Original Article

Introducing an Antenatal Care Electronic Health System for Low and Middle Income Countries: A Cross-Sectional Study on 1217 Iranian Pregnant Women

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Abstract

Objective: Maternal health care is one of the main challenges worldwide, especially in low- and middle-income countries (LMICs) such as Iran. In this cross-sectional study, we introduce an electronic health software for maternal care that is active under the supervision of the Valiasr Reproductive Health Research Center of Tehran University of Medical Sciences in providing maternal health education to Iranian pregnant women. In addition to describing the details of this open-source software and encouraging LMICs health policymakers to develop such software, this manuscript also provides a cross-sectional report and statistical analysis on anonymous Iranian pregnant women who registered in this system.

Materials and methods: Since 2015, we have launched an electronic health software in Iran called "niniMED Pregnancy Calendar" in Persian. This system has multiple educational and motivational features for pregnant women, including momentary weight recommendations based on pregnancy week and recommended dates for common tests during pregnancy according to the first day of the last menstrual period in Jalali calendar format. Additionally, we measured user satisfaction with this system using a questionnaire.

Results: From 2015 to 2017, 1,217 anonymous Iranian pregnant women registered in this system. The average age of pregnant Iranian women was 30.67 years (30 years and 8 months). Users had a body mass index (BMI) of 24.68 $kg.m^{-2}$, which had a significant direct relationship with their gestational age (P=5.81e-05) and indicated an improvement in appropriate weight for Iranian women compared to previous studies. We showed that there was a significant direct relationship between the age of Iranian pregnant women and the likelihood of a high-risk pregnancy (P=0.008). We also observed a significant inverse relationship between pregnancy week and their tendency to receive pregnancy-related education (P=0.018). Finally, we found that more than 88% of pregnant Iranian women assessed membership in such systems as completely useful for pregnancy.

Conclusion: The development of such electronic health systems for informing pregnant women can provide low-cost maternal education to LMICs pregnant women and potentially assist in managing weight gain during pregnancy and reducing associated risks. It can also be widely accepted by pregnant women.

Keywords: Antenatal Care; Electronic Health (E-Health); Pregnancy; Maternal Health Care

Introduction

Pregnancy is considered a sensitive period in many ways. During pregnancy, women face many health challenges that pose serious risks to their health. According to a 2017 estimate by the World Health Organization (WHO) and UNICEF, out of every 100,000 live births, 211 cases resulted in maternal death (1). Although the number has experienced a significant decrease in the past decades, it is still far from the global goal of sustainable development, which is 70 maternal deaths per 100,000 live births (2). In addition to increasing the risk of miscarriage, inattention to pregnancy health care compliance can lead to the undiagnosis of genetic diseases in the fetus as well as the birth of a child with various preventable defects. In this way, it is estimated that at least 6% of live births worldwide are associated with a congenital anomaly, accounting for 140 million births worldwide, leading to the deaths of at least hundreds of thousands of children, and imposing direct and indirect economic costs on millions of people (3, 4). It has also been estimated that genetic disorders are responsible for a significant portion of these abnormalities, which consist of about 1% of live births, and cause 20% of total infant hospitalizations and the same rate of infant mortality (5).

In low- and middle-income countries (LMICs), this issue is doubly important. In such a way, in these countries, the death rate of women with maternal causes is about 120 times higher than the same rate in high-income countries (HICs) (1 in every 45 mothers compared to 1 in 5400 mothers) (2).

Also, the statistics on the psychological, social, and economic costs caused by the birth of disabled infants are significant. According to a literature review conducted in 2021, the lifetime economic costs of childhood disability ranged from 41,000 to 4,300,000 $, which is more intolerable for people in LMICs and imposes a significant economic burden on these societies (6). This shows that there is an increasing demand to provide modern and accessible solutions so that these pregnant women receive the necessary information to have a healthy pregnancy (7).

The lack of adequate prenatal education in these countries has progressed to the point where myths like "eating for two" or absolute rest are still considered pregnancy principles (8). However, the results of numerous studies say otherwise. For instance, obesity or overweight during pregnancy can lead to a wide range of pregnancy complications, such as gestational hypertension (9), preeclampsia (10), gestational diabetes mellitus (GDM) (11), the birth of infants with heart defects and/or neural tube defects (NTDs) (12), and giving birth to a large-for-gestational-age (LGA) infant (13).

Receiving inadequate antenatal care in LMICs is another issue. WHO has recommended (14) that every pregnant woman receive a medical visit at least eight times during each pregnancy; a recommendation that is not met by about half of pregnant women in these societies (15). However, a recent Cochrane review (16) found that population groups in LMICs that received fewer antenatal visits have a greater risk of pregnancy complications, both in terms of increased perinatal mortality and stillbirth.

On the contrary, it is now widely accepted that maternal deaths are largely preventable. According to the information reported by the Maternal Mortality Review Committees (MMRCs), at least 80% of pregnancy-related deaths are preventable (17). By observing the standard health principles in maternity care, it is also possible to prevent the birth of infants suffering from different types of genetic or congenital disorders. For instance, prenatal diagnosis can lead to the identification of chromosomal abnormalities in infants with trisomy 21, 18, 13, monosomy X, and other sex chromosome aneuploidies, which account for 95% of chromosomal abnormalities (18, 19).

Meanwhile, managing weight gain during pregnancy is of particular importance. For example, a 2008 hospital study (20) on 157 pregnant women in Kazakhstan showed that obese women had longer hospital stays on average, were more prone to eclampsia and pre-eclampsia, had a higher risk of caesarean section or abnormal birth, and had more complications as well. Giving birth to infants with pneumonia and fetal macrosomia is also more common among obese mothers.

