Forecasting of Menstruation using a Calendar-based Method based on a Web Application

Aida Yasmin Zainal Abidin[1], Tajul Rosli Razak[2*]

[1, 2]College of Computing, Informatics and Mathematics, Universiti Teknologi Mara (UiTM) Shah Alam, 40450, Selangor, Malaysia

[*] Corresponding author: tajulrosli@uitm.edu.my

ABSTRACT

Accurately predicting menstrual dates is valuable for women, yet it poses a significant challenge, particularly for those with irregular cycles. This study introduces a web application that utilises a calendar-based method to predict upcoming menstrual dates while offering additional features such as tracking past periods, logging symptoms, and providing personalised health advice. Using the software development life cycle approach, the critical contribution of this work is the development of a user-friendly tool that not only aids in menstrual tracking but also highlights the limitations of calendar-based predictions, especially for women with irregular cycles. Our findings suggest that while the method provides accurate predictions for women with regular cycles, it is less reliable for those with irregular cycles due to its dependence on a fixed cycle length range. This study underscores the need for more adaptive models to improve prediction accuracy for a broader population.

1   INTRODUCTION

According to [1], menstruation or menstrual cycle can be defined as the "periodic discharge of blood from the uterus occurring more or less at regular monthly intervals throughout the active reproductive life of a female". The cycles are calculated from the first day of menstruation to the first day of the next menstruation [2]. In other words, the cycle is the number of days between periods. The first occurrence of menstruation is called menarche, usually around the age of 12.1 years [3]. Menopause, on the other hand, is defined as the stopping of menstruation. This is due to the irreversible loss of the reproductive system's function [4]. The older a female becomes, the shorter their cycle becomes and more regular [2].

Menstrual cycles are usually divided into two categories: standard and irregular. Females with standard cycles range from 21 to 35 days and cycles any less or greater than that fall into irregular cycles [2]. The standard length of the period is 5-6 days, but this also varies among women [5]. Closely related to menstruation are the concepts of ovulation and fertility. According to [6], the fertile window is the duration a woman may likely conceive between five days before ovulation and the day

of ovulation. Thus, by knowing one's own menstrual health or reproductive system, one is said to be engrossed in self-care [7].

Menstrual applications come in handy in helping to achieve the above goal. Period self-tracking applications help women track their menstruation and symptoms and even get predictions of their upcoming menstruation [8]. Most apps needed user information, such as menstruation period, symptoms and body temperature [8]. Some applications require additional information, such as daily basal body temperature and sexual activities [2]. Most of these applications predict upcoming menstruation based on previous cycles. For example, they generate menstrual cycles based on cycle lengths [2]. Those apps also predict ovulation 14 days before menstruation [9].

However, not all of the applications mentioned above are accurate and necessarily helpful to the users. Thus, accurate period-tracking applications are essential to help women prepare for their menstruation.

Most period-tracking applications require users to input the date of their menstruation, and the app will use an algorithm to predict the date of upcoming menstruation [9]. While this method can be reasonably precise for users with regular cycles, it is not the case for users experiencing irregular cycles [2]. Most of the time, the app will also predict the ovulation to be precisely 14 days after past menstruation [9]. However, this is not always the case, with at least a 79% possibility of the prediction being inaccurate [9].

Many people lack a comprehensive understanding of fertility and reproductive cycles, with ovulation being particularly challenging to self-detect. Individuals experiencing irregular ovulation, for example, those with polycystic ovary syndrome (PCOS), might overlook crucial symptoms of their condition and even miss indicators of infertility. Consistent use of period-tracking apps can enhance users' awareness of their fertility. Research indicates that women who use menstrual apps tend to understand fertility information better than those who do not [7].

Unwanted pregnancies have a higher risk of happening when one does not know about their fertility. Misinterpreting ovulation and reproductive cycles can create a perception of infertility, potentially resulting in individuals not taking adequate precautions to prevent pregnancy. Users of hormonal contraception that suppresses ovulation, such as contraceptive pills and injections, may lack a clear understanding of how their contraceptive method works. The recent approval of contraceptive apps by regulatory bodies in the EU and the US legitimises these apps as a contemporary form of pregnancy prevention [7].

