Determinants of Menstrual Tracking Mobile Application Acceptance Among Adolescent Girls in Lafto Sub City, Addis Ababa

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(PhD)[1]

Abstract

The world has been passing through the fourth industrial revolution and the traditional health system has been evolving to digital health. The objective of this study is to explore determinants of menstrual tracking mobile application acceptance among adolescent girls in Lafto sub-city, Addis Ababa. We employed cross-sectional design, sequential mixed research approach (Quan⇒qual) with integrated Health Belief and Technological Acceptance Model to investigate the aim of the study. Additionally, the sample size was estimated using the inverse square root method and we adopted a combination of stratified and simple random sampling techniques. We also used the self-administered questionnaires using Google form and a total of 161 adolescent girls participated voluntarily. We employed Stata version 17 and R-studio version 4.3 for descriptive and PLS-SEM analysis, respectively. The finding of our research showed that the majority of the indicator error values produced by PLS–out of sample were less than those produced by linear regression model, which depicted that the overall model had a moderate predictive power. Moreover, all latent path coefficients were significant predictors of behavioural intention to use such apps except perceived threat to teenage pregnancy and menstrual irregularity. But both had significant indirect effects. Based on the above findings, we recommend health software developers to increase the significant predictors (perceived usefulness, perceived ease of use, perceived self-efficacy and cues to

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action), and decrease perceived barriers which lead to positive attitude to use and self-tracking motivations that ultimately impacts acceptance of such apps among adolescent girls.

Keywords: Menstrual Tracking Mobile Apps; HBM; TAM; PLS-SEM

1. Introduction

The world has been passing through the fourth industrial revolution (Snowdon, 2021) and the traditional health system has been evolving to digital health. Consequently, self-tracking digital health technologies, which promote client-centeredness, are arriving in the arena of the healthcare delivery system. Menstrual tracking mobile applications are one of such technologies, which are designed for women to track their menstrual progress, to prevent pregnancy; to verify their menstrual experiences; to track their period of pain etc. Moreover, adolescent girls have been suffering from menstrual irregularity (MI) and teenage pregnancy (Admassu et al., 2022; Mamo et al., 2021; Mittiku et al., 2022). To begin with, menstruation in adolescent girls is characterized by irregularities compared to adult women and it can take up to 1-3 years for them to have regular cycles after menarche (Gazibara et al., 2020; Mittiku et al., 2022). As a result, MI is common in adolescent girls and this creates anxiety, depression, and in general emotional dissatisfaction, which affects their quality of life (Mittiku et al., 2022).

Secondly, teenage pregnancy rate is estimated to be: 18.8% in Africa; 19.3% in SSA; 54.6% in East Africa; 23.6% in Ethiopia; and 4.1% in Addis Ababa (Kassa et al., 2018; Worku et al., 2021; Mamo et al., 2021; Abita et al., 2022). According to Addis Ababa Health Bureau (unpublished) DHIS report of facility based teenage pregnancy of the last 9 months (July 8, 2022 to April 8, 2023), teenage pragnancy rate was higher in Akaki Kaleti; Lemi Kura; Kolfe Keranyo and Lafto sub cities than other sub cities. Moreover, 709-970 teenage girls were tested positive for pregnancy in the four sub cities; whereas, in other sub cities it was less than 583. As a result, teenagers face a higher risk of abortion and mortality, as adolescent girls are more likely to experience complications and death during pregnancy and childbirth compared to women in their twenties (AFY, 2007).

Additionally, the major consumers of the digital world are the adolescent and youth population group. Consequently, smartphone mobile connections are increasing in sub-Saharan Africa. The GSMA (2021) report showed that the percentage of smartphone connections was 49% and projected to be 61% in 2025. According to the report, 46% of the population subscribed to mobile services in 2021 and projected an additional 100 million new users by 2025, which the adolescent population will contribute to this growth. Similarly, in Ethiopia, smartphone adoption was 43% in 2021 and projected to increase as adolescents and young groups constitute the country's major population (GSMA, 2021). Thus, adolescent consumers will remain the primary source of mobile internet growth for the foreseeable future.