The term "smart healthcare services" mainly refers to situations in which advanced technologies (such as mobile apps) are integrated into medicine to optimize monitoring, diagnosis, or treatment remotely (21). Smart medical services during pregnancy are more important in LMICs. A 2021 report titled "The State of the World's Midwifery (SoWMy)" from the United Nations Population Fund (UNFPA) admits that the world is facing a shortage of about 900,000 midwives, and this shortage is remarkably severe in

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poor countries (22). However, in the last two decades, mobile phone-related technologies have become increasingly available to inform pregnant women about scientific health care practices (23). Especially if they are integrated with artificial intelligence (AI), the development of these applications can compensate for a significant part of the lack of midwives, especially in LMICs.

In summary, the benefits of electronic pregnancy care solutions include the following (24-31):

1. Encouraging pregnant women to follow health recommendations
2. Helping pregnant women learn about identifying and managing common risks during pregnancy
3. Improving women's satisfaction with health care received
4. Obtaining financial benefits for the health system
5. Acting as a motivator for health care staff and midwives

However, like any other technology, some researchers have also suggested disadvantages or ambiguous points for such software. For example, the impact of improved use of these technologies on maternal or infant mortality rates is still unclear (31, 32), or users may be at risk of misinterpreting the information provided by these software, which will make them reluctant to receive professional medical services (25).

Some studies have shown that by 2019, at least 87% of the population of LMICs were Internet users (33), and about 75–79% of Internet access, at least in some developing countries, is via mobile Internet networks (34). Therefore, it is not far-fetched that access to such technologies has caused significant changes in health care in developing countries.

Using technology in remote prenatal care has a long history. Before smartphones hit the market, personal digital assistants (PDAs) pioneered the use of technology to monitor the health status of patients, including pregnant women (35). The use of SMS-based pregnancy services is also another technology that has been evaluated as helpful in some studies (36), suggested that it can increase the physical activity of pregnant women and reduce their overall anxiety score during pregnancy (37).

With the introduction of smart phones, a great revolution took place in the field of using technology to improve prenatal health care. A meta-analysis (38) published in 2019 showed that the use of social media and mobile health (mHealth) applications improves the conditions of pregnant women in weight management, asthma control, gestational diabetes prevention, mental health improvement, and increasing essential health education during pregnancy. The size of such effects was also evaluated as ranging from moderate to large.

Although each of these programs has its own advantages, there are some shortcomings in them that deprive pregnant women of various benefits. For instance, the use of some of them requires a specific device (for example, they run well on a mobile phone but do not have a desktop or web version) or the released version of their application is limited to a specific operating system such as Android or IOS. Also, the need to pay fees to subscribe, makes the use of such systems a problem for poor societies.

With the aim of introducing a health care system based on the scientific findings of the world, since 2015, we have started an intelligent system, entitled "NiniMED Pregnancy Calendar." "Nini" is a common informal word in Persian and has the same meaning as the English word "Baby." Although this system existed only in Persian at the beginning, an English version has also been developed now and can be accessed at https://ninimed.ir/calendar/en.

Materials and methods

The pregnancy calendar software has a creative structure. At the time of registration, the pregnant mother enters limited information, including the date of her birth, the date of the first day of her LMP, her height, and her weight before pregnancy. Then this information is processed with a transparent algorithm. According to the scientific resources of the system, which are considered the feed of the algorithm, the calendar converts the received input information into outputs that include the necessary detailed information to guarantee the health of the pregnant woman and her fetus. These details include the ideal real-time weight range of the woman, as well as the recommended dates for performing routine screening and diagnostic tests.

With the aim of avoiding self-medication and recommending regular medical visits to pregnant women, we clearly specified in the system that our emphasis on antenatal care is not just a disclaimer but a part of the educational process of our pregnancy calendar.

Like all other software, the pregnancy calendar contains content presented to the audience through a user interface (UI). Since many pregnant women in developing countries do not have expertise in English

and/or do not have the facilities to search through the vast amount of scientific and pseudo-scientific information available on the Internet, we provided them with the tips recommended by health organizations in developed countries. Whenever the scientific content used in the system was regularly updated with new information, we also implemented this update in the system algorithm.

The UI of the software was simply composed of input controls (including text fields, checkboxes, drop-down lists, radio buttons, and data fields), navigation sections, and information sections. Throughout the project's launch and development, we always considered the fact that the user who joins the system is not supposed to be an expert. Therefore, with the aim of having a good user experience (UX), we tried to make the UI simple, both in the design and programming phases as well as in the implementation phase.

The built-in UI was responsive and suitable for viewing on screens with a width of 300 to 4000 pixels, including smartphones, phablets, tablets, laptops, personal desktop computers, and smart TVs. However, internet access was required to enter the system (at the moment, we are trying to add the offline connectivity feature in future releases).

The Waterfall model (39) was used to develop the system. In this approach, the entire software development process is divided into separate phases, and the output of one phase serves as the input of the next phase. This means that each stage of the development process begins only if the previous stage has been completed.

Based on this, the development of the pregnancy calendar included the following steps:

- **Concepts:** The initial concept included the transformation of complex scientific content into user-friendly content for pregnant women of any educational spectrum and any level of literacy, especially in developing countries. The initial concept was implemented with the help of graphic software and discussed in detail in the presence of developers.
- **Requirements:** At this stage, appropriate scientific resources were selected. Other requirements were considered as well (including server, UI technical details, and expected costs).
- **Design:** In this stage, conceptualization was done and the UI was designed. The design of different parts of the project was cascaded, and the design of each part started after the finalization of the previous part.
- **Implementation:** In this step, the UI programmed files were installed from the local host onto the accessible server.
- **Test:** In this step, various inputs were entered into the system as a test, and according to the given inputs, the accuracy and precision of the algorithm were evaluated. Debugging was also done, and the related problems were fixed.
- **Maintenance:** To prevent unexpected errors, in addition to regularly monitoring the server's uptime, the debugging system was permanently activated on the server side. Further, users had the option to contact the technical manager of the system via email, contact number, and social network links (including WhatsApp and Telegram). Based on this, the observed bugs were fixed as soon as the developers were informed.

