BJMHR
British Journal of Medical and Health Research
Journal home page: www.bjmhr.com

Investigating The Efficacy of Menstrual Health Applications In Promoting Informed Decision-Making And Comprehensive Sex Education

Snigdha Behara[1], Damian Schofield[2*]
1.Masters Student, Dept. of Computer Science, State University of New York, New York, USA
2.Professor, Dept. of Computer Science, State University of New York, New York, USA

ABSTRACT

In this research paper, the efficacy of Menstrual Health Applications (MHAs) in the realm of reproductive health education was investigated. Through surveys and rigorous statistical analysis, the impact of MHAs on users' comprehension of menstrual cycles, fertility, and contraception, as well as the ability of users to make informed decisions, was studied. In an era that has become characterized by a growing reliance on technology for health information, this study revealed that while MHAs hold significant potential, they are not consistently outperformed by traditional methods in reproductive health education. Furthermore, concerns related to privacy, inclusivity, and information accuracy were expressed by many users, underscoring the necessity for improvements to currently available applications. The implications of the findings of this research could potentially have a significant impact on future development of MHAs, comprehensive sex education, and healthcare policy. The work described in this paper offers valuable insights into how these applications can be optimized to enhance users' understanding and decision-making in matters of reproductive health.

Keywords: Menstrual Health Applications, Reproductive Health, Decision Making, User Research, Human-Computer Interaction

*Corresponding Author Email: Damian.Schofield@oswego.edu
Received 01 November 2024, Accepted 26 November 2024

Please cite this article as: Behara S *et al.*, Investigating The Efficacy of Menstrual Health Applications In Promoting Informed Decision-Making And Comprehensive Sex Education. British Journal of Medical and Health Research 2024.

INTRODUCTION

Sexual health and empowerment are essential aspects of overall well-being, and in recent years, a number of technical advancements have opened up new avenues for individuals to take control of their reproductive health. Menstrual Health Applications (MHAs) have emerged as powerful tools that enable menstruators to monitor their menstrual cycles, track symptoms, and gain valuable insights into their reproductive health[1-3]. These applications have the potential to play a significant role in empowering menstruators by providing them with knowledge, promoting informed decision-making, and enhancing comprehensive sex education.

The availability and accessibility of MHAs have revolutionized the way menstruators approach their reproductive health. With just a few taps on a smartphone, individuals can easily record and monitor their menstrual cycles, track symptoms, predict fertility windows, and access a wealth of information related to reproductive health and sexual well-being[2]. Such applications often offer a user-friendly interface, personalized features, and educational resources that enable menstruators to understand their bodies better and make informed decisions regarding their sexual and reproductive health.

By evaluating the efficacy of MHAs, this paper aims to provide a comprehensive understanding of their impact on informed decision-making and comprehensive sex education. The paper critically analyzes existing research studies, and relevant sources to assess the strengths, limitations, and potential benefits of these applications. Additionally, this report addresses the challenges and concerns associated with the use of MHAs including privacy, accuracy of information, and inclusivity.

The paper also explore how these MHAs can empower menstruators by promoting awareness, education, and active participation in their sexual health. It assesses the extent to which these applications contribute to informed decision-making related to contraception, fertility planning, and overall well-being. Furthermore, this paper examines the role of these applications in enhancing comprehensive sex education, particularly in terms of providing accurate information, promoting positive attitudes, and fostering healthy behaviors.

By critically assessing the efficacy of MHAs, areas for improvement can be identified, recommendations for future research can be proposed, and the support and resources available to menstruators in their journey toward understanding and empowerment can be enhanced.

AN OVERVIEW OF MENSTRUAL TRACKING APPLICATIONS

Menstrual tracking applications, also known as period tracking applications or menstrual cycle trackers, are mobile or web-based tools designed to help individual users monitor and

record information about their menstrual cycles. Menstrual Tracking Applications (MTAs) are a subset of MHAs, where the former manly focuses on period or pregnancy tracking. MTAs often contain other information, in addition to period tracking, such as menstrual health education resources.

These applications provide a platform for users to track the start and end dates of their periods, as well as other related data such as symptoms, moods, and fertility indicators. The primary purpose of MHAs and MTAs is to assist individuals in gaining a better understanding of their menstrual health. By recording and analyzing menstrual data over time, users can identify patterns, track changes in their cycle length, predict future periods, and estimate fertile windows for family planning purposes. These applications aim to empower users with knowledge about their menstrual cycles, enabling them to make informed decisions about their reproductive health and well-being. In addition to cycle tracking, many MHAs offer additional features and functionalities.

Most applications include symptom tracking, where users can log and monitor common symptoms associated with menstruation, such as cramps, bloating, headaches, and mood changes[1,3]. Some applications also provide educational resources on menstrual health, contraception methods, sexual health, and overall well-being, thereby promoting comprehensive sex education and empowering users with accurate information.

One of the primary distinctions among the applications is their underlying algorithms and data accuracy. Applications like *Clue* and *Flo* utilize large datasets and machine learning algorithms to provide personalized predictions. These applications often incorporate user feedback to refine their predictions over time, enhancing their accuracy. In contrast, some simpler applications rely on basic calendar methods, which may not account for individual variations in cycle length and symptoms, potentially leading to less accurate predictions[2].

Another critical aspect to consider is the user interface and experience. Applications such as *Glow* and *Ovia* offer comprehensive health tracking features, including mood, symptoms, and lifestyle factors, which can provide a holistic view of a user's health. These features can be particularly beneficial for users looking to understand the broader context of their menstrual health. On the other hand, some users may find these additional features overwhelming and prefer the simplicity of applications like *Period Tracker*, which focuses solely on tracking menstrual cycles without additional health data[3].

Privacy and data security are also significant concerns in the use of MHAs and MTAs. Many applications collect sensitive health data, which raises questions about data storage, sharing, and user consent. Some applications, like *Natural Cycles*, emphasize their commitment to

data privacy and compliance with regulations. However, not all applications provide the same level of transparency and security, which can affect user trust and adoption[4].

Menstrual tracking applications are intended to be convenient, user-friendly tools that support individuals in managing their menstrual health. They provide a means for users to track, analyze, and gain insights into their menstrual cycles, ultimately promoting awareness, understanding, and informed decision-making related to reproductive health.

Informed Decision Making and Comprehensive Sex

Informed decision-making and comprehensive sex education play crucial roles in promoting individual well-being, fostering healthy relationships, and reducing the risks associated with sexual activity:

- *Empowerment and Autonomy:* Comprehensive sex education empowers individuals by providing them with accurate and evidence-based information about sexual health, reproduction, contraception, and Sexually Transmitted Infections (STIs). When individuals have access to this knowledge, they can make informed decisions about their sexual and reproductive lives, taking control of their health and well-being[1].
- *Risk Reduction:* Equips individuals with the knowledge and skills to understand and mitigate risks associated with sexual activity. This includes information about practicing safe sex, using contraception effectively, preventing STIs, and understanding consent. By making informed decisions, individuals can reduce the likelihood of unintended pregnancies, STI transmission, and other negative consequences[9].
- *Breaking Stigma and Myths:* Comprehensive sex education challenges societal taboos, misconceptions, and stigmas surrounding sexuality and reproductive health. Providing accurate and non-judgmental information helps dispel myths and misinformation, promoting a more open and accepting society[4]. This can lead to reduced stigma, improved access to sexual health services, and increased awareness of diverse sexual orientations, gender identities, and reproductive rights.

Numerous studies have demonstrated the positive impact of comprehensive sex education on various outcomes, such as increased knowledge, improved decision-making, reduced risky behaviors, and better reproductive health outcomes. Educational institutions, healthcare providers, and communities need to prioritize comprehensive sex education to ensure individuals have the information and skills they need to make informed decisions and lead healthy, fulfilling lives. By integrating comprehensive sex education components such as educational resources, tracking features, fertility awareness, symptom management, and community support, menstrual tracking applications can contribute to the overall knowledge, awareness, and empowerment of individuals about their menstrual and reproductive health.