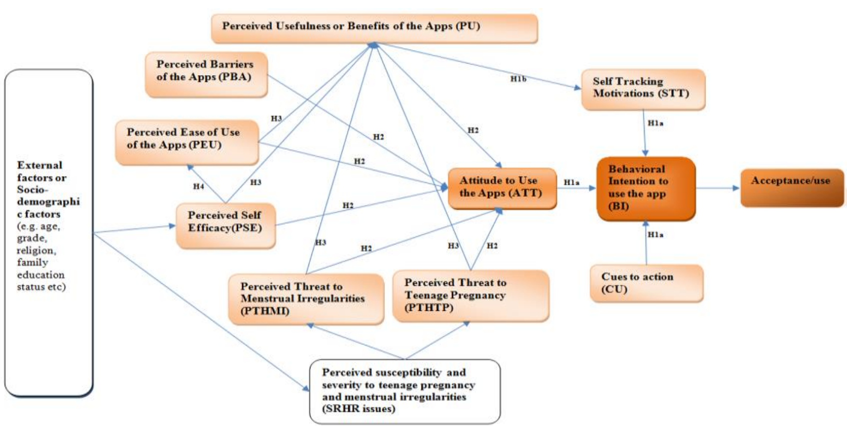
Despite the fact that there are lots of adolescent smartphone users in Ethiopia, little is known about the acceptance of menstrual tracking mobile apps. Besides this, in Ethiopia, empirical studies on mobile health were focused on improving the maternal health through delivery related mobile applications (Christiansen et al., 2023; Endehabtu et al., 2019; Lund et al., 2016; Olusola et al., 2022; Parellada et al., 2020; Thomsen et al., 2019) as well as on improving the antenatal and postnatal care services using text messages, voice call and even through mobile apps (Medhanyie et al., 2015; Kassa et al., 2019; Atnafu et al., 2017; Kebede et al., 2019; Little et al., 2013).

Therefore, based on our preliminary assessment the acceptance of menstrual tracking mobile apps among adolescent girls in Ethiopia has not been thoroughly studied. The objective of this study is to explore determinants of menstrual tracking mobile apps acceptance among adolescent girls using Technological Acceptance (TAM) and Health Belief Models (HBM).

TAM was developed by Davis et al. (1989) to identify client's acceptance to technology. Davis hypothesized "perceived usefulness and perceived ease of use" as factors that affect clients acceptance to techs (Ahlan & Ahmad, 2014; Ammenwerth, 2019; Davis et al., 1989; Ma & Liu, 2011; Zaineldeen et al., 2020). However, a notable drawback of TAM is its focus merely on technological aspects, failing to explain why clients choose to use specific technology.

In contrast, the Health Belief Model (HBM) was developed by American social psychologists to explain the reason for the failure of people to participate in preventing and detecting disease programs or to predict why people will take action to control, to prevent, to screen for conditions etc. Moreover, *perceived susceptibility and severity* of a disease; *perceived benefits* of available strategies for disease reduction; *perceived barriers* related to the application of these strategies (cost, difficulty etc.); *cues to action* that prompt individuals to act and *self-efficacy*, which is a confidence in one's tended ability to perform the new health behaviour are the key structures of the model (Abraham et al., 2014; Champion et al., 2005). The purpose of the study is, therefore, to fill the knowledge gaps by integrating the two models as illustrated below in the conceptual framework, to investigate the subject of the study.

Fig 1: Conceptual Framework



Source: authors sketch

In this proposed integrated model, we assumed 4 hypotheses. Firstly, acceptance or behavioural intention (BI) to use the apps are directly and significantly affected by the cues to action (CU), self-tracking motivation (STT), and attitude to use the app (ATT) (H1a). Similarly, the adolescent girls' STT is directly and significantly affected by the perceived usefulness (PU) (H1b). Secondly, ATT is directly and significantly affected by the PU, perceived ease of use (PEU), perceived barriers (PBA), perceived self-efficacy (PSE), perceived threat to teenage pregnancy (PTHTP) and perceived threat to menstrual irregularity (PTHMI) (H2). Thirdly, the PU is directly and significantly affected by the PEU, PSE, PTHMI and PTHTP (H3). Finally, the PEU is directly and significantly affected by the PSE (H4)