Adobe Photoshop CC 2014 and Paint.net 4.0 software were used to implement the concept design and initial sketch. In the current version of the software, the UI is designed based on Bootstrap v4.6.0 and the SB Admin 2 template. SB Admin 2 is an open-source, MIT-licensed admin dashboard template written for Bootstrap, whose original core was created by the Start Bootstrap team (40). Also, HTML5, CSS 3, Javascript ES10, jQuery v3.2.1, Select2.js 4.1.0, Chart.js v2.9.4, Fontawesome v5.15.3, and persianDatepicker v0.1.0 are used to design the UI. On the server side, PHP 7.4 and MySQL 5.5 were used. XAMPP 8.2.0 was used to develop the program on localhost. The server used belonged to Netafraz Iranian Ltd., which includes 12-core processors and 64 GB of RAM memory and is connected to the global Internet network at an approximate speed of 1000 mbps. The web server used on the server was a combination of Apache and Nginx, which are used for dynamic and static content, respectively. Further, phpMyAdmin 5.2.0 was used to manage databases. “Let's Encrypt SSL” certificate was used to increase the security of users' private information. It is a free, automated, and open-source certificate authority provided by the Internet Security Research Group (ISRG) (41).

The current version of the pregnancy calendar is available in two separate English and Farsi sub-folders at the addresses https://ninimed.ir/calendar/en and https://ninimed.ir/calendar/fa, respectively, which are in sync with each other in terms of the database. Also, they can be easily installed on any desired domain to be exclusively used by patients of

OB/GYNs, midwives, maternity wards, and other pregnant women's health care providers.

The project was carried out for the first time in Iran, a developing country that is on the list of LMICs. For marketing purposes, advertising banners of the pregnancy calendar were placed on popular websites where the majority of visitors were Iranian pregnant women. We also paid special attention to the search engine optimization (SEO) of a complementary content-oriented website. After clicking on the advertisement banners, users entered the main page of the pregnancy calendar website. There was a link on the main page to register new users or login for existing users (Figure 1). By using cookies, users were able to stay logged in for 30 days, which made it faster and easier for them to access their profile.

Information used: According to what the project developers had decided in the concept design phase, the information presented in the system was divided into two categories: 1) informative information, and 2) motivational information. In fact, the main goal of this project was to provide first-class, informative information. But in order to make the UI more attractive for pregnant women and motivate them to visit the system regularly, sections under the title of the second category were added to the system (Tables 1, 2).

As a key part of the informative data, users were presented with an overview of their pregnancy status as soon as they entered. This section includes the week, the month, and the trimester of pregnancy; the recommended date range for natural delivery (based on the user's pregnancy information); the recommended date range for a cesarean section; the height and weight of the fetus in the current week; and the chance of survival of the fetus in case of premature birth in the current week.

Another informative section included the ideal pregnancy weight for the current day of the user's pregnancy. The Utah Department of Health had published useful tables (42) adapted from the National Academy of Sciences entitled "Weight Gain During Pregnancy: Reexamining the Guidelines," which recommended the normal weekly weight gain during pregnancy based on the mother's BMI. Although these guidelines were potentially beneficial, the difficulty of manually calculating their information made them practically useless for pregnant women. Therefore, we decided to dedicate a key part of the system to an algorithm that prepares these tables according to the height and weight of the pregnant woman and her pregnancy week in a user-friendly way (Figure 2).

Due to the fact that adequate antenatal care is vital for a healthy pregnancy, we dedicated an important section to providing a schedule for visiting the doctor during the user's pregnancy. In this way, the user knew precisely on what dates she should visit her health care provider according to the recommendations of reliable health organizations. Finally, another informative section of the calendar was the scheduled program for performing the most common tests during pregnancy.