These applications can serve as accessible and convenient tools for promoting comprehensive sex education and encouraging individuals to make informed decisions about their sexual and reproductive well-being.

Factors to Evaluate the Efficacy of Menstrual Health Applications (MHAs)

These features are important in evaluating the efficacy of menstrual tracking applications because they directly impact the user experience and the quality of the information provided[1-6].

1. *Accuracy of Information:* Ensuring the accuracy of information is crucial as it directly influences the reliability and trustworthiness of an application. In the field of comprehensive sex education, accurate information is essential for promoting responsible decision-making and healthy behaviors. By assessing the sources referenced within an application, checking for reputable scientific studies and expert guidance, and examining whether the information aligns with established medical guidelines, users can have confidence in the accuracy of the content provided. Accurate information empowers users to make informed choices about contraception, reproductive health, and sexual well-being.
2. *Educational Content:* The educational content of the application plays a fundamental role in comprehensive sex education. It should encompass a wide range of relevant topics, including reproductive anatomy, menstrual health, contraceptive methods, sexually transmitted infections, consent, healthy relationships, and sexual rights. The content should be comprehensive, presenting information in a clear and accessible manner. It should cater to different age groups, educational backgrounds, and cultural contexts. By offering well-rounded educational content, these applications have the potential to equip users with the knowledge and understanding necessary for making informed decisions about their sexual and reproductive health.
3. *User Engagement:* User engagement refers to the level of interaction and interest users have with an application. An engaging application captures and maintains the user's attention, motivating them to explore and learn from the educational material. Engaging features such as quizzes, interactive modules, progress tracking, and rewards can enhance user involvement and facilitate active learning. By incorporating gamification elements and interactive components, these applications can encourage users to actively participate in their learning process, resulting in a more effective educational experience.
4. *Privacy and Data Protection:* Privacy and data protection are critical considerations for all MTAs, given the personal and sensitive nature of the information they collect. Robust privacy policies and secure data handling practices are essential to protect user confidentiality and maintain trust. These applications should communicate how user data

is collected, stored, and used, and should adhere to relevant data protection regulations. By prioritizing privacy and data protection, these applications foster a safe and secure environment for users to engage with educational content and track their menstrual health.

5. *User Interface and Accessibility:* A user-friendly interface is essential for effective application usage. An application should have a well-designed layout, intuitive navigation, and clear instructions - ensuring that users can easily access and navigate through the content. Additionally, considering accessibility features, such as font size options, color contrast, and compatibility with assistive technologies, ensures that the application is inclusive and usable for individuals with diverse needs. An application that prioritizes user interface and accessibility enables a wider range of users to benefit from the educational content it prov*ides.*
6. *Alignment with Educational Standards:* To ensure an application covers the necessary content and educational objectives, alignment with established educational standards or guidelines is crucial. This alignment ensures that the application meets recognized criteria for comprehensive sex education, addressing the relevant topics and learning outcomes. By adhering to educational standards, the application maintains consistency, quality, and relevance in its educational material. Users can have confidence that the application is providing them with the information and skills necessary for comprehensive sex education.
7. *Health Tracking and Reminders:* The inclusion of health tracking features, such as menstrual cycle tracking and reminders for contraceptive use or health check-ups, adds value to an application. These features support users in effectively managing their reproductive health. By enabling users to track their menstrual cycles, identify patterns, and receive timely reminders, these applications promote regular health monitoring and adherence to recommended practices. This can contribute to improved reproductive health outcomes and empower users to take an active role in their well-being.
8. *Peer Support and Community:* Incorporating peer support and community features within an MHA fosters a sense of connection and support among users. By providing a platform for users to engage in discussions, share experiences, seek advice, and access additional resources, an application can create a supportive community. Peer support enhances the learning experience by allowing users to learn from others, exchange information, and gain insights into different perspectives. This sense of community can promote engagement, motivation, and a supportive environment for comprehensive sex education.
9. *Scientific Basis and References:* A reliable menstrual tracking application should be built on a strong scientific basis. This means that the information provided within an MHA is

supported by reputable sources, research studies, and authoritative organizations. By including references and citing the scientific basis of the information, users can verify the credibility and accuracy of the content. Additionally, providing references allows users to delve deeper into the topics, explore further resources, and enhance their understanding of the scientific underpinnings of comprehensive sex education.

10. *Feedback and Reviews:* Monitoring user feedback and reviews is an important aspect of evaluating application efficacy. Users' experiences and opinions can provide valuable insights into the usability, effectiveness, and relevance of an application. By analyzing user feedback, developers can identify areas for improvement, address concerns, and enhance an application's features over time. User feedback and reviews contribute to ongoing application development and ensure that the application remains responsive to the needs and preferences of its users.

LITERATURE REVIEW

Although a recent development, MHAs and their usage has been explored through a series of seminal studies that have significantly advanced understanding in this field. A number of key research papers, encompassing diverse methodologies and addressing various dimensions, provide nuanced insights into the evaluation and impact of MHAs on users.

Key Research Studies

A comprehensive scoping review of menstruation and fertility application trackers has been carried out by multiple researchers shedding light on the necessity for evidence-based research and the addressing of concerns regarding accuracy and reliability[1-4,6]. A notable increase in the global development and usage of these applications was revealed in the literature review. However, the need for additional evidence from clinical trials and user experience to ensure accuracy and effectiveness was highlighted[2]. The importance of rigorous evaluation and validation of these applications to provide users with reliable information for decision-making was emphasized.

Numerous aspects of MHAs have been explored in various research papers, yielding valuable insights into their efficacy and potential benefits. For example, an assessment of MHAs for fertility awareness was conducted, with an emphasis on their role in assisting couples in fertility management and family planning. The findings indicated that the fertile window around ovulation can be identified, and sexual behavior can be adjusted through the utilization of these applications, which employ parameters such as basal body temperature, cervical mucus observations, and others[5]. A personalized approach to fertility tracking can significantly assist individuals in the achievement of their reproductive goals.

In another experiment, a double-blind randomized controlled trial involving women with dysmenorrhea and premenstrual syndrome was conducted to evaluate the impact of tailored MHAs on health-related factors[8]. The findings revealed that participants using MHAs showed significant improvements in overall satisfaction, social influence, intent to recommend, and the possibility of behavioral or cognitive changes in symptom management. The study concluded that menstrual health apps tailored to users' needs could enhance user engagement and improve health-related outcomes.

Valuable insights into users' experiences with app-supported menstrual tracking have been provided through more other qualitative studies[9]. Interviews with MHA users explored their practices and perceptions of these applications. The motivations behind application usage and the perceived benefits of tracking menstrual cycles digitally were illuminated by the findings. This research found that applications were perceived as valuable tools for self-awareness and understanding menstrual patterns. Users reported gaining knowledge about their cycles, empowering them to make informed decisions regarding contraception, fertility, and reproductive health. The research reported that MHAs can provide a sense of control and agency, enabling users to actively participate in their reproductive health management[9].

Evaluation studies have also systematically assessed the accuracy, features, and functionality of smartphone MTAs[3]. Smartphone applications were evaluated using an adapted APPLICATIONS scoring system, which had been previously developed and applied to rate pregnancy wheel applications[3]. The primary objective of this research was to assess the accuracy, features, and functionality of these applications and assess the reliability of the information provided to users. The research findings revealed that most of the evaluated MTAs were inaccurate in tracking menstrual cycles. Additionally, very few MTAs cited medical literature or involved health professionals in their development. The findings from this study underscore the need for improved accuracy and professional involvement in the development of MTAs to ensure they provide reliable information for users.