2. Materials and Methods

The design that we employed in this study is cross sectional with sequential mixed research approach (Quan→qual). The survey tools or items were developed by taking lessons from previous studies performed in different disciplines (annex 7). The items on PU (8 indicators), PEU (3 indicators), BI (2 indicators) and ATT (3 indicators) were developed from (Buabeng-Andoh, 2018; Davis, 1989; Levy et al., 2019). While, the items on PTHMI (3 indicators), PTHTP (3 indicators), CU (2 indicators), PSE (2 indicators), and PBA (4 indicators) were developed from (Champion et al., 2005; Mohamed et al., 2019; Niculaescu et al., 2021). Lastly, the item on STT (6 indicators) was developed from (Gimpel et al., 2013). Each item was measured on a Seven-point Likert scale, ranging from "strongly disagree" (1) to "strongly agree" (7). Since we used the PLS-SEM data analysis approach in the study we used the inverse square root method proposed by Kock and Hadaya (2018) for estimation of the sample size. Assuming a minimum path coefficient of 0.2, and 5% significance level, we get $(2.486/0.2)^2 = 155$. So, an approximate minimum sample of 155 was required in the study. Hence, we collected 161 samples through Google forms with a response rate of 96%.

The sampling frame was a student roaster and there are 7 private secondary high schools in Jemo1 Wereda 13 and all of them have classes from grade 9-12, except two high schools. Then, we employed a combination of stratified and simple random sampling techniques in order to select the actual participants. Thus, we stratified each school into six classes (9, 10, 11 and 12 natural sciences and social sciences), and the participants were selected randomly. Because many girls are reluctant to openly discuss sensitive issues like menstrual irregularity and teenage pregnancy, the selection of KII strictly followed a non-probability, snowball sampling method, in which a total of 21 unstructured in-depth KII were conducted until saturation point reached via phone call and text after the quantitative phase had completed. we also used Stata version 17 for descriptive analysis, R studio version 4.3 for PLS-SEM analysis and thematic analysis for qualitative data to present it after the result of the quantitative data.

Lastly, PLS-SEM is suitable to overcome issues related to small sample size and normality assumptions since it is a non-parametric technique (Hair et al., 2021). And, it has two basic steps―the measurements and the structural model assessment. The former describes how well the observed indicators measured the unobserved constructs, and the latter describes the path relationship of the constructs (Hair et al., 2021).

3. Results and Discussions

The study of the findings is based on PLS-SEM data analysis, which has two basic steps―the measurement models and the structural model assessment. The former deals with how well the observed indicators (survey items) measured the unobserved (latent) constructs, and the latter describes the path relationship of the constructs. Additionally, the descriptive statistics are shown in annex 1. We present, first the measurement model assessment and then the structural model assessment followed by the discussions of our hypothesis.

3.1 The Measurement Model Assessment

The reflective measurement (reliability and validity) model part of the PLS-SEM analysis displays satisfactory measures. According to Hair et al., (2021) indicator loading above 0.708 or indicator square loadings above 0.5 are recommended to ensure indicator reliability. In addition, to ensure internal consistency reliability, Composite Reliability (RhoC) Cronbach's Alpha (CA) and reliability coefficient (r_{xx}). A should be greater than 0.7 (Hair et al., 2021). As shown in annex 2, all the values exceeded the acceptable level, which shows that the items are reliable. Also, this table shows that AVE, which indicates the grand mean value of the squared loadings of the items associated with the construct, is greater than the acceptable level of 0.5. This confirms the convergent validity of the proposed items. In addition, the study employed three types of discriminant validity measures. Firstly, as it is shown in annex 3, the square root of each latent construct's AVE is greater than the correlations with other latent constructs, which satisfies the Fornell and Larcker (1981) criterion to measure discriminant validity.