This paper presents a web application that implements the calendar-based method to predict the upcoming period dates. Its features include predicting upcoming period dates, keeping records of past period dates, logging symptoms, and a chatbot that gives general advice based on the symptoms. The symptoms include flow, mood, and pain level.

2   MATERIAL AND METHODS

Dysmenorrhea, also known as period pain, is the pain experienced before or during menstruation. The most common symptoms experienced include severe pelvic or abdominal pain, vomiting, and even psychological symptoms like anxiety. Abdominal pain is expressed as a dull, continuous

muscular ache. Some also described it as such their organs are twisting. It was also reported that back pain, headaches, and muscle weakness usually occur during menstruation [10].

Due to the symptoms experienced before and during menstruation, along with the concept of ovulation and fertility, knowing when the next period is happening is essential. By knowing when to expect menstruation, one can predict their ovulation period and prepare necessarily for work or travel plans [2]. It is also essential to help women to know their fertile window [6]. This can help women in family planning, as they can know when they are most fertile. This knowledge can be used for women trying to conceive or avoid pregnancy [7]. This also increases one's reproductive system and menstrual health knowledge. According to [7], one is said to practice self-care when one knows one's reproductive system. Misinterpretation of one's fertility can lead to more significant problems, such as unwanted pregnancies [7].

Period tracking applications have features that allow women to track their menstruation records and log the symptoms they undergo [11]. Women who use tracking applications have higher fertility knowledge than those who do not [7]. These applications allow users to predict period dates, ovulation dates and fertility days [8]. A small number of these applications also act as contraceptive methods. Some are authorised in the US and Europe for pregnancy prevention [7].

The primary purposes of the period tracking applications are to track periods and avoid pregnancy [9]. Some apps ask for additional related information such as temperature, cervical fluid and hormone levels, which can indicate phases in the menstrual cycle. Some also allow users to input related symptoms and activities like pain, mood, sexual activity, sleep and exercise [7].

However, these applications need to be more accurate. They predict the wrong days of the cycle and, thus, the wrong fertility window, as most do not have professional recommendations [12]. This is especially true for women with irregular menstrual cycles. This is because most applications only apply simple derivation based on previous cycles [2].

The most common method used in these applications is a calendar-based method. The calendar-based method is best suited for women with regular cycles. Two calendar-based methods are used in most app applications: the rhythm method and the standard day's method. In the rhythm method, the past six cycle lengths are monitored. The shortest and the most extended cycle lengths among the six cycles are used to determine the fertile window. From the shortest length, subtract 18 days. Then, the result will be the first day of the fertile window. From the most extended length, subtract 11 days, giving the last day of the fertile window. For example, if the shortest and longest lengths are 26 and 30, respectively, the first day of the fertile window will be the cycle's 8th day (26 subtract 18), and the last day will be the 19th day (30 subtract 11). On the other hand, the standard days' method automatically sets the 8th day to the 19th day of the cycle as the fertile window [13]. The rhythm method has a slightly higher accuracy than the standard days method, at 89% compared to 70% [14].

There are many similar applications with the same purpose: to keep records and track the menstrual cycle. Each application provides different additional features while keeping the primary purpose the same. One is the application 'My Cycle' by developer analyst Aleksei Neiman. The app allows features like logging in period dates and symptoms, predicting the start of the next period and giving information such as chances of pregnancy by highlighting the fertile window. First-time users can log in with their previous period dates or set their cycle length and period themselves. The symptoms logged in are just for record purposes, as the app does not provide information on the symptoms

experienced. The app implements a calendar-based algorithm with a note section where users can input any text for their records.

In this paper, the developed web application will apply the MERN stack in its architecture. MERN, which stands for MongoDB, Express, React, and Node.js, is a troupe of JavaScript technologies that developers often use together. Each of the four technologies serves its purpose during the development phase. MERN stack requires knowledge of JavaScript and JSON in its development. Another similar JavaScript-based technologies group is the MEAN stack, which stands for MongoDB, Express, Angular and Node. MEAN stack and MERN stack are mainly similar. What differentiates them is that, instead of React, the MEAN stack applies Angular technology. Thus, apart from knowledge of JavaScript and JSON, another additional knowledge is required: TypeScript. Angular is a more complex framework than React, as it is a complete web framework [15]. Due to these additional knowledge requirements, the MERN stack was chosen for this project because of its simplicity for beginners to learn. This stack will allow for a quicker completion time of the project.