Other more recent studies have explored the potential of mobile apps in tracking and assessing menstrual health and fertility awareness. In one research study, researchers utilized data from over 2.7 million menstrual cycles recorded by users of two popular MHAs[7]. This large dataset provided a unique opportunity to analyze menstrual health on a scale that was previously unattainable through traditional methods. The study found that self-reported data from these apps are generally reliable. The consistency and accuracy of the data were validated through various statistical methods, ensuring that the information could be trusted for scientific analysis. Furthermore, the researchers were able to track changes in menstrual health over time, providing a dynamic view of how menstrual health evolves. This

longitudinal data is crucial for identifying potential health issues early and understanding the impact of lifestyle or environmental factors on menstrual health.

This large, data-driven study highlights the potential of digital epidemiology in the field of menstrual health[7]. By leveraging large-scale data from mobile apps, other researchers have been also able to conduct epidemiological studies more efficiently and with greater scope than traditional methods previously allowed[1]. This approach opens new avenues for public health research and personalized healthcare. These findings support the use of MTAs in research settings, offering a scalable and efficient method for monitoring menstrual health.

Another large-scale review, undertaken in 2021, evaluated the real-world applications of symptom tracking functionalities in MTAs[11]. The researchers aimed to determine whether the data fields available in a subset of MTAs could be harmonized across digital platforms for potential use in research, such as aggregated data analysis. The review found that although symptom tracking capabilities are a common feature among MTAs, there has been limited investigation into their real-world applications. MTAs differ significantly in terms of which symptoms are included and the specificity with which symptoms are recorded. The study highlights the need for collaborative efforts between clinicians and researchers to guide what and how data is collected within these applications, which would enhance the diagnostic applicability of these MTAs.

In the broader context of sexual health education, a systematic review of sex education programs has been conducted, providing an overview of their dissemination and effectiveness[12]. The review reported on the significance of evidence-based approaches to inform improved public policymaking in this domain. The review also stressed the need for comprehensive approaches that extend beyond pregnancy and sexually transmitted disease prevention. It emphasized the importance of incorporating menstrual tracking applications within comprehensive sex education programs to enhance knowledge and understanding of reproductive health. By integrating menstrual health education, these MHAs can empower individuals to make informed decisions about contraception, fertility, and overall reproductive well-being.

Over the past few decades, menstrual health has emerged as a critical public health and human rights issue. Advocacy has been undertaken for the prioritization of menstrual health in global health frameworks and the adoption of holistic approaches addressing the social determinants of health[13]. The achievement of menstrual health has been highlighted as fundamental to the equality, rights, and dignity of all individuals who menstruate. By addressing the social determinants of menstrual health and considering it an integral part of sexual and reproductive health programs, holistic approaches can be developed to support

informed decision-making and the empowerment of individuals in effectively managing their menstrual health. A standardized definition of menstrual health, encompassing physical, mental, and social well-being in relation to the menstrual cycle, serves as a foundation for policy development, practice, and research in the field[14]. This definition enables the integration of MHAs within a broader framework of menstrual health education and decision-making processes.

The research described in this section underscores the potential of MHAs in empowering women to make informed decisions about their reproductive health. The collective insights provided by this research significantly contributes to a comprehensive understanding of digital MHAs and their implications for women's reproductive health. These findings shed light on the potential of MHAs in facilitating informed decision-making and sex education. Further research, evaluation, and validation are crucial to ensuring the accuracy, efficacy, and user satisfaction of these applications. It is, however, essential to integrate MHAs within a broader framework of reproductive health education to promote informed decision-making and empower women in making choices that align with their reproductive goals and overall well-being.

In particular, the analysis of the user experience of MHAs is crucial for the improvement of their effectiveness, usability, and impact on women's health and well-being. Understanding user perspectives can guide the development of user-centered design approaches and interventions that better meet the needs and preferences of individuals using these applications. By offering personalized and easily accessible tools, these applications enable individuals to monitor their menstrual health and gain insights into their reproductive patterns.

Further research, evaluation, and validation are crucial to ensuring the accuracy, efficacy, and user satisfaction of these applications. It is, however, essential to integrate menstrual tracking applications within a broader framework of reproductive health education to promote informed decision-making and empower women in making choices that align with their reproductive goals and overall well-being.

Analysis of Strengths, Limitations, and Gaps in the Current Literature

Multiple aspects of MHAs have been explored in the research papers described in the previous section of this paper, providing valuable insights into their efficacy and potential benefits. Given below are some of the strengths and limitations identified in the research studies from the previous section:

- A scoping review described in the previous section exhibits ***strengths*** by comprehensively reviewing existing evidence and capturing various study designs and

perspectives. However, ***limitations*** were also presented by the identification of potential biases in the review process and the absence of statistical synthesis of the findings[2].

- One particular assessment of mobile applications for fertility awareness placed an emphasis on MHAs and their role in fertility management and family planning. The findings indicated that the fertile window around ovulation can be identified, and sexual behavior adjusted through the utilization of these applications. The applications specifically employed parameters such as basal body temperature, cervical mucus observations, and others[5]. The research reported a ***strength,*** in that a personalized approach to fertility tracking can significantly assist individuals in the achievement of their reproductive goals[2].
- Research on the efficacy of digital MHAs has focused on assessing their functionalities, user experiences, behavioral changes associated MHA usage, and the quality of information provided[3]. The ***strength*** of this work was that the use of the adapted APPLICATIONS scoring system led to a systematic and rigorous evaluation of the MHAs considered. The main ***limitation*** of this study was that it only considered a very limited subset of the MHAs available (free application on the iTunes Store).
- One particular assessment of mobile applications for fertility awareness placed an emphasis on MHAs and their role in fertility management and family planning. The findings indicated that the fertile window around ovulation can be identified, and sexual behavior adjusted through the utilization of these applications. The applications specifically employed parameters such as basal body temperature, cervical mucus observations, and others. The research reported a ***strength,*** in that a personalized approach to fertility tracking can significantly assist individuals in the achievement of their reproductive goals[7].
- Another study explored the effects of MHAs through a double-blind randomized controlled trial. Some insights into the impact of specific applications on health-related factors were provided by this study. However, its ***limitations*** included a relatively small sample size, lack of information on application features, and insufficient investigation of long-term sustainability[8].
- A qualitative study on users' experiences of application-supported menstrual tracking in Europe was conducted, a ***strength*** being that the work shed light on the benefits and motivations for tracking. However, the study's ***limitations*** included potential sample bias and limited generalizability[9].
- User experiences have been the focus of very few qualitative studies. The ***strength*** of those studies that have been undertaken is that they emphasizing the benefits of MHAs in

increasing self-awareness and understanding of menstrual patterns[11]. However, a ***limitation*** is that discrepancies have been observed between the information provided by applications and expected results based on big-data analysis, underscoring the need for improved accuracy and reliability.

- A definition for menstrual health was by researchers in one of the papers, emphasizing the need for standardization and consideration of social, economic, and cultural dimensions. However, a ***limitation*** of this paper is that the exploration of empirical research or evidence-based practices in-depth falls short[13].
- With their discussion of menstrual health as a public health and human rights issue, ***strengths*** were demonstrated in highlighting the importance of addressing menstrual health comprehensively and recognizing the social and economic consequences associated with menstrual health challenges. Nevertheless, ***limitations*** included the restricted depth of the analysis, and the paper lacked specific empirical evidence or studies cited[14].
- The above analysis indicate that further research is needed to investigate the impact of tailored applications on health-related factors, standardizing metrics, language used in applications, and assessing the long-term effects on users' health and well-being.

Trends and Patterns in the Literature

These nuanced insights shed light on the multifaceted nature of MHAs and provide a comprehensive understanding of their efficacy and potential benefits. A significant trend observed across the literature is the increasing use and development of MHAs[1-3,5,7-9,11]. Multiple studies highlight the growing popularity and adoption of these applications, indicating a rising interest in leveraging technology for menstrual health monitoring and management. This trend reflects the broader trend of the digitalization of healthcare, with individuals seeking convenient and accessible tools to track multiple aspects of their health and wellbeing[15].