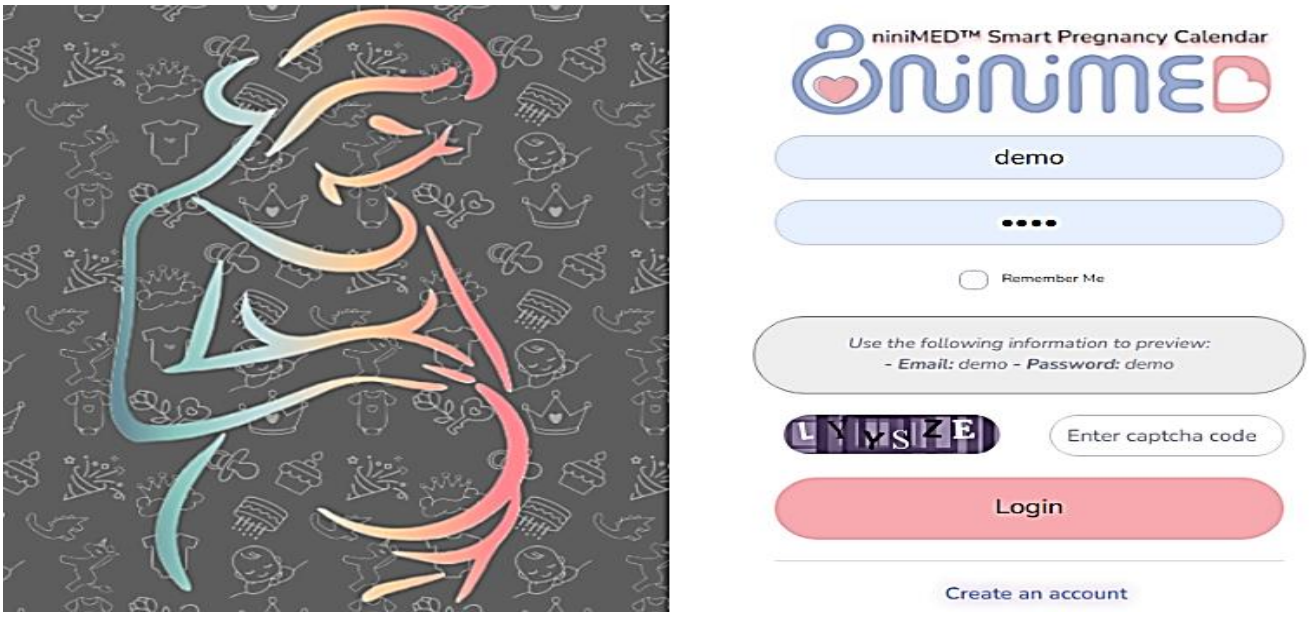

Figure 1: The login page where users could access their page by entering the email and password they had chosen

Table 1: Types and purposes of the items used in the pregnancy calendar

Item	Type	Purpose
Country	Select	• Display the system by default in the official language of the user's country • Introduction of pregnancy care centers according to the user's place of residence (*upcoming releases*)
Nickname	Text	Creating a friendly environment for the user and inducing a sense of personal ownership
Email	Text	Creating a unique user account
Password	Text	Creating a unique user account
The birthdate	Date	• Preventing the entry of underage users • Providing specific recommendations related to high-risk pregnancy for elderly mothers • Providing information about the estimation of the mother's age at the time of the child's birth, at the time of her marriage, etc. (*motivational*)
The date of the first day of LMP	Date	• Automatic calculation of the day, week, month, and trimester of pregnancy • Creating a dynamic progress bar for the user's pregnancy (*motivational*) • Estimating the time range recommended by health organizations for a natural delivery or caesarean section • Using this as a feed for the algorithm to estimate the real-time ideal weight range on each day of pregnancy • Using this as a feed for the algorithm to provide recommended time intervals for various tests and screenings during pregnancy • Using this as a feed for the algorithm to provide a recommendation for a doctor's or healthcare provider's appointment date
User's height	Text	• Using this as a feed for the algorithm to estimate the real-time ideal weight range on each day of pregnancy • Providing specific recommendations related to high-risk pregnancy for obese mothers • Estimating the child's height in adulthood (*motivational*)
User's weight (just before pregnancy)	Text	• Providing specific recommendations related to high-risk pregnancy for obese mothers
Spouse's height	Text	Estimating the child's height in adulthood (*motivational*)
High-risk conditions	Select	Providing specific recommendations related to high-risk pregnancy

These tests included chorionic villus sampling (CVS), first trimester ultrasound, first trimester screening, nuchal translucency (NT), pregnancy blood test, amniocentesis test, triple screening, quad screen test, anomaly scan, Rh incompatibility test, Glucose tolerance test (GTT), nonstress test (NST), and biophysical profile (BPP). It is notable that the recommended dates were presented to the user in accordance with her LMP date.

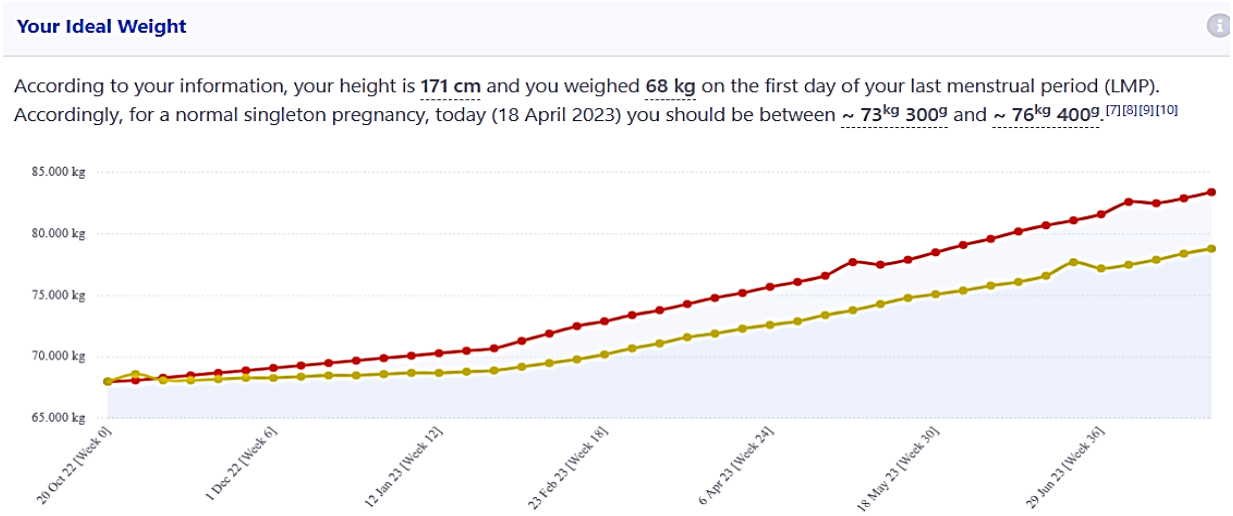

Figure 2: A section of the system that suggested a pregnant woman's ideal weight for the current week based on the first day of her LMP.