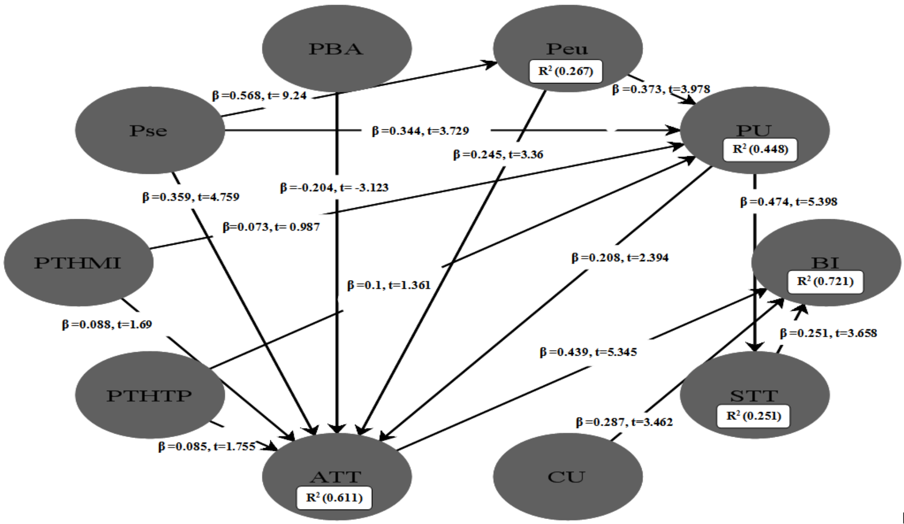
Secondly, an item must be correlated with its own latent construct rather than with other construct in order to ensure cross loading discriminant validity at indicator level (Hair et al., 2021). Thus, as it is shown in annex 3, the outer loading indicator values of the items exceed the cross-loading values, which satisfy the item level discriminant validity. The last type of discriminant validity measure is called heterotrait–monotrait ratio (HTMT); and its threshold value for conceptually similar latent constructs is <0.9; while, for conceptually different constructs, it is <0.85 (Hair et al., 2021). Therefore, as it is shown in annex 5, all of the constructs HTMT values are <0.85, except ATT and BI (0.896). However, as both constructs are conceptually similar and their correlation is <0.9, it is concluded that HTMT discriminant validity of the measurement model is established. Additionally, according to Hair et al., (2021) recommendations, vif is not an issue if it is <3, and annex 6 shows that vif of the latent construct is <3. The overall model predictive power is calculated using $PLS_{predict}$ algorithms (Hair et al., 2021). This indicates a model's ability to predict new or future observations. Consequently, we used root mean square error (RMSE) for prediction since the prediction error is symmetric and not highly skewed.

Therefore, the $PLS_{predict}$ showed that the majority of the indicator error values produced by PLS–out of sample were less than those produced by linear regression model. This indicates the integrated model has a medium predictive power. Moreover, the study used Cohen's (1988) criteria to explain the path coefficients. According to him, coefficients of 0.02, 0.15 and 0.35 indicates low, moderate and strong effects, respectively. We also used t-values >1.96 to decide the significant relationship and a standardized bootstrap method with 10, 000 subsamples as per Hair et al., (2021) recommendation to determine the path coefficients.

3.2 The Structural Model Assessment

The structural model assessment describes the relationship of the constructs developed to test our hypothesis. Here we used standardized bootstrap method with 10,000 subsamples as per Hair et al (2021) recommendations in order to determine the path coefficients and we also used T value > 1.96 to decide the significance of a relationship as it is shown in fig 2. In addition, we used Cohen's (1988) criteria to explain path coefficients. According to him, coefficients of 0.02, 0.15 and 0.35 signifies small (or low or weak), medium and large (strong) effects, respectively. The effects of one determinant on another determine the strength of the correlation between factors under study. Having these criteria, the discussions of the findings of our hypothesis will be presented in four sections as follows.

Fig 2 Structural Model



Source: author sketch

3.2.1 Self-Tracking Motivation and Behavioural Intention to Use Menstrual Tracking Mobile App

Hypothesis 1a stated that *cues to action*, *self-tracking motivations and attitude to use have a positive significant effect on behavioural intention to use menstrual tracking mobile app*.

The study revealed that ATT has a strong, positive and significant effect on BI *(β=0.439, t =5.345, p=0.05)*. Likewise, the study depicted that STT and CU has a direct, positive and moderate significant effect on BI *(β=0.251, t =3.658, p=0.05) and (β=0.287, t =3.462, p=0.05)*, respectively. On the contrary, out of the 5 STT factors (Gimpel et al., 2013), self-design and self-discipline were the only included variables in the present study as the three of them were invalid and reliable.

Similarly, it is inconsistent with a study performed by Apps et al., (2018). They identified that self-discipline, self-entertainment and self-design motivations were found to affect BI. A possible explanation for the inconsistency can be the narrow scope of the present study on menstrual tracking mobile apps, besides to the invalidity and unreliability issues of the three constructs.