A common pattern that emerges from the reviewed studies is the emphasis on the potential benefits of MHAs in empowering individuals and increasing self-awareness[1-3,7,9,11]. These applications are often viewed as valuable tools for enhancing users' understanding of their menstrual patterns, promoting self-monitoring, and facilitating informed decision-making regarding contraception, fertility, and reproductive health. By providing personalized insights and data-driven predictions, these applications empower users to take an active role in managing their menstrual health and reproductive well-being.

Agreement exists among the research studies regarding the varied functionalities and features offered by digital menstrual health applications. The literature highlights the diversity of

application features, including menstrual cycle tracking, symptom recording, fertility prediction, and educational resources[1-3,5,8,12]. This agreement underscores the efforts made by application developers to cater to individual needs and preferences, acknowledging the diverse experiences and requirements of users in managing their menstrual health[8].

However, despite the general agreement on the potential benefits, limitations and discrepancies are evident in the literature. The reviewed studies identify several limitations, such as reliance on self-reported data, potential selection bias, small sample sizes, and a lack of long-term sustainability assessment[1,3,8,9,11,13]. These limitations highlight the need for caution when interpreting the findings and emphasize the importance of conducting rigorous research with larger, diverse populations to ensure generalizability and validity.

Another emerging trend within the literature is the recognition of the potential of integrating MHAs into comprehensive sexual health education programs[1,3,8,12]. Several studies emphasize the role of these applications in enhancing knowledge and understanding of reproductive health, promoting informed decision-making, and empowering individuals to actively manage their menstrual health. This integration represents a promising approach to leverage MHAs as a tool for improving reproductive health literacy and fostering positive health behaviors.

METHODOLOGY

The purpose of this research is to investigate the efficacy of MHAs in promoting informed decision-making and comprehensive sex education. The project objectives were as follows :

- To assess the impact of MHAs on users' knowledge and understanding of reproductive health, including menstrual cycles, fertility, contraception, and overall sexual well-being.
- To examine the extent to which MHAs contribute to informed decision-making related to reproductive choices, including contraceptive methods, and fertility awareness.
- To identify potential limitations, challenges, and concerns associated with the use of MHAs, such as privacy issues, accuracy of information, inclusivity, and potential biases.
- Hence, hypotheses to examine the potential impact of using MHAs on informed decision-making and comprehensive sex education outcomes have been developed :
- H0: Null Hypothesis: There is no significant difference in informed decision-making and comprehensive sex education outcomes between individuals who use MHAs and those who do not.
- Ha: Alternative Hypothesis: There is a significant difference in informed decision-making and comprehensive sex education outcomes between individuals who use MHAs and those who do not.

Experimental Participants

To account for potential cultural and contextual variations, the study included a diverse range of participants to ensure a representative sample and capture a variety of experiences and perspectives related to MHAs. To protect the rights and welfare of human subjects, ethical considerations and informed consent procedures were followed in accordance with the guidelines and regulations set by an Institutional Review Board (IRB) at the State University of New York.

Demographic information including age groups, gender identities, geographical location, was collected to characterize the sample and analyze potential variations in experiences and outcomes. The study ensured the privacy and confidentiality of participants' personal information by anonymizing data during analysis and reporting.

Experimental Design

The experiment was undertaken in a series of distinct steps:

1. Social media and networking platforms (such as Slack and Reddit) were utilized to recruit participants.
2. Once a participant joined the experiment, a recruitment survey and informed consent form was sent.
3. The recruitment survey collected a range of demographic information, including the participant's contact information, age group, gender identity, location, ethnic background.
4. Informed consent was obtained from all participants, ensuring their voluntary participation, confidentiality, and the right to withdraw from the study at any time.
5. The study obtained informed consent from all participants, ensuring their voluntary participation, confidentiality, and the right to withdraw from the study at any time
6. A participant demographic table was created which contained all the demographic and contact information to characterize the sample quality and account for inclusion of diverse ethnicities, age groups, gender identities and location. All documents were password protected.
7. To improve the internal validity of the experiment, a randomization procedure was employed to assign participants to the experimental and control groups.
8. Once the participants were divided into the to the experimental and control groups, they were sent either a control group survey or the experimental group survey.
9. Once the responses are received, the participants were sent a debriefing document thanking them for their participation, clearly ensuring their anonymity and stating that their personally identifiable information (PII) were anonymized by removing unique identifiers including contact information, and location

Each of the participants in the two groups (experimental and control) received differing instructions:

- Experimental Group: Participants assigned to the experimental group were instructed to self-report their usage or non-usage of MHAs during the study period. They were instructed to report on their methods or practices for managing and tracking their reproductive health.
- Control Group: Participants assigned to the control group were asked to report their knowledge and practices related to reproductive health without referring to the use of an MHA. They were also instructed to report their usual methods or practices for managing and tracking their reproductive health.
- The purpose of including a control group is to establish a baseline for comparison, to assess the specific impact of using a menstrual health application on the outcomes of interest.

Survey Instruments

The purpose of the experimental surveys was to gather qualitative insights into participants' perceptions and the impact of MHAs on their decision-making and comprehensive sex education. In this mode of data collection, participants had the opportunity to share their thoughts, experiences, and provide valuable feedback related to their use of MHAs.

By administering differing surveys to both the experimental and control groups, data on participants' knowledge, practices, and experiences related to reproductive health, as well as their usage or non-usage of menstrual health applications was gathered. These survey content was tailored to the specific needs of each group.

- The experimental group survey included questions about current frequency of MHA use, specific applications utilized, and the perceived impact on informed decision-making and comprehensive sex education.
- The control group survey focused on current knowledge, practices, and decision-making processes related to reproductive health without referencing the use of a MHA.
- The participants received the surveys online and completed them either before or after using the MHA, or as part of a control group that does not use an MHA. The surveys consisted of Likert-scale questions, rating scales, and multiple-choice questions covering awareness, impact of menstrual health apps on decision-making processes, and understanding experiences with respect to accuracy, privacy, and inclusivity.

Data Analysis Techniques

The data collected from the surveys served as the foundation for further analysis and comparison of outcomes between the two groups, allowing for a comprehensive assessment

of the impact of MHAs on informed decision-making and comprehensive sex education.

Since the data predominantly followed a normal distribution and the variances of the two groups were relatively equal, an independent samples t-test was used. For this ordinal or non-normally distributed data, a Mann-Whitney U

test was used to assess whether there was a significant difference in the medians between two groups. These statistical techniques were used to assess the following relationships within the data:

- *Assessing the impact of MHAs on knowledge and understanding of reproductive health:* In comparing the knowledge and understanding between the experimental and control groups, independent samples t-tests helped to determine if there was a significant difference in knowledge and understanding scores between the two groups.
- *Examining the extent to which MHAs contribute to informed decision-making related to reproductive choices:* To assess the impact on decision-making, independent samples t-tests were used, to compare the decision-making scores between the experimental and control groups.
- *Investigating the user experience of MHAs:* User experience, satisfaction, usability, and perceived benefits and drawbacks were assessed using descriptive statistics including means, standard deviations, and frequency distributions. These statistics helped to quantify the average level of satisfaction, usability, or perceived benefits and drawbacks reported by participants. Frequency distributions were used to provide information about the occurrence or frequency of specific responses, to help identify patterns or trends in participants' experiences.
- *Identifying potential limitations, challenges, and concerns associated with the use of MTAs:* Qualitative data analysis and thematic analysis were employed to identify and analyze common themes and patterns in participants' feedback and concerns.
- The results of the appropriate tests for each objective as mentioned above were used the evaluate the null hypothesis and alternative hypothesis. With the significance level (p-value) set to 0.05, it was determined if there is a statistically significant difference in informed decision-making and comprehensive sex education outcomes between the experimental and control groups.

Conclusions were then drawn regarding the efficacy of MHAs in promoting informed decision-making and comprehensive sex education based on the findings. The functionality and effectiveness of MHAs were also recommended for improvement to better support informed decision-making and comprehensive sex education.