Table 2: Descriptions of the items used in the pregnancy calendar

Item	Type
Automatic calculation of the exact age of the user	• *Motivational*. By year, month, and day.
User lifetime progress bar	• *Motivational*. In comparison to the global average age of women's life expectancy.
High-risk reminder box	• *Informative*. Reminding the user that her pregnancy is likely to be considered high-risk.
Automatic calculation of weeks, months, and trimesters of pregnancy	• *Informative*. With the aim of facilitating pregnancy calculations and the automatic calculation of weeks, months, and trimesters instead of the user calculating them by marking them in printed calendars.
Dynamic progress bar for the user's pregnancy	• *Motivational & informative*. Dynamically and instantaneously, up to 7 decimal places are being completed.
A graph of the approximate past and remaining days of pregnancy	• *Motivational & informative*. Through a doughnut chart.
Estimation of the time range of natural childbirth	• *Informative.* Based on the recommendations of reliable health organizations.
Estimation of the time range of cesarean delivery	• *Informative*. Based on the recommendations of reliable health organizations.
Estimation of the approximate height and weight of the fetus	• *Motivational*. Based on some conducted studies.
Estimating the chance of fetal survival in cases of premature birth	• Informative. With the aim of emphasizing compliance with health tips in order to prevent the birth of a premature infant.
Approximate and real-time weight range recommendations for pregnant women	• *Informative*. With the aim of emphasizing the importance of following a proper diet, this section presents the approximate daily weight range recommended for users with an accuracy of 100 grams. It is based on scientific findings and does its calculations according to the date of the first day of the user's LMP, her height, and her pre-pregnancy weight.
Estimating the mother's age at the time of the child's possible marriage and drawing the progress bar of the user's lifetime at that time	• *Motivational*. Based on the average of the current marriage age of boys and girls.
Estimating the child's height in adulthood	• *Motivational*. Based on the heights of the pregnant woman and her partner and the resources used in the system, it provides an estimate of the child's height in adulthood.
Scheduled doctor's visit	• *Informative*. Based on the system's scientific resources, in this section we have presented the recommended times to see a doctor related to a low-risk singleton pregnancy according to the user's LMP date, emphasizing the fact that for a possible high-risk pregnancy, the appointments should be more.
Section of routine tests during pregnancy	• *Informative*. There is a list of common pregnancy tests along with the time frame allowed for each based on the user's LMP date, emphasizing that it may not be necessary for the user to perform all of these tests or that their doctor may recommend a test that is not on this list.
Providing an approximate range for daily calorie intake	• *Informative*. In this section, according to the user's LMP date and her body mass index (BMI), the approximate ideal calories for daily consumption during pregnancy on the current date (today) are displayed.
Search engine for the safety of food consumption in pregnancy	• *Informative*. In this section, a search engine is embedded in the top bar of the system, where the user searches for the desired food and learns about its benefits and side effects during pregnancy. (*upcoming releases*)

After registering in the system, each user could use the services of the system for a maximum of 40 weeks (280 days), starting from the date of the first day of her LMP (Figure 3).

We paid special attention to respecting the users' privacy throughout the project. In this context, we wouldn't receive and store any identity information, including the user's given name and surname; also, the security of the servers was provided by the SSL protocol; the users' information was backed up on a daily basis; and a cookie consent popup would have been displayed to the users.

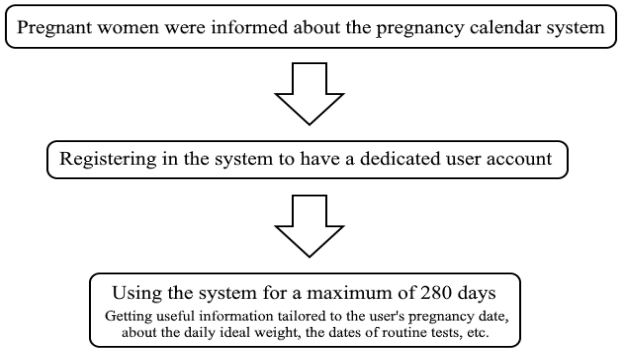

Figure 3: The flow of providing information from the system to the user during the 40 weeks

Table 3: The voluntary user feedback questionnaire

Number	Inquiry	Options
1	I could easily access this system during my pregnancy.	☐ Totally ☐ Considerably ☐ Somewhat ☐ Not at all
2	How useful was your membership in this system during your pregnancy?	
3	To what extent was this system effective in controlling your weight during pregnancy?	
4	Would you recommend membership in this system to other women?	
5	How closely did you adhere to the recommendations regarding timing of medical visits in the system?	
6	How often did you visit the system during your pregnancy?	☐ Every day ☐ A few days a week ☐ Once a week ☐ Several times a month ☐ Once a month or less
7	Did you discuss the recommended medical tests in this system with your healthcare provider?	☐ Yes ☐ No

Feedback questionnaire: Given the primary objective of this software to aid expectant mothers in achieving an informed pregnancy, we opted to engage users of the system in a voluntary research survey through a pop-up interface. The questionnaire comprised 7 essential inquiries that required minimal time commitment from the volunteers (Table 3).

Results

Information of registered users: From June 23, 2015, to November 15, 2017, 1270 Farsi-speaking pregnant women registered in the system, of which 1217 registered correctly, and other users left the registration incomplete. According to the information obtained during this time period, the average age of Iranian pregnant women was 30.67 years (equivalent to 30 years and 8 months). The youngest pregnant woman was 18 years old, and the oldest was 55 years old. If we separate the age range of the participants into four-year intervals, the age ranges of 28 to 32 years, 33 to 37 years, and 23 to 27 years had the highest number of pregnant women, respectively.

Rate of high-risk pregnancy: Our investigation of the prevalence rate of high-risk pregnancy among Iranian pregnant women registered in the calendar shows that there was a direct relationship between the age of a pregnant woman and the probability of her pregnancy being high-risk, and this relationship is statistically significant (P=0.008) (Figure 4).

User registration time information: The relationship between the time of registration in the pregnancy calendar and the past period of the woman's pregnancy is also significant. In the first trimester of their pregnancy, 45.03% of pregnant women registered in the system, which is more than double the number of pregnant women who registered in the third trimester (22.02%). In the same way, registration frequency in the first weeks and months of pregnancy has been higher than in the following weeks and months (Figure 5).