Additionally, the finding on CU is inconsistent with a study performed by Orji et al., (2012). They identified that it had weak or no effect ($\beta=0.03$, $p \leq 0.01$) on BI. One explanation they mentioned for the low or no effect of the construct was inappropriateness in filling out the questionnaires by the participants. Thus, ATT, CU and STT explained 72.1% (R2) of the variations in BI. In contrast, the R2 identified by Buabeng-andoh (2018) was too low (23%) compared to the present study. This is because the present study integrates HBM and TAM with a focus on menstrual tracking mobile apps; whereas, the former integrated theory of reasoned action (TRA) and TAM with a focus on mobile learning acceptance. In short, ATT, STT and CU have a significant, positive and direct effect on BI.

Hypothesis 1b stated that *the adolescent girl's perceived usefulness of menstrual tracking mobile apps has a positive significant effect on self-tracking motivations*.

The study revealed that PU has a strong, positive and significant impact on STT ($\beta=0.474$, $t=5.398$, $p=0.05$) and, it explains 23.9% (R2) of the variations in STT. Consequently, the low R2 may be due to that the study didn't include other key predictors of STT. Therefore, the findings support the proposed hypothesis H1a and H1b.

3.2.2 Attitude to Use Menstrual Tracking Mobile App

Hypothesis 2 stated that *the adolescent girl's perceived usefulness, perceived ease of use, perceived self-efficacy, perceived threat to teenage pregnancy and menstrual irregularity has a positive significant effect on attitude to use the app; but perceived barriers have a negative effect*.

The study revealed that ATT is affected by PU ($\beta=0.208$, $t=2.394$, $p=0.05$) and PEU ($\beta=0.245$, $t=3.36$, $p=0.05$). Both act as a complementary mediator in the relationship between PSE and ATT. The PU mediating effect enabled the adolescent girls to develop the ATT as they are confident and believe it will enhance their performance to track their cycle, to verify menstrual experiences, to prevent pregnancy and extra. While, the PEU mediating effect enabled them to develop the ATT as they are confident and believed that the easier the menstrual tracking mobile app to use, the more accepted and useful it can be. This finding is in line with previous empirical studies performed by Kim et al., (2012), Alloghani et al., (2015) and Buabeng-andoh., (2018). The mediating effect finding is consistent with Farrag et al., (2022) studies. Hence, both support the proposed hypothesis2. On top of this, the study showed that PBA has a medium, direct, significant and negative impact on ATT ($\beta = -0.204$, $t = -3.123$, $p = 0.05$). This result is consistent with Orji et al., (2012) findings. In addition, the path coefficient of PBA (-0.204) of the study does not significantly differ from their finding (-0.2).

In contrast, the study revealed that PSE has the strongest positive and significant effects on ATT ($\beta = 0.359$, $t = 4.759$, $p = 0.05$). This finding is in agreement with previous studies by Orji et al., (2012). However, the present study identified its effect in three dimensions—ATT, PEU and PU– compared to their study. Thus, both support the proposed hypothesis2. Additionally, the study revealed that ATT is not directly affected by PTHTP ($\beta = 0.085$, $t = 1.755$, $p = 0.05$) and PTHMI ($\beta = 0.088$, $t = 1.69$, $p = 0.05$). Both have insignificant relationship to ATT ($t < 1.96$). However, both constructs have a medium, positive, indirect significant total effects on ATT by PTHTP ($\beta = 0.105$, $t = 2.044$, $p = 0.05$) and PTHMI ($\beta = 0.103$, $t = 2.061$, $p = 0.05$). This shows that these two constructs didn't support the proposed hypothesis 2.

Moreover, one possible explanation as to Champion et al., (2005) is, if the perceived threat and barriers are low, it implies the benefits are perceived to be very high. Also, the interview analyses are consistent with this theoretical explanation. Here are the two themes that support Champion et al., (2005) reasonings. First, teenage pregnancy was seen as a threat among participants and perceived as having severe psychological, spiritual, social, and health related consequences on their life. In line with argument, one participant said that ‘‘if an adolescent girl is pregnant, society will discriminate and treat her as filthy’’. Another participant noted that being pregnant at adolescent age is “so embarrassing, shameful and it may cause a separation of the girl from her parents”.