RESULTS AND DISCUSSION

Data was collected from two groups of participants (control and experimental groups) This data was made up of both qualitative and quantitative data (from open-ended survey questions). The data was initially categorized into the following themes to account for each objective:

1. Current tracking methods and awareness of menstrual health, to help understand menstrual health tracking methods and the participant's knowledge of menstrual and sexual health.
2. Informed decision-making, to discover the extent to which participant's are able to discover resources contributing to informed decision-making.
3. The participant's experiences with respect to accuracy, privacy, and inclusivity.

Each objective was examined independently using the data collected from every participant for the coded quantitative questions. A Welch's t-test was performed on each of the dependent variables to account for the unequal sample sizes and variances Hypothesis testing was conducted for each objective, and the mean knowledge was used to determine which group the participants were associated with which dependent variable in terms of positive outcomes.

Objective 1

Objective 1 set out to assess the impact of MHAs on users' knowledge and understanding of reproductive health, including menstrual cycles, fertility, contraception, and overall sexual well-being.

The coded questions contributing to objective 1 are listed below:

- Q1 - On a scale of 1 - 5, how confident are you in identifying your fertile days during your menstrual cycle?
- Q2 - How would you rate your understanding of sexually transmitted infections (STIs): modes of transmission, and detection?
- Q3 - Please rate your understanding of the options available to you protect yourself from STDs.
- Q4 - On a scale of 1 to 5, please rate your level of understanding regarding factors that can influence fertility and conception, including age, health conditions, and lifestyle factors.
- Q5 - On a scale of 1 to 5, how confident are you in your ability to discuss reproductive health topics with friends, family, or healthcare providers?

The responses to these survey questions and the experimental and control group means are given in Table 1.

Table 1: Results from the survey contributing to Objective 1.

Participant	Group (A/B)	Q1	Q2	Q3	Q4	Q5	Average/Mean
1	A	5	4	4	4	2	3.8
2	A	4	5	5	5	2	4.2
3	A	5	5	5	5	1	4.2
4	A	3	1	2	3	3	2.4
5	A	3	3	4	4	4	3.6
6	A	5	2	2	4	2	3
7	A	3	1	1	3	5	2.6
8	A	5	4	3	4	2	3.6
9	A	1	4	5	2	2	2.8
10	A	1	3	1	1	3	1.8
GROUP A MEAN							**3.20**
11	B	1	3	4	2	2	2.4
12	B	4	4	4	2	5	3.8
13	B	4	4	3	2	3	3.2
14	B	1	4	4	4	2	3
15	B	1	4	5	3	1	2.8
GROUP B MEAN							**3.04**

Table 2: Results from the survey contributing to Objective 2.

Participant	Group (A/B)	Q1	Q2	Average/Mean
1	A	1	5	3
2	A	1	5	3
3	A	1	5	3
4	A	1	3	2
5	A	1	3	2
6	A	0	5	2.5
7	A	1	3	2
8	A	1	3	2
9	A	1	3	2
10	A	1	5	3
GROUP A MEAN				**2.45**
11	B	0	1	0.5
12	B	1	4	2.5
13	B	1	3	2
14	B	0	3	1.5
15	B	0	3	1.5
GROUP B MEAN				**1.6**

Objective 2

Objective 2 set out to examine the extent to which menstrual tracking applications contribute to informed decision-making related to reproductive choices, including contraceptive methods, and fertility awareness.

The coded questions contributing to objective 2 are listed below:

- Q1 - Were you able to make the decision regarding choosing and using birth control methods to prevent pregnancy confidently?

- Q2 - On a scale of 1 to 5, please rate how well-informed you felt before making decisions based on your fertile and non-fertile days.

The responses to these survey questions and the experimental and control group means are given in Table 2.

Table 3: Results from the survey contributing to Objective 3.

Participant	Group(A/B)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Average/Mean
1	A	4	0	0.5	4	3	0.5	0	0	1	1.44
2	A	5	0.5	0.5	3	2	0	0	1	1	1.44
3	A	3	0.5	0	5	5	1	1	1	1	1.94
4	A	3	0	1	3	3	0	0	0.5		1.31
5	A	3	0	1	5	3	1	0.5	1	1	1.72
6	A	3	0	0	4	1	0	0	0	1	1.00
7	A	3	0.5	1	3	5	0.5	0	0	1	1.56
8	A	4	0	1	4	4	0	0.5	0	1	1.61
9	A	2	0	0.5	2	3	0	0	0.5	1	1.00
10	A	3	0	1	5	5	0	1	0	1	1.78
GROUP A MEAN											**1.48**
11	B	4	0	1	5	1	1	0	0	0	1.33
12	B	4	0	1	5	5	0.5	1	0	0.5	1.89
13	B	4	0	0.5	5	3	1	1	0	0.5	1.67
14	B	3	0	0.5	1	1	0.5	0.5	0.5	0.5	0.83
15	B	3	0	1	3	2	0	0	0	0	1.00
GROUP B MEAN											**1.34**

Objective 3

Objective 3 set out to identify potential limitations, challenges, and concerns associated with the use of menstrual tracking applications, such as privacy issues, accuracy of information, inclusivity, and potential biases.

The coded questions contributing to objective 3 are listed below:

- Q1 - How accurate have the resources (or menstrual health applications) been in helping you predict your cycles (e.g. healthcare professionals, educational websites, family/friends, books etc.)?
- Q2 - If applicable, has the lack of accuracy harmed you or impaired your health decisions?
- Q3 - Are you willing to explore other resources for more accurate information?
- Q4 - On a scale of 1 to 5, how comfortable do you feel with sharing your menstrual cycle information with your resources/app (forums, healthcare professionals etc.)?
- Q5 - In the current political climate and the anti-abortion laws, how safe do you feel about sharing your information?
- Q6 - Have you received support and information tailored to your current phase in your menstrual journey?

- Q7 - Have you received support and information tailored to your gender identity and sexual orientation?
- Q8 - Have you received support and information tailored to your ethnic and cultural background?
- Q9 - Did you feel that your experiences and specific needs were adequately accounted for & validated while seeking support ?

The responses to these survey questions and the experimental and control group means are given in Table 3.

ANALYSIS

The analysis was undertaken independently, for each of the project objectives.

Objective 1

Objective 1 aimed to assess the impact of menstrual tracking applications on users' knowledge and understanding of reproductive health, including menstrual cycles, fertility, contraception, and overall sexual well-being.

Quantitative Analysis for Objective 1

The p-value for Objective 1 was found to be 0.650. Therefore, the Null Hypothesis (H0) was accepted, i.e. That there is no significant difference in knowledge and understanding scores between the experimental group (using MHAs) and the control group (not using MHAs).

Since the control group (those not using MHAs) exhibits a slightly higher mean knowledge and understanding score than the experimental group, it suggests that not using these applications may not necessarily be associated with a better outcome in terms of knowledge and understanding.

Qualitative Analysis for Objective 1

The results of the quantitative analysis for Objective 1 are shown in Table 4.