2.1   Period Dates Prediction

This study focuses on developing a web application that implements a calendar-based method to determine the upcoming period dates.
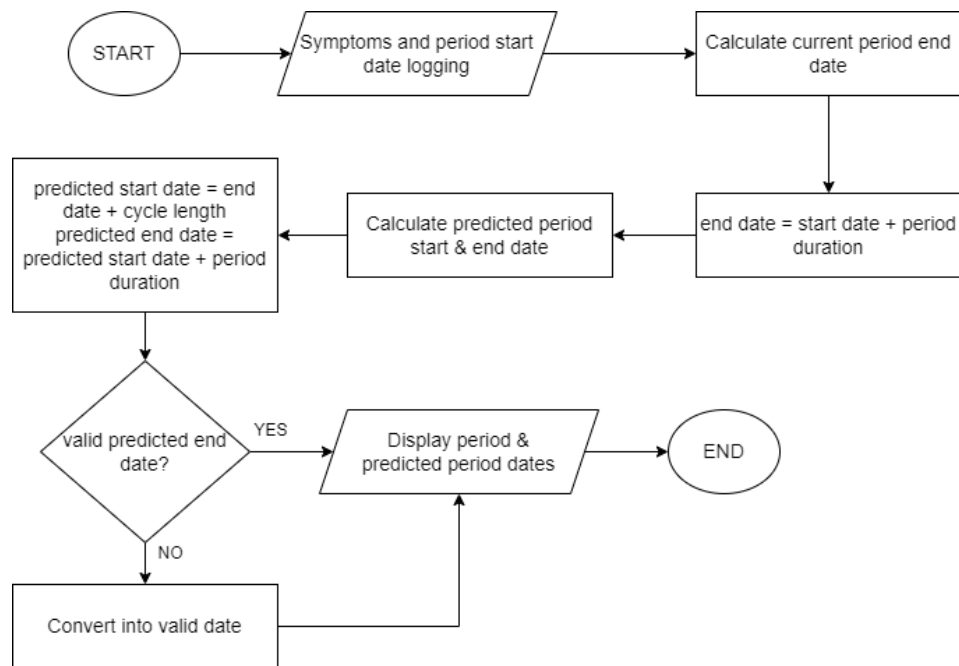

Figure 1 : Flowchart displaying current and predicted period dates

Figure 1 shows the flowchart of the processes displaying the current and predicted period dates. This study employed a straightforward calendar-based prediction method using a fixed cycle length approach. Users provided their period duration and average menstrual cycle length during account registration. This information formed the basis for all future predictions.

User need to log the start date of their current period. This data is then used as a reference point for subsequent predictions. The system added the user's specified cycle length to the most recent logged

period start date to forecast the next period. For instance, if a user reports a 28-day cycle length and their last period begins on May 1, the next period is predicted to start on May 29.

The predicted period duration is then calculated using the user's specified period length. When calculating the period end dates, the system accounts for cases where the period extends into the next month. This is particularly relevant for periods that start nearing the end of the month. For example, if a user with six days' length logs the start date on May 30, adding May 30 with six days results in an invalid date. The system tackles this issue by determining how many days to carry over to the next month and subtracting the remaining days from the period length.

Each newly logged period becomes the new reference point for future predictions. This allows the system to adjust based on the most recent data. The current and predicted period dates are then presented to the users as a calendar. Users can view the dates of their past recorded periods, given that they have logged them. This allows users to keep track of their past period dates and cycle lengths for their analysis.

This method provides personalised predictions based on user-reported data. It also simplifies the algorithm's execution and allows users to input and update their data efficiently. The system accumulates more data as users consistently log their actual period dates. This growing dataset could be used to refine the prediction algorithm, improving accuracy over time.

2.2 Fertility Window and Ovulation Day Determination

While this method helps predict the menstrual cycle, it has some limitations in pinpointing the ovulation day and determining the fertility window. The fertility window is typically considered six days long in each cycle, five days before and one day after ovulation. In the regular cycle, the fertility window is often between days 8 and 19, but this can vary from one woman to another.