In the second point, participants highlighted several strategies to mitigate this threat. One participant noted, “If a girl gets pregnant, she may not be accepted by her family, and they might pressure her to have an abortion.” Another participant added, “This age is not the right time for dating.” However, a contrasting perspective was offered by another participant, who argued, “Nowadays, it's quite challenging to avoid dating; therefore, using contraceptives is essential.” Thus, participants had high PTHTP, but low PBA, which implies that the health-related activities to decrease the threats are perceived increasingly.

Additionally, participants PTHMI are merely if it is persistent and recurrent. One respondent noted that menstrual irregularity (MI) was initially perceived as a significant concern during the first few cycles, but over time, it came to be regarded as a normal occurrence. In contrast, another participant expressed the view that if the irregularities are frequent and persistent, medical advice should be sought to address the issue.

Participants identified several key factors contributing to MI, including stress during exam periods, poor dietary habits, adolescence, and a family history of irregular cycles. To address these concerns, they proposed various solutions such as family counseling, peer support, increased awareness about MI, lifestyle adjustments, and the use of menstrual tracking apps to help monitor and manage irregularities more effectively. Thus, participants PTHMI and PBA are low, which implies that the health-related activities/behaviors to decrease the threats are perceived increasingly. To sum up, the insignificant direct effect of the constructs on ATT could be the result of high perception of the adolescent girls on various strategies to decrease the threat. However, both have indirect only effect on ATT through the mediator of PU, which wasn't hypothesized initially. Hence, this implies that adolescent girls', who wants to decrease PTHTP and PTHMI, will develop a positive attitude to use menstrual tracking mobile apps through the mediator of PU, which is consistent with the study by Kim et al., (2012) and Ahadzadeh et al., (2015). This also implies that PTHTP and PTHMI alone is not enough to develop an attitude to use the mobile app.

Therefore, PU, PEU, PBA, PSE, PTHMI and PTHTP together explain moderately 61.1% (R2) of the variations in ATT. While PU, PEU, PBA and PSE support the proposed hypothesis2, PTHTP and PTHMI didn't. In general, this finding is consistent with a study performed by Buabeng-andoh (2018). But, in his studies, ATT had 0.476 (R2); and the difference in R2 is because of the inclusion of HBM and the variance accounted determinants on ATT is large compared to the former study.

3.2.3 Perceived Usefulness of Menstrual Tracking Mobile App

Hypothesis 3 stated that *the adolescent girl's perceived ease of use, perceived self-efficacy, perceived threat to teenage pregnancy and menstrual irregularity has a positive significant effect on perceived usefulness of the menstrual tracking mobile app*.

The study showed that PEU has a strong, positive and significant impact on PU ($\beta=0.373$, $t=3.978$, $p=0.05$) and it acts as a complementary mediator in the relationship between PSE and PU. This mediating effect enabled the adolescent girls to develop the PU as they were confident and believed that the easier the menstrual tracking mobile app to use, the more accepted and useful it can be. This finding is consistent with previous TAM related studies performed by Buabeng-andoh (2018), Kim et al., (2012), and Alloghani et al., (2015). Additionally, the study showed that PSE has a strong, direct, positive and significant impact ($\beta=0.344$, $t=3.729$, $p=0.05$) on PU. This finding is in agreement with a study by AlQudah et al, (2021) and Farrag et al, (2022). Thus, both constructs support hypothesis3. In contrast, the study revealed that PU is not directly affected by PTHTP *(β=0.1, t=1.361, p=0.05)* and PTHMI *(β=0.073, t=0.987, p=0.05)*. Both have insignificant relationship to PU (*t*<*1.96)*, and these two constructs didn't support the proposed hypothesis3. This implies that PTHTP and PTHMI alone is not enough to develop perceived usefulness of menstrual tracking mobile apps.

Lastly, the study revealed that PEU, PSE, PTHMI and PTHTP together explain 44.8% (R2) of the variance in PU. However, the R2 values of the present study are larger compared to the study held in Ghana to predict students' adoption to mobile learning (33.8%) (Buabeng-Andoh, 2018). This is due to the inclusion of HBM in the study accounted for this difference compared to the former study.

3.2.4 Perceived Ease of Use of Menstrual Tracking Mobile App

Hypothesis 4 stated that *the adolescent girl's perceived self-efficacy has a positive significant effect on perceived ease of use of menstrual tracking mobile apps*.