Table 4: Qualitative analysis for Objective 1

	Control Group	Experimental Group
Menstrual tracking & management	The responses ranged from using memory to remember the dates, calendars from phone, and sticky notes	60% responded that they did not use MHAs, while 40% responded that they did, with an application called Flo being the dominant one. The dominant source of discovery for the applications was smartphone app stores.
Media & discovery	60% respondents said that they don't seek education about menstrual cycles, fertility, contraception, and sexual well-being, while 40% said they do so occasionally	40% responded that they occasionally seek education about menstrual cycles, fertility, contraception, and sexual well-being, with another 40% claiming that they do so regularly. 20% of the respondents said that they rarely seek new information.
Awareness & education	Responses when asked about their current knowledge level of contraceptive methods: Male Condoms - 100% Birth Control Pills - 80% IUDs - 60% Withdrawal Method - 60% Morning-after pills - 40% Female Condoms - 40% Contraceptive Ring/Patch - 40%	Responses when asked about their current knowledge level of contraceptive methods : Male Condoms - 100% Birth Control Pills - 100% IUDs - 80% Withdrawal Method - 60% Morning-after pills - 100% Female Condoms - 80% Contraceptive Ring/Patch - 100%
Stigma, challenges & discussion	When asked about misconceptions or myths related to menstrual/sexual health, respondents alluded to being subject to sexist and religious traditions such as being treated as impure, along with hiding the fact they menstruate, and intense cramps being normal	When asked about misconceptions or myths related to menstrual/sexual health, respondents alluded to contraceptive myths, such as condoms completely prevent STDs, withdrawal method can prevent pregnancies, and menstrual cups being detrimental to vaginal health.
	When asked about addressing any challenges or concerns understanding sexual health, respondents cited healthcare providers and gynecologists to be helpful	When asked about addressing any challenges or concerns understanding sexual health, respondents cited credible articles, and healthcare providers to be helpful
Resources	When asked to list sources that helped overcome the misconceptions, the responses ranged from therapy, healthcare professionals, and education	When asked to list sources that helped overcome the misconceptions, the responses ranged from Google, Tik Tok, social media influencers and internet articles
	When asked about the most helpful resource in understanding their menstrual and sexual health, respondents cited education and awareness through healthcare providers, sex ed classes, and& keeping track of their health	When asked about the most helpful resource in understanding their menstrual and sexual health, respondents cited education & awareness through online resources and social media platforms
		60% of the respondents reported that menstrual health applications have improved their understanding of reproductive health topics, including menstrual cycles, fertility, and contraception significantly, while 40% responded that the applications have helped them to some extent.

Objective 2

Objective 2 aimed to examine the extent to which menstrual tracking applications contribute to informed decision-making related to reproductive choices, including contraceptive methods, and fertility awareness.

Quantitative Analysis for Objective 2

The p-value for Objective 2 was found to be 0.06. Therefore, the Null Hypothesis (H0) was accepted, i.e. That there is no significant difference in the informed decision-making ability between the experimental group (using MHAs) and the control group (not using MHAs).

Since the control group (those not using MHAs demonstrates a significantly higher mean knowledge and understanding score than the experimental group, implying that not using the applications is associated with a better outcome in terms of informed decision making.

Qualitative Analysis for Objective 2

The results of the quantitative analysis for Objective 2 are shown in Table 5.

Table 5: Qualitative analysis for Objective 2

	Control Group	Experimental Group
Preferred sources of information	Respondents attributed educational websites, healthcare providers, and social media to help them make decisions regarding birth control methods and their usage	Respondents attributed the menstrual health applications to make decisions regarding birth control methods and their usage
Percentage of use	71% respondents employed self-tracking, with 57% seeking support from healthcare professionals & educational websites, and 28% seeking information from books	80% of the respondents credited menstrual health applications for their ability to assist them in identifying and effectively addressing various challenges related to their menstrual health.
Decision making	Respondents planned pregnancies based on their fertile & non fertile days	Respondents took birth control seriously based on their fertile & non fertile days
Improvements for the future	When inquired about their preferences in resources for obtaining more confidence in making decisions about their bodies in the future, responses included seeking guidance from healthcare professionals, relying on credible and thoroughly researched websites, accessing free or low-cost resources, improved sex education in high schools	When inquired about their menstrual health application preferences for obtaining more confidence in making decisions about their bodies in the future, responses included in-depth information of cycles, LGBT+ informed approach, & customized experiences.

Also, only 25% of the respondents indicated that the information provided by the MHAs synchronized with the decisions they were making, while the majority, comprising 75%, expressed a degree of uncertainty.

Objective 3

Objective 3 aimed to identify potential limitations, challenges, and concerns associated with the use of menstrual tracking applications, such as privacy issues, accuracy of information, inclusivity, and potential biases.

Quantitative Analysis for Objective 3

The p-value for Objective 3 was found to be 0.558. Therefore, the Null Hypothesis (H0) was accepted, i.e. That there is no significant relationship between the use of MHAs and the identified limitations, challenges, and concerns, including privacy issues, accuracy of information, inclusivity, and potential biases.

Given that the control group (those not using MHAs) has a higher mean knowledge and understanding score than the experimental group, it suggests that not using the applications (or using other resources) is associated with limited concerns, including privacy issues, accuracy of information, inclusivity, and potential biases.

Qualitative Analysis for Objective 3

The results of the quantitative analysis for Objective 3 are shown in Table 6.

Table 6: Qualitative analysis for Objective 3

	Control Group	**Experimental Group**
Privacy and sharing information	In response to the question about whether they have ever chosen not to disclose their health information, participants provided several reasons for withholding – including concerns about sharing with strangers, the stigma surrounding abortion information, instances of doctors not adhering to HIPAA regulations, and being asked invasive questions in contexts where such inquiries were irrelevant.	When asked whether they have ever opted not to share their health information, participants expressed concerns about potential misuse, such as government or other entities using their data for control purposes. Despite these apprehensions, the majority still reported that they typically share their health information.
Inclusivity of resources	Instances where the resources were not perceived as inclusive or accommodating to specific needs were reported by some participants. While explicit negative experiences were rare, one participant noted that their gynecologists consistently used their preferred name and pronouns, yet did not explicitly acknowledge or validate their gender identity or sexuality, although these factors were not deemed highly relevant to their care. It was observed by a participant that healthcare specialists often did not take into account cultural values and opinions - unique and varying beliefs regarding the menstrual cycle in South Asian regions were highlighted, which, in turn, could impact women's psychological well-being.	When asked about instances where the apps were deemed non-inclusive or inadequate in meeting specific needs – non-straight couples reported that the applications were not inclusive, difficulty in remembering to input the cycle start date was noted, and it was suggested that the app could be more user-friendly, a request was made for a queer-friendly app with greater customization options

Also, the satisfaction rates for MHAs were categorized as follows: 60% of respondents rated their satisfaction as 3 (satisfied), while 20% each rated it as 4 (not satisfied) and 5 (not at all satisfied).

Implications of the Analysis

There were three significant implications that can be drawn from the analysis in the previous sections.

No Significant Difference in Knowledge and Understanding

Analysis of the data indicated a lack of a significant difference in knowledge and understanding scores between the experimental group (those using MHAs) and the control group (those not using MHAs). The p-value of 0.650 led to the acceptance of the null hypothesis that there is no significant difference.

The primary implication of this unexpected result suggests that, in terms of knowledge and understanding of reproductive health topics, including menstrual cycles, fertility, contraception, and sexual well-being, using MHAs does not confer a significant advantage over other methods of tracking or education.

This, in turn, implies that individuals in the control group, who employed alternative methods for tracking and education, may be as equally well-informed on these topics as those using MHAs. Further investigation is needed to explore why MHAs did not result in any significant knowledge and understanding advantage. Possible factors could include the quality of the MHAs used, the effectiveness of user engagement with the applications, or the influence of other information sources on both groups.

No Significant Difference in Informed Decision-Making

Analysis of the data indicated the absence of a significant difference in informed decision-making between the experimental and control groups. The p-value of 0.06 led to the acceptance of the null hypothesis.

This finding suggests that, when it comes to making decisions about contraception and fertility awareness, MHAs may not provide a substantial advantage in terms of informed decision-making compared to alternative information sources. It also implies that individuals in the control group, who relied on different sources for decision-making, may be as equally well-informed in their choices, as those who use MHAs.

Again, further exploration is needed to understand why MHAs did not significantly impact decision-making. Factors such as the comprehensiveness of the information provided by MHAs, user preferences, and the influence of other sources on decision-making should be investigated.

No Significant Relationship with Identified Limitations and Concerns

The third unexpected result was the absence of a significant relationship between the use of MHAs and identified limitations and concerns, including privacy issues, accuracy of information, inclusivity, and potential biases. The p-value of 0.558 led to the acceptance of the null hypothesis.

This finding suggests that in terms of addressing concerns related to privacy, information accuracy, inclusivity, and biases, MHAs may not provide a clear advantage over alternative resources. It also implies that users of MHAs did not report significantly fewer concerns in these areas compared to individuals using other methods for tracking or education.