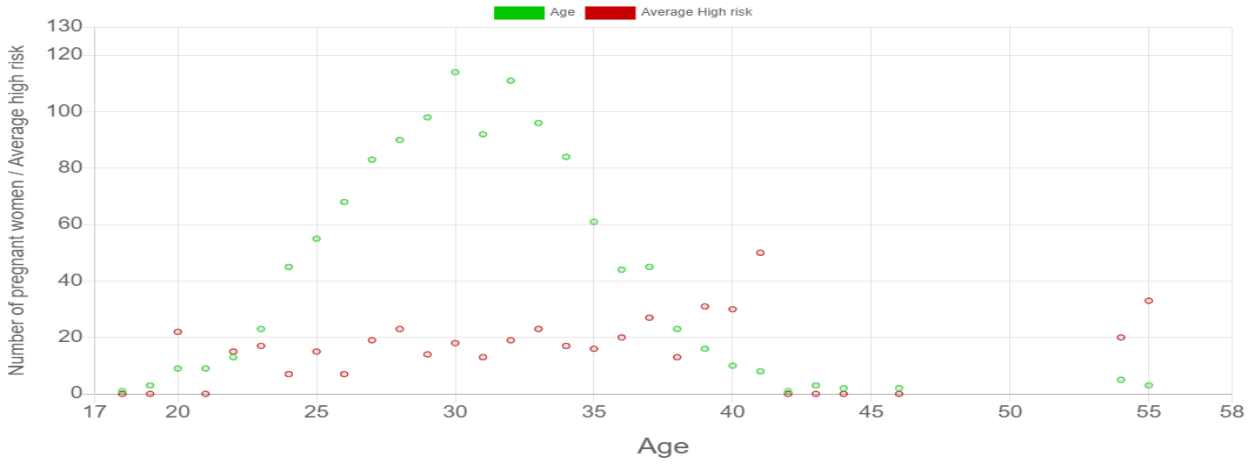

Figure 4: Relationship between the age of a pregnant woman and the probability of a high-risk pregnancy

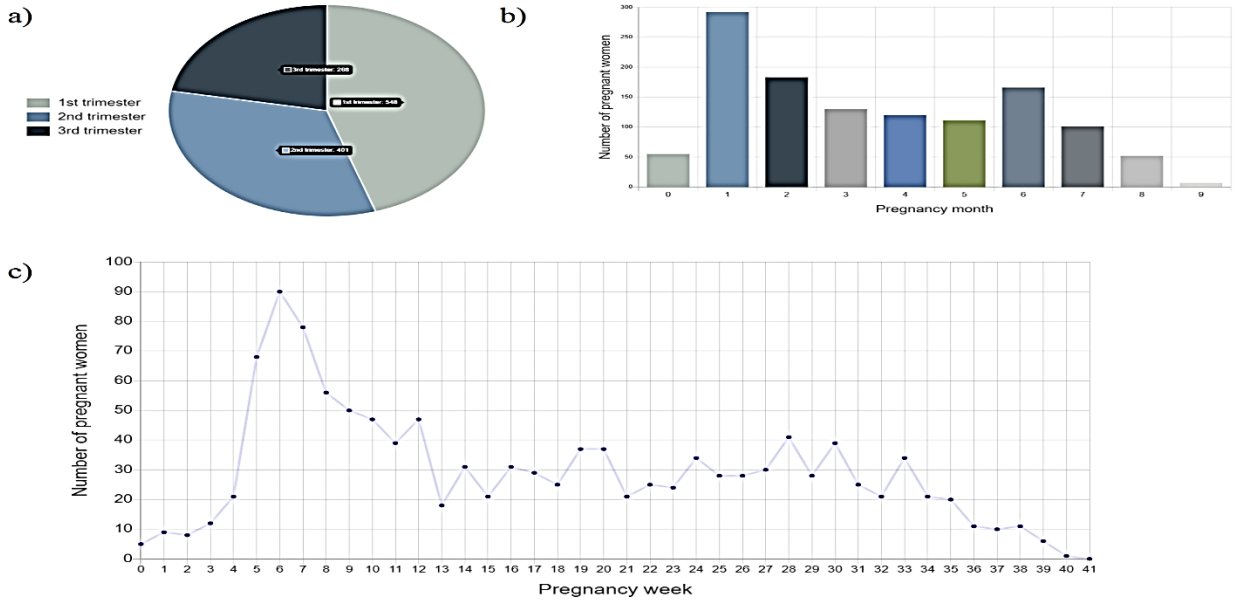

Figure 5: Frequency of pregnant women registered in the system according to a) trimester, b) month, and c) week of pregnancy.

It is important to mention that the inverse relationship between the week of pregnancy and the act of registering in the pregnancy calendar was significant (*P*=0.018).

Pre-pregnancy body mass index: The average pre-pregnancy BMI of Iranian women was 24.68 $kg.m^{-2}$, with the highest frequency of weight related to the range of "normal weight" and then "overweight" (Figure 6.a). The average BMI in Iranian women of reproductive age was significantly higher in the age group above 38 years than in the age groups below 38 years. (Figure 6.b). Also, the age of the Iranian women investigated in this research was a factor that had a direct impact on their BMI, and this effect was statistically significant (*P*=5.81e-05) (Figure 6.c).

