received his bachelor's, master's, and Ph.D. degrees from the Faculty of Public Health, University of Indonesia. He previously worked as a nutrition researcher for the Health Research and Development Agency. His research interests include public health, especially nutrition, maternal and child health, stunting, and low birth weight babies (E-mail: agus_gizi@yahoo.com).