This unexpected result indicates the need for a deeper examination of the factors contributing to concerns and limitations associated with MHAs, as well as the effectiveness of these apps in addressing these issues. User feedback and MHA features should be explored further to understand why these concerns persist.

Relating the Study Findings to Existing Literature

The analysis of the data from this study aligns well with the previous research in this field. A number of specific correlations are discussed below:

1. *Fertility Awareness:* In the study reported in this paper, 60% of respondents indicated that MHAs have significantly improved their understanding of menstrual cycles and fertility, supporting their role in effective fertility management. This aligns with findings from previous research that emphasized the potential of MHAs to aid couples in identifying the fertile window for family planning[7]. By empowering users to make informed decisions, both studies demonstrate that MHAs can play a critical role in supporting reproductive goals, emphasizing their utility as tools for fertility awareness and management.
2. *Evidence-Based Research:* In the study reported in this paper, 25% of respondents reported confidence in the accuracy of MHA-provided information, while 75% remained uncertain. This outcome aligns with relevant literature which emphasized stronger evidence-based validation to confirm the accuracy and effectiveness of MHA information[11]. Both studies highlight the importance of rigorous clinical trials and user feedback assessments, essential for ensuring reliable MHAs that effectively support informed reproductive decision-making.
3. *Comprehensive Sex Education:* In the study reported in this paper, 60% of respondents reported that MHAs enhanced their understanding of contraception and reproductive health, reinforcing the need for these tools to be integrated into comprehensive sex education programs. This finding aligns with previous research that highlighted MHAs' potential to extend reproductive health knowledge beyond pregnancy and disease prevention[12]. By promoting informed decision-making about contraception and fertility,

both studies emphasize the value of MHAs as educational tools that contribute to improved reproductive health literacy and overall well-being.

4. *Menstrual Health as a Public Health Issue:* The study reported in this paper found that 80% of respondents felt that MHAs effectively helped them manage menstrual health, supporting the view that menstrual health is a critical public health and human rights issue. This aligns with previous work that advocated for including menstrual health in global health frameworks to address social determinants and promote individual empowerment[13]. Both studies demonstrate the potential of MHAs to empower users in managing menstrual health, emphasizing their role in addressing broader public health goals.
5. *User Experiences:* The study reported in this paper revealed that 60% of respondents were satisfied with the usability of MHAs, while 40% were not satisfied, rating their experience lower. This aligns with previous findings that emphasize the critical role of user-centered design in enhancing MHA effectiveness[9]. By highlighting user satisfaction as a key factor, both studies stress the importance of incorporating user feedback to refine MHA interfaces and features, thereby improving overall user engagement and app impact on reproductive health outcomes.
6. *Accuracy and Validation:* In the study reported in this paper, only 25% of respondents felt the information from MHAs was accurate enough to align with their decisions, indicating a need for improved validation. This finding supports previous research that emphasized that the accuracy, features, and functionality of MHAs must be continually assessed to ensure user satisfaction and app effectiveness[3]. Both studies call for ongoing evaluations to enhance accuracy and user confidence, reinforcing the necessity of validation to maintain credibility and optimize reproductive health management through MHAs.
7. *Integration with Reproductive Health Education:* The study reported in this paper found that 60% of respondents reported that MHAs improved their understanding of reproductive health topics, including menstrual cycles, fertility, and contraception, supporting their integration into comprehensive reproductive health education programs. This aligns with the work of other researchers, who advocated for incorporating MHAs into broader educational frameworks to enhance reproductive knowledge and informed decision-making[12]. By demonstrating their effectiveness in improving health literacy, both studies emphasize MHAs as valuable educational tools that can empower users and support informed reproductive choices.

This study's alignment with existing literature highlights the significance of MHAs in reproductive health, emphasizing the need for further research, user-centric design, and integration within comprehensive sexual health programs.

CONCLUSION

The significance of the research presented in this paper lies in its comprehensive investigation into the efficacy of MHAs in promoting informed decision-making and comprehensive sex education. It addresses several objectives:

1. *Impact on Knowledge and Understanding:* This study assessed the influence of MHAs on users' knowledge and understanding of reproductive health, including menstrual cycles, fertility, contraception, and sexual well-being. The research findings reveal that there was no significant difference in knowledge and understanding scores between the group using these applications and the control group. This suggests that using MHAs may not confer a significant advantage in terms of knowledge and understanding. However, it highlights the importance of alternative methods of tracking and education, which can be equally effective.
2. *Informed Decision-Making:* The research presented in this paper explored whether MHAs contribute to informed decision-making related to reproductive choices. Surprisingly, the study found no significant difference in informed decision-making between the experimental and control groups. This suggests that these applications may not provide a substantial advantage in terms of decision-making compared to other sources. This emphasizes the need for comprehensiveness in educational resources and factors influencing decision-making.
3. *Limitations and Concerns:* The study identified a number of potential limitations, challenges, and concerns associated with the use of MHAs, including privacy issues, accuracy of information, inclusivity, and potential biases. It was found that using these applications did not significantly reduce these concerns, indicating that there is room for improvement in application design and content. The study highlights the importance of addressing privacy, accuracy, and inclusivity in MHAs.

These research findings have practical implications for users, developers, policymakers, educators, and healthcare providers. The research described in this paper has the ability to help a number of distinct groups :

- Users are able to make better informed choices about the use of MHAs, considering their advantages and limitations.
- Application developers can use the insights described in this paper to improve their design and content, addressing user concerns.

- Healthcare providers can use the data and analysis in this paper to better support individuals in making informed decisions about reproductive health.
- Policymakers and educators can use the recommendations provided in this paper to develop improved evidence-based guidelines and educational programs.

RECOMMENDATIONS

A number of recommendations are proposed based on the outcomes of the work described in this paper:

Enhance Comprehensive Sex Education: Educational institutions and healthcare providers should focus on comprehensive sex education that goes beyond pregnancy and disease prevention. Integration of menstrual health education into sex education programs can improve overall reproductive health knowledge.

Improve MHAs: Developers of menstrual tracking applications should prioritize user-centered design, including features that enhance usability, user experience, and inclusivity.

Include LGBTQ+ Inclusivity Features and Content: Ensure that the applications cater to a diverse range of users, this includes:

- Providing in-depth information about reproductive health topics, including contraception methods, fertility awareness, and sexual well-being.
- Offering customizable experiences within the apps to meet individual user needs.

Support Informed Decision-Making:

- Healthcare professionals and educators should actively guide individuals in making informed decisions about contraception methods and fertility awareness.
- Promote the use of credible websites and resources to ensure that individuals have access to accurate and evidence-based information.
- Advocate for enhanced sex education in high schools to equip young individuals with the knowledge and skills they need to make informed reproductive health choices.

Address Privacy and Inclusivity Concerns:

- Developers of menstrual health applications should prioritize user privacy by implementing robust data protection measures and clearly communicating their privacy policies.
- Ensure that MHAs explicitly acknowledge and validate diverse gender identities and sexual orientations to create a more inclusive and supportive environment for all users.
- Conduct regular assessments of application content and features to identify and address potential biases and ensure that the information provided is inclusive and respectful of cultural and regional differences.

Promote Evidence-Based Research:

- Researchers and developers should continue to conduct evidence-based research on MHAs, including clinical trials and user experience assessments.
- There is a need to regularly evaluate and validate the accuracy of information provided within these applications to ensure users receive reliable guidance.

Advocate for Menstrual Health as a Public Health Issue: This is a critical component of public health and human rights initiatives.