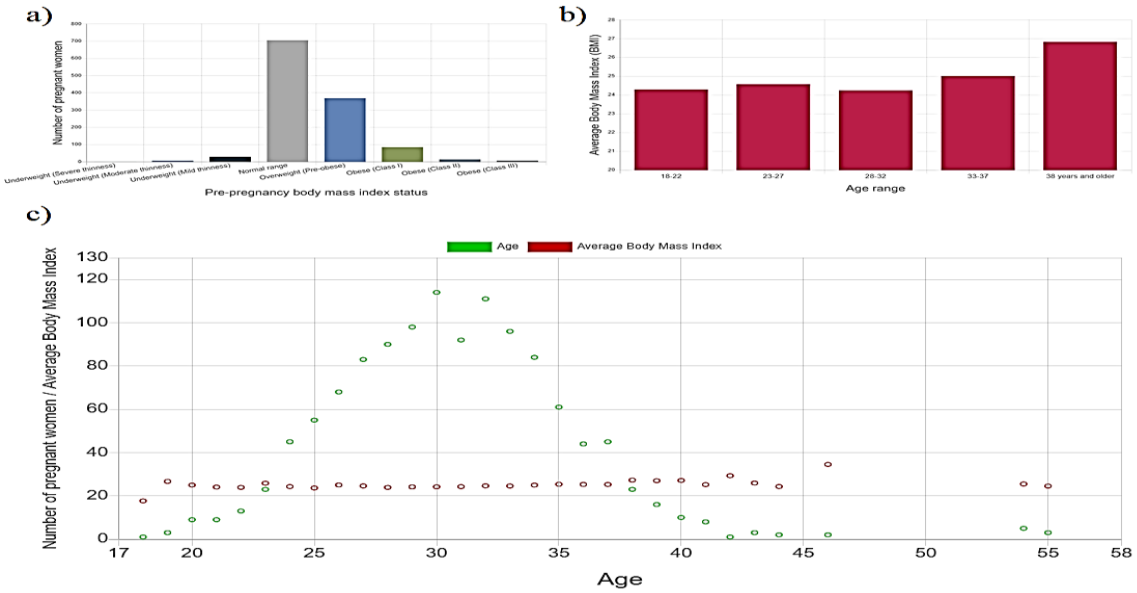

Figure 6: a) A graph showing the frequency of Iranian pregnant women in each range of BMI; b) Women who conceive at an older age have a higher BMI; c) A relative comparison of the ages of registered women and their BMI status.

The feedback questionnaire: Among the participants who utilized the system, a total of 137 users (11.3%) voluntarily completed the feedback questionnaire. The analysis of the results obtained from the users indicated that 89.8% of the respondents found accessing the system to be totally/considerably easy. 88.3% of the users evaluated their membership in the system as being totally/considerably useful for their pregnancy. Furthermore, 84.7% of the users considered the use of this system to be totally/considerably effective in managing their pregnancy weight, while 79.6% considered the system to be totally/considerably recommended for pregnant women. Additionally, it was found that 56.2% of the participants followed the system's suggested timeline for visiting their healthcare provider (Figure 7.a). Furthermore, it was observed that 78.8% of users visited the system at least once a week to check for updated information (Figure 7.b).

Finally, 54.7% of the participants reported that they asked their doctor or health care provider about the common tests during pregnancy that were pointed out to them in the system.

Height status of registered users and their spouses: As mentioned earlier, in order to estimate the height of the child in adulthood, we also collected the height of the users' spouses during registration. Hence, we also attempted to analyze the heights of couples. We found that in 98.03% of cases the husbands were taller than their wives, while in only 1.97% of the cases the wives were taller, and the highest frequency was observed in couples in which the husband is 10 cm taller than his wife (Figure 8).

Discussion

Paying attention to the health of pregnant women to ensure a successful pregnancy that leads to the birth of a healthy baby has become a public concern now more than ever. In this cross-sectional study, while introducing and implementing an intelligent eHealth system for pregnant women, whose membership can significantly increase the necessary knowledge for a pregnant woman, especially in developing countries, we also carried out investigations on 1217 anonymous Iranian pregnant women who were members of the system at the time.

Desire to receive pregnancy-related education: This should be brought to the attention of the midwives and other health professionals in the field of women's pregnancy health, so they can pay more attention to educating pregnant women in the first trimester of pregnancy.

High-risk pregnancies: The fact that the frequency of high-risk cases in older pregnant women was significantly higher than that in younger women is probably because with increasing age, some factors that cause "high-risk pregnancy," such as psychological diseases, infectious diseases, cancer, or obesity, gradually start to appear.