The study revealed that PSE has the strongest positive and significant effects on PEU (*β=0.568, t=9.24, p=0.05*). This finding is consistent with a study by El-Wajeeh et al., (2014) and Farrag et al, (2022). And, PSE explains (R2) 26.7% of the variations in PEU. Accordingly, the low R2 may be due to that the study didn't include other key predictors of PEU.

4. Conclusion and Recommendation

4.1 Conclusion

This paper presented an integrated conceptual model for perceptions of menstrual tracking mobile applications acceptance among adolescent girls based on TAM and HBM. The key findings of the study are presented as follows. Firstly, STT, CU and ATT have a significant, positive and a direct effect on BI. Similarly, PU has a significant, positive and a direct impact on STT. Additionally, PEU, PSE and PU have a significant, positive and a direct effect on ATT; whereas, PBA has a negative. In contrast, PTHMI and PTHTP have insignificant, direct relationship to ATT; but both have significant indirect effect on ATT through the mediator of PU. On top of this, PEU and PSE have a significant, positive and direct effect on PU; while, PTHMI and PTHTP have an insignificant, direct relationship. Finally, PSE has a significant, positive and a direct effect on PEU. Therefore, PU, PEU, PSE, PBA, CU, ATT and STT are significant predictors of BI to use menstrual tracking mobile apps except PTHTP and PTHMI, which both have indirect effects only.

4.2 Recommendation

Based on the findings, we recommend the following five actions with their strategies. Firstly, health software developers should focus on increasing the PU of menstrual tracking mobile apps by ensuring the apps algorithms to calculate fertile and infertile days are accurate as well as by ensuring the apps have features to track period symptom; to transfer user's data to inform healthcare professionals; to access menstrual related and contraceptives ideas. Secondly, they should focus on increasing the PEU of menstrual tracking mobile apps by ensuring the apps operating systems are easy; the language used in the apps is clear and understandable; the apps are flexible for interaction and adolescent friendly. Thirdly, they should consider the CU by ensuring the apps has notification on upcoming period, cycle length, fertile days, infertile days so that adolescents can check their menstrual health status; by preparing routine educational talks regarding teenage pregnancy and menstrual irregularity in the school as well as in podcast; by preparing short trainings on the health benefits of tracking and personalized care; and, advertising the menstrual tracking mobile app. Fourthly, they should consider in developing the adolescent girls PSE to consume such apps by ensuring the apps has reminder to log in each day; by ensuring the apps has easy to follow guidelines and steps to download/install; by providing clear instructions with frequently asked questions and video tutorials; and by providing online chat support. Finally, they should consider on decreasing the PBA to use menstrual tracking mobile app by preparing events and ensuring to work with parents so that they can support adolescent girls as well as by ensuring support groups where other adolescents who are using this app can connect with and help new users.

4.3 Limitation

The study has several limitations. First, it was confined to Lafto sub-city, specifically Jemo 1 Wereda 13, and focused solely on private high schools. Future research should consider expanding to other sub-cities, adopting different data collection methods and sampling procedures, and including public high schools as well as a broader range of participants for a more comprehensive analysis. On top of this, the instrument used to measure three of the self-tracking motivation (STT)―Self entertainment, Self-association and Self-healing (Gimpel et al., 2013)―should be revised and re-evaluated in future studies in the contexts and understanding of the adolescent girls as it had problems in establishing reliability and discriminant validity. Additionally, the integrated model explained 23.9% of the variations in STT by PU and 26.7% variations in PEU by PSE, leaving 76.1% and 73.3% unexplained, respectively. Hence, to address this unexplained difference, future studies should extend the model with additional factors that affect menstrual tracking mobile apps acceptance. All in all, since the sample was collected in Addis Ababa, there are limitations in generalizing the results to other cities and countries due to differences in cultural beliefs and perceptions in terms of technology usage.

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Conflict of Interest

The authors declare they have no competing interests.