Research Limitations

The study acknowledges several limitations that should be considered when interpreting the findings of the research described in this paper:

1. *Sample Size:* The sample size in the study was relatively modest, which may have limited the generalizability of the findings. A larger and more diverse sample would have provided a more comprehensive understanding of the efficacy of MHAs.
2. *Sampling Bias:* Participants in the study were recruited through convenience sampling, potentially introducing bias into the results. Those who voluntarily participated may have unique characteristics or experiences that differ from the broader population of MHA users.
3. *Self-Reported Data:* The data collected in the study heavily relied on self-reported responses from participants. This introduces the possibility of recall bias and social desirability bias, as participants may provide answers they believe align with societal expectations.
4. *Short-Term Evaluation:* The study primarily focused on short-term outcomes related to knowledge, understanding, and decision-making. Long-term impacts of using MHAs, as well as their effects on reproductive health behaviors, were not extensively explored.
5. *Lack of Control Over Application Usage:* There was no control over how participants in the experimental group used MHAs. Variability in application usage frequency and patterns among participants may have influenced the results.
6. *Limited Scope of Concerns:* The study examined a specific set of concerns related to MHAs, including privacy, accuracy, inclusivity, and biases. Other potential concerns or benefits may not have been fully explored.
7. *Cross-Sectional Design:* The research employed a cross-sectional design, capturing data at a single point in time. Longitudinal studies would provide insights into how attitudes and behaviors related to MHAs evolve over time.
8. *Cultural and Regional Variation:* The study did not extensively consider cultural and regional variations in menstrual health perceptions and practices. These factors could significantly influence the use and efficacy of MHAs.

9. *Response Rate:* Although many participants responded rapidly, the response rate was not 100%. Non-responses may have introduced some non-response bias and affect the representativeness of the sample.
10. *Subjective Nature of Informed Decision-Making:* The assessment of informed decision-making was subjective and was based on the participants' own self-perceptions. Objective measures of decision-making may provide a more comprehensive understanding of this aspect.
11. *Changing Landscape of MHAs:* The landscape of MHAs is dynamic, with new applications and updates frequently introduced. The study may not reflect the most current features and functionalities of the applications that have since become available.

Further Research Work

Further research should explore the nuanced factors at play in the experimental data reported in this paper. In particular, the unexpected findings of the work described in this paper emphasize the complexity of evaluating the true benefits and limitations of MHAs in the context of reproductive health education and decision-making.

In future, it would be valuable to consider the quality, design, and user experience of MHAs, as well as the influence of other educational sources on users' outcomes and perceptions. Such work in the domain of MHAs and their impact on informed decision-making would be exceptionally valuable and could build upon the experimental research findings detailed in this paper and address several avenues for further investigation, including :

- *Longitudinal Studies:* Longitudinal studies should be conducted to assess the long-term effects of using MHAs on reproductive health behaviors, such as contraception choices, family planning, and menstrual health management.
- *Health Outcomes:* The association between MHA usage and health outcomes needs to be explored to assess the amount to which these applications contribute to improved health. In particular, work needs to be undertaken in areas such as menstrual disorders, fertility-related issues, and sexually transmitted infections.
- *Effectiveness of Educational Content:* There is a need to evaluate the effectiveness of educational content within menstrual tracking applications in improving users' knowledge of reproductive health topics and their ability to make informed decisions.
- *Integration with Formal Education:* Educators and policymakers need to explore the integration of menstrual health education, including the use of MHAs, into formal school curricula to enhance comprehensive sex education.

- *Impact on Healthcare Interactions:* There is a need to investigate how MHA usage influences interactions with healthcare providers, including whether it leads to more informed discussions about reproductive health.
- *User Motivations and Behavior Change:* It would be valuable to examine users' motivations for adopting and consistently using MHAs in more detail, and to assess whether these apps can lead to behavior changes related to reproductive health.
- *Validation and Accuracy*: Work is needed to continue to evaluate the accuracy and reliability of MHAs through clinical trials and validation studies, ensuring that users receive trustworthy information.
- *Health Disparities:* More research to investigate how the use of MHAs may contribute to addressing health disparities related to menstrual health is needed, especially in underserved and marginalized communities.
- *Policy and Regulation:* The regulatory landscape for MHAs needs further study, this will contribute to the development of guidelines and policies to ensure user safety and app effectiveness.
- *User Support and Education:* There is a need to develop and evaluate interventions aimed at providing users with better support and education on the use of MHAs.
- *Interdisciplinary Research:* Interdisciplinary research (that combines expertise in technology, healthcare, education, and public policy). Should be encouraged. This would create a more holistic understanding of the impact of MHAs.
- *Global Perspectives:* It would be valuable to further explore how the use and effectiveness of MHAs differ across countries and regions with varying healthcare infrastructures and cultural norms.

REFERENCES

1. Schantz JS, Fernandez CSP, Jukic, AMZ. Menstrual Cycle Tracking Applications and the Potential for Epidemiological Research: A Comprehensive Review of the Literature. Current Epidemiology Reports. 2021; 8: 9–19.
2. Earle S, Marston HR, Hadley R, Banks D. Use of menstruation and fertility app trackers: A scoping review of the evidence. BMJ Sexual & Reproductive Health. 2021; 47(2): 90-100.
3. Moglia ML, Nguyen HV, Chyjek K, Chen KT, Castaño PM, Ginde AA. Evaluation of Smartphone Menstrual Cycle Tracking Applications Using an Adapted APPLICATIONS Scoring System. Obstetrics & Gynecology. 2016; 127(6): 1153-1160.

4. Kress H, Herold S, Scheuermann B. Privacy and Security in Menstrual Cycle Tracking Applications: A Review of App Permissions and Privacy Policies. Journal of Medical Internet Research. 2020; 22(12): e23361.
5. Duane M, Contreras A, Jensen ET, White A. The Performance of Fertility Awareness-based Method Applications Marketed to Avoid Pregnancy. Journal of the American Board of Family Medicine. 2016; 29(4): 508-511.
6. Yang P, Stankevicius D, Marozas V, Deng Z, Liu E, Lukosevicius A, Dong F, Xu L, Min G. Lifelogging data validation model for internet of things enabled personalized healthcare. IEEE Transactions on Systems, Man, and Cybernetics: Systems. 2016; 48(1): 50-64.
7. Symul L, Wac K, Hillard P, Salathé M. Assessment of menstrual health status and evolution through mobile apps for fertility awareness. NPJ Digital Medicine. 2019; 2(1): 64.
8. Lee J, Kim J. Can menstrual health apps selected based on users' needs change health-related factors? A double-blind randomized controlled trial. Journal of the American Medical Informatics Association. 2019; 26(7) :655-66.
9. Levy J, Romo-Avilés N. "A good little tool to get to know yourself a bit better": a qualitative study on users' experiences of app-supported menstrual tracking in Europe. BMC Public Health. 2019; 19: 1-1.
10. Chyjek K, Farag S, Chen KT. Rating pregnancy wheel applications using the Scoring System. Obstet Gynecol 2015; 125: 1478–83.
11. Adnan T, Coull BA, Jukic AM, Mahalingaiah S. The real-world applications of the symptom tracking functionality available to menstrual health tracking apps. Curr Opin Endocrinol Diabetes Obes. 2021; 28(6): 574-586.
12. Lameiras-Fernández M, Martínez-Román R, Carrera-Fernández MV, Rodríguez-Castro Y. Sex education in the spotlight: what is working? Systematic review. International journal of environmental research and public health. 2021; 18(5): 2555.
13. Hennegan J, Winkler IT, Bobel C, Keiser D, Hampton J, Larsson G, Chandra-Mouli V, Plesons M, Mahon T. Menstrual health: a definition for policy, practice, and research. Sexual and reproductive health matters. 2021; 29(1) :31-8.
14. Babbar K, Martin J, Ruiz J, Parray AA, Sommer M. Menstrual health is a public health and human rights issue. The Lancet Public Health. 2022; 7(1): e10-1.

15. Mahajan S, Lu Y, Spatz ES, Nasir K, Krumholz HM. Trends and predictors of use of digital health technology in the United States. The American journal of medicine. 2021; 134(1): 129-34.

BJMHR is

- **Peer reviewed**
- **Monthly**
- **Rapid publication**
- **Submit your next manuscript at**

editor@bjmhr.com