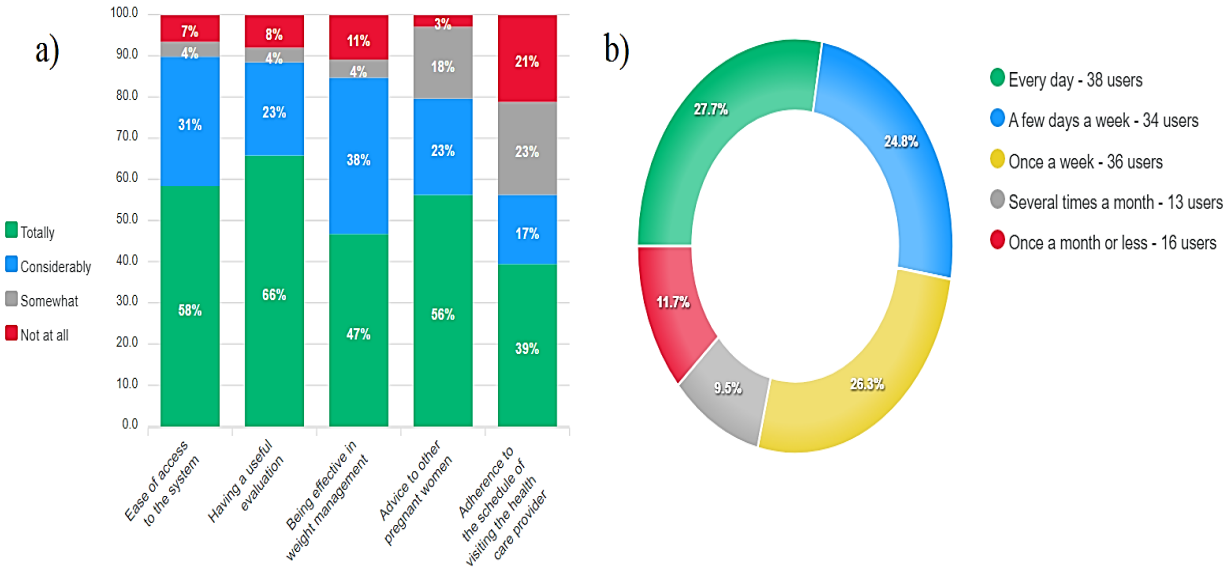

Figure 7: a) The stacked chart of the results of the feedback questionnaire; b) Frequency of visiting the system during pregnancy

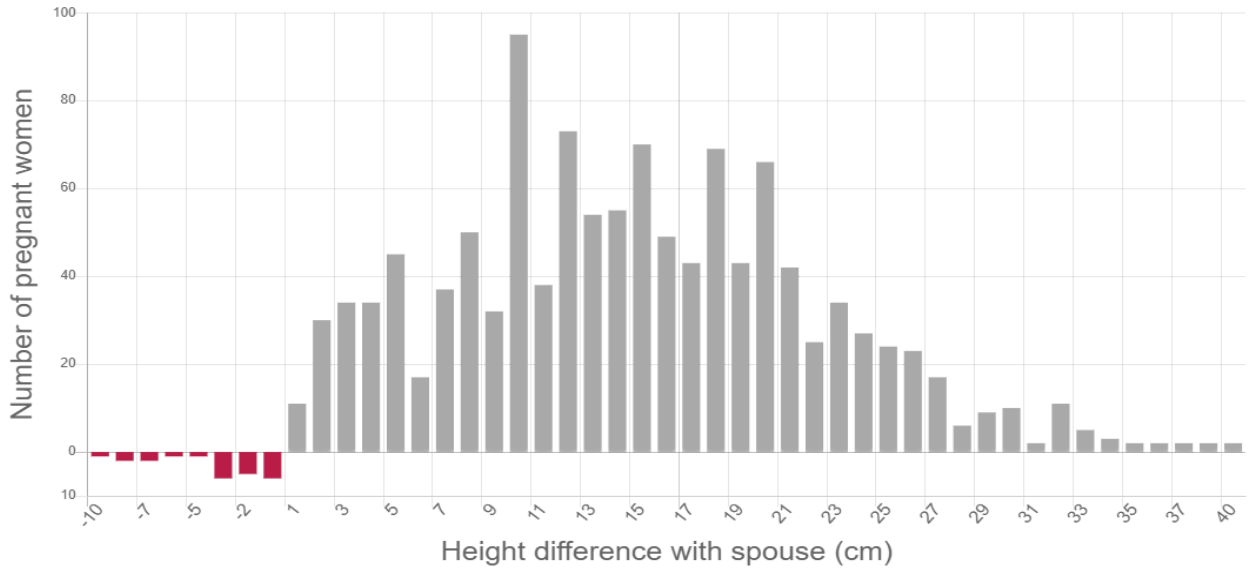

Figure 8: Height difference of Iranian husbands and wives, as a secondary result of the study

Body mass index: In terms of the average BMI of the studied women (24.68 $kg.m^{-2}$), this number was lower than the average obtained from a previous study (43) on 14176 Iranian women between 1999 and 2000, which was 25.33 $kg.m^{-2}$.

However, as made clear in that study, high BMIs were much more common among women aged 40 to 60 years, whereas the current sample consisted mainly of young women in their reproductive years. Therefore, if we only consider the age range of 20 to 30 years, there are 607 women whose average BMI is 24.32; 3.9% are underweight (BMI less than 18.5), 61.9% are normal weight (BMI between 18.5 and 24.9), 26.5% were overweight (BMI between 25 and 29.9), and 7.6% were obese (BMI greater than 30); those are promising numbers compared to the previous research in the same age range (Table 4). This can indicate that the fitness of young Iranian women has increased. The possible causes may be the widespread education in the field of the health benefits of having an appropriate weight as well as the popularization of women's sports clubs in Iran during the last two decades.

Also, the tendency for obesity that occurs due to aging and was also studied in this research can be of interest to health policymakers and pregnant women's health staff who encourage women to not procrastinate their pregnancy in order to have a healthier pregnancy.

The users' feedback: The feedback questionnaire aimed to evaluate the usability and user-friendliness of the system. Results showed positive feedback from participants across all seven questions, indicating their overall satisfaction with the system. Specifically, over 88% of respondents found the system to be totally/considerably useful. These findings lend support to the notion that there is a need for more pragmatic pregnancy systems, such as those that assist in pregnancy weight management, especially in LMICs.

Conclusion

The above-mentioned pregnancy calendar system is an example of an e-Health application system for pregnant women, which, as shown in the time frame of the study, was widely accepted by a range of Iranian pregnant women. Support for such projects, especially from developing country policymakers, has the potential to reduce maternal deaths as well as the financial costs of giving birth to children with preventable problems. As discussed in the present study, the development of such projects can also be a basis for analytical research with the aim of discovering the factors affecting the health of pregnant women.

Table 4: Comparison of two cross-sectional studies on BMI status of Iranian women aged 20 to 30

Research	Study time frame	Underweight (%)	Normal (%)	Overweight (%)	Obese (%)
Bakhshi et al., 2012	1999 - 2000	10.5	57.8	22.6	9.1
Present study	2015 - 2017	3.9	61.9	26.5	7.6

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