The calendar-based method cannot determine the exact day of ovulation. Ovulation is typically assumed to occur 14 days before the start of the next period. However, this too can vary among women and even from one cycle to another of the same woman. The ovulation day can change due to many factors, making self-detect challenging. It can be detected through observation of the physical changes one experiences.

In this study, the system does not display or calculate ovulation or fertility for these reasons and uncertainties.

2.3   System Architecture

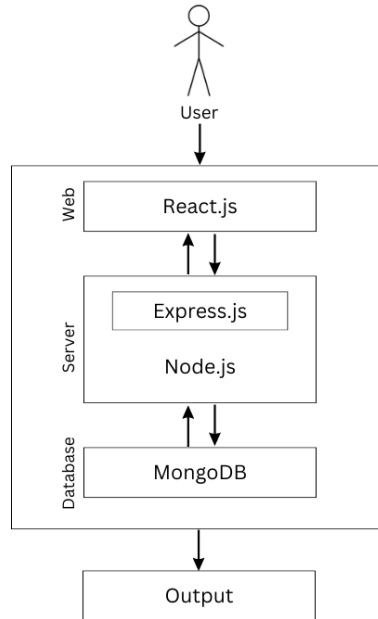The web application will apply the MERN stack in its architecture, as detailed in Figure 2.

Figure 2 : System Architecture

React.js is used to develop the user interfaces and their components in its web tier. MongoDB is used in its database tier. It is a document-oriented database, and its query language is built on JSON and JavaScript. This makes storing, manipulating and representing JSON data relatively easy, which further causes it to work well with Node.js. Express.js and Node.js are used in its back-end or server side. Express.js is a Node.js web application framework that allows for improved productivity due to its URL routing and HTTP handling features. Node.js is needed to use Express.js. Due to its drivers in MongoDB, it is relatively simple to use Node.js alongside Express.js as it also offers many libraries and modules. In the front-end layer, React.js is used because of its open-source JavaScript library in developing user interfaces and its components. It provides easy integration with other libraries and frameworks and allows for component reusability for consistent UI. Users will interact with web applications utilising the MERN stack, producing output for the users [15].

3   RESULTS AND DISCUSSION

During the testing phase of this study, black-box testing and user acceptance testing (UAT) are performed. Results from the UAT that involved 10 test users are illustrated in Figure 3.
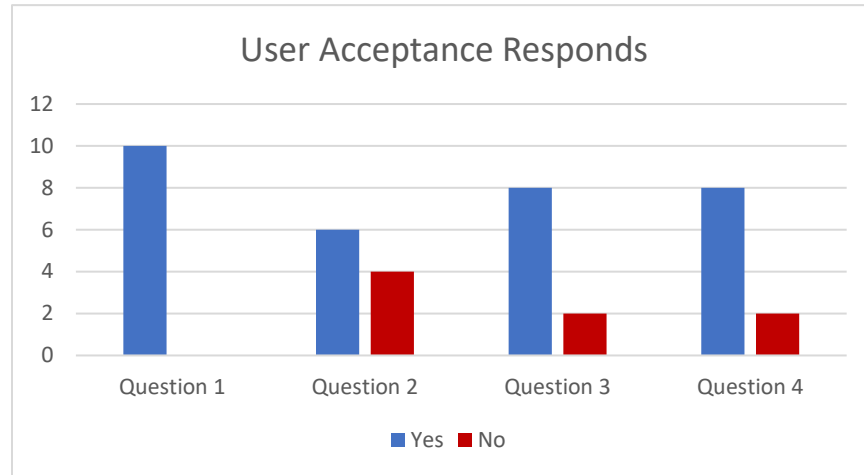

Figure 3 : Bar Chart of User Acceptance Responses

The questions asked are as follows:

a)   Do you think the site helps keep records of period dates?

b)   Does this site help predict your ovulation day and fertility window?

c)   In your opinion, will using this site increase your fertility knowledge?

d)   Do you think you will benefit from this site?

From the UAT, all test users agree that the study made keeping track of period dates more accessible. However, 40% of the test users think the study does not help them predict the upcoming period dates. However, 80% of the test users agree that the study allows them to gain more knowledge about their fertility. Lastly, the same number of test users agree that the study does serve them some benefits and advantages.