Authors' Contribution

Conceptualization: Bernabas Petros

Methodology: Bernabas Petros and Yeshtila Wondemeneh

Analysis: Bernabas Petros and Yeshtila Wondemeneh

Writing – original draft: Bernabas Petros

Writing – review & editing: Bernabas Petros and Yeshtila Wondemeneh

Appendix

Categorical Variables		Frequency	Percent
School	School of Indiana	17	10.56
	South West Academy	22	13.66
	Felegeneway Academy	19	11.8
	Dream Success Academy	24	14.91
	School of Redemption	34	21.12
	Abune Gorgorios School	37	22.98
	Dynamic Academy	8	4.97
Grade	9	23	14.29
	10	47	29.19
	11 N/S	22	13.66
	11 S/S	17	10.56
	12 N/S	33	20.5
	12 S/S	19	11.8
Average grade point in the first semester	90 – 100	54	33.54
	80 – 89	65	40.37
	70 – 79	37	22.98
	60 – 69	4	2.48
	50 – 59	1	0.62
Religion	Orthodox Christian	109	67.7
	Muslim	16	9.94
	Protestant	31	19.25
	Others	5	3.11
Parents Education	Primary School	12	7.45
	Secondary School	47	29.19
	Technical/Vocational	9	5.59
	Undergraduate Degree	37	22.98
	Graduate Degree	56	34.78
Menstruating	Yes	158	98.14%
	No	3	1.86%
Period regular	Yes	88	54.66%
	No	70	43.48%
Having Smartphone	Yes	143	88.12%
	No	18	11.18%
Years of using Smartphone	0-2 years	44	27.33%
	3-5 years	62	38.51%
	Over 5 years	37	22.98%
Experience of Self tracking Mobile app usage	Yes	34	21.12
	No	127	78.88%
Knowing Menstrual Tracking Mobile app	Yes	62	38.51%
	No	99	61.49%
Experience of Menstrual Tracking Mobile App usage	Yes	24	14.91%
	No	38	23.6%
Years of Menstrual Tracking Mobile App usage	0-2 years	19	11.8%
	3-5 years	2	1.24%
	Over 5 years	3	1.86%

Continuous Variables	Mean	Sd	Min	Max
Age	16.75	1.46	13	19
Menarche	12.58	1.23	10	16

Annex 1 Reflective measurement model assessment; Source: Author Construction

Construct	Indicator loading	Square Indicator loading	CA	CR	AVE	rho_A
Threshold	>0.7	>0.5	>0.7	>0.7	>0.5	>0.7
PU1	0.802	0.644	0.922	0.936	0.648	0.927
PU2	0.709	0.503				
PU3	0.847	0.717				
PU4	0.87	0.756				
PU5	0.802	0.643				
PU6	0.769	0.591				
PU7	0.816	0.666				
PU8	0.816	0.666				
PEU1	0.839	0.703	0.866	0.916	0.785	0.92
PEU2	0.894	0.799				
PEU3	0.924	0.854				
PBA1	0.787	0.619	0.863	0.907	0.709	0.864
PBA2	0.848	0.719				
PBA3	0.852	0.726				
PBA4	0.879	0.773				
PSE1	0.881	0.777	0.74	0.885	0.794	0.744
PSE2	0.9	0.811				
PTHMI3	0.877	0.769	0.766	0.863	0.679	0.795
PTHMI4	0.815	0.664				
PTHMI5	0.777	0.604				
PTHTP3	0.714	0.510	0.811	0.888	0.729	0.87
PTHTP4	0.911	0.829				
PTHTP5	0.92	0.847				
ATT1	0.841	0.708	0.819	0.892	0.734	0.82
ATT2	0.87	0.757				
ATT3	0.859	0.738				
CU1	0.927	0.859	0.798	0.908	0.831	0.813
CU2	0.896	0.803				
STT4	0.781	0.61	0.883	0.911	0.631	0.89
STT6	0.781	0.609				
STT7	0.801	0.642				
STT8	0.765	0.585				
STT9	0.866	0.75				
STT10	0.768	0.59				
BI1	0.948	0.898	0.895	0.95	0.905	0.899
BI2	0.955	0.912				

Annex 2: Reflective measurement model assessment; Source: Author Construction

	PU	PSE	PTHTP	PTHMI	PU	PBA	CU	STT	ATT	BI
PU	**0.886**									
PSE	0.517	**0.891**								
PTHTP	0.235	0.357	**0.854**							
PTHMI	0.064	0.125	0.191	**0.824**						
PU	0.599	0.551	0.291	0.142	**0.805**					
PBA	-