From the UAT, most users are satisfied with the system's functionalities. Implementing the calendar-based system can provide accurate predicted period dates, particularly for women with regular cycles. While most users find it easy to detect their fertility window through the system, a notable number of users may still find it challenging. However, the UAT proves that the system is still a medium for users to increase their fertility knowledge.

The lack of inaccuracy, especially for irregular cycles, is due to several reasons. This method utilises a fixed cycle length approach. It adds the cycle length to the last date of the period to obtain the predicted date. The algorithm then uses the most recent actual cycle to calculate the upcoming one. If the cycle changes significantly every time, the predicted dates are still calculated using the past most recent cycle length. In other words, it adds the most recent cycle length to the last recorded

period date to generate the next prediction. This simplistic approach fails to cater for significant change with the cycle length.

Next, the algorithm prioritises the most recent cycle data for its calculations. As explained above, the most recent cycle length determines the next one. While this is not a problem in regular cycles, it could pose a problem in irregular cycles. When the cycle changes significantly every month, the most recent cycle may differ from the overall pattern, leading to inaccurate predictions.

This method also uses the most recent cycle length data for its predictions. A woman's menstrual cycle can quickly change due to many factors. They include diet, health conditions such as PCOS, stress and hormone imbalance. The recent changes in these components could affect the period date prediction. Thus, since this method utilises a limited dataset, which is only the past cycle length, its prediction could come out to be off than the actual dates. In irregular cycles, it does not incorporate pattern recognition or trend analysis. If a woman has a specific cycle pattern, for example, alternating between long and short cycles, this method could not capture this pattern and utilise it for future predictions.

4   CONCLUSION

In conclusion, this study shows that while the calendar-based method can predict the upcoming period dates, its accuracy and reliability are limited, particularly for irregular cycles. This method shows positive results for users with regular cycles rather than irregular ones. This is due to several reasons. One of these is due to the algorithm assumption of regularity in the cycle. It does not account for the natural variability that many women experience. This oversimplification can lead to inaccurate predictions, especially for those with irregular cycles. Its lack of adaptability is another factor that causes limited accuracy. Cases of irregular cycles, which are different every time, may need to be catered to better with this concept of fixed cycle length. This method relies solely on past data and not on current physical changes, which may give better results based on current changes a woman may experience. Since the menstrual cycle can be affected by many factors, such as diet, stress and health conditions, a method that tracks the physical changes in a woman's body may be a better option for determining the upcoming period dates. While its accuracy can still be improved with more data, it may need to provide high accuracy for cycle length that changes significantly every time. In short, this method's one-size-fits-all approach is not the best option for predicting the upcoming menstruation.

As for future recommendations, using a method that tracks real-time physical changes is a potential area to work on. A method such as the Fertility Awareness-Based (FABM), which includes monitoring the Basal Body Temperature (BBT) and the cervical mucus, could provide more comprehensive and recent information on a woman's body. This then could be used to build a personalised and robust prediction model. Another future work is the implementation of an Artificial Neural Network (ANN) to predict future menstruation. ANN is part of deep learning that can provide more accuracy on a case-to-case basis. It can cater well to both regular and irregular cycle cases. The advantage of having a customised analysis for every user will further enrich the system's performance.

REFERENCES

[1]   J. Michael et al., "Knowledge and practice of adolescent females about menstruation and menstruation hygiene visiting a public healthcare institute of Quetta, Pakistan," BMC Women S Health, vol. 20, no. 1, Jan. 2020, doi: 10.1186/s12905-019-0874-3.

[2]   Y. Wu, J. Zhang, Y. Chen, W. Shi, and H. Tan, "MC-Tracking: Towards ubiquitous menstrual cycle tracking using the smartphone," IEEE Transactions on Mobile Computing, vol. 23, no. 5, pp. 5604–5615, Aug. 2023, doi: 10.1109/tmc.2023.3310941.O. J. C et al., "Improving Menstrual Cycle Prediction Accuracy using Advanced Machine Learning Model Methods," Journal of IoT and Machine Learning, vol. 1, no. 2, pp. 1–7, Dec. 2023, doi: 10.48001/joitml.2023.121-7.

[3]   C. B. Munro, E. N. Walker, R. Schembri, D. Moussaoui, and S. R. Grover, "Periods Shouldn't Bring Any Adolescents' World to A Full Stop. Period. An Online Survey of Adolescents' Experience of Menstruation," Journal of Pediatric and Adolescent Gynecology, vol. 37, no. 1, pp. 18–24, Sep. 2023, doi: 10.1016/j.jpag.2023.09.004.

[4]   H. Özcan, Y. Dinçer, Ç. Yiğitbaş, and Y. M. Jama, "The Psychological Dimension of Menopause among Somalia Women: Phenomenological Study," Womens Studies International Forum, vol. 99, p. 102733, Jul. 2023, doi: 10.1016/j.wsif.2023.102733.

[5]   S. Suman, S. Mukherjee, M. P. Selvan, V. A. Mary, S. Jancy, and S. P. Shyry, "Menstrual Cycle Tracking Using Deep Learning," 2023 3rd International Conference on Pervasive Computing and Social Networking (ICPCSN), pp. 146–152, Jun. 2023, doi: 10.1109/icpcsn58827.2023.00030.

[6]   S. Sohda, K. Suzuki, and I. Igari, "Relationship Between the Menstrual Cycle and Timing of Ovulation Revealed by New Protocols: Analysis of Data from a Self-Tracking Health App," Journal of Medical Internet Research, vol. 19, no. 11, p. e391, Nov. 2017, doi: 10.2196/jmir.7468.O. J. C et al., "Improving Menstrual Cycle Prediction Accuracy using Advanced Machine Learning Model Methods," Journal of IoT and Machine Learning, vol. 1, no. 2, pp. 1–7, Dec. 2023, doi: 10.48001/joitml.2023.121-7.

[7]   B. Hohmann-Marriott and L. Starling, "'What if it's wrong?' Ovulation and fertility understanding of menstrual app users," SSM - Qualitative Research in Health, vol. 2, p. 100057, Feb. 2022, doi: 10.1016/j.ssmqr.2022.100057.

[8]   K. Naren, P. Gupta, A. Parihar, and R. Kumar, "Menstrual Cycles Prediction using Artificial Neural Network," 2023 International Conference on Computational Intelligence and Sustainable Engineering Solutions (CISES), vol. 26, pp. 436–440, Apr. 2023, doi: 10.1109/cises58720.2023.10183554.

[9]   U. Patel, A. Broad, R. Biswakarma, and J. C. Harper, "Experiences of users of period tracking apps: which app, frequency of use, data input and output and attitudes," Reproductive BioMedicine Online, vol. 48, no. 3, p. 103599, Oct. 2023, doi: 10.1016/j.rbmo.2023.103599.

[10]   F. N. Chéileachair, B. E. McGuire, and H. Durand, "Coping with Dysmenorrhea: A Qualitative Analysis of Period Pain Management Among Students Who Menstruate," BMC Women S Health, vol. 22, no. 1, Oct. 2022, doi: 10.1186/s12905-022-01988-4.

[11]   M. Faizzati and F. Arifiansyah, "Interaction Design of Fertility Tracking Application Using User-Centered Design," 2022 International Conference on Data and Software Engineering (ICoDSE), pp. 95–100, Nov. 2022, doi: 10.1109/icodse56892.2022.9971817.

[12]   P. Arunkumar, K. Abarna, N. Nagamithra, G. Suweatha, and P. Varssha, "Application using Machine Learning to Promote Women's Personal Health," 2023 5th International Conference on Smart Systems and Inventive Technology (ICSSIT), Jan. 2023, doi: 10.1109/icssit55814.2023.10061126.

[13]   J. Gray, "Calendar Method: Birth control, calendar & effectiveness," Natural Cycles, Aug. 13, 2024. https://www.naturalcycles.com/cyclematters/calendar-method

[14]   O. J. C et al., "Improving Menstrual Cycle Prediction Accuracy using Advanced Machine Learning Model Methods," Journal of IoT and Machine Learning, vol. 1, no. 2, pp. 1–7, Dec. 2023, doi: 10.48001/joitml.2023.121-7.

[15]   A. Ariscrisnã and A. Santos, "What is MERN stack and how does it work?," Jul. 19, 2023. https://www.imaginarycloud.com/blog/what-is-mern-stack-and-how-does-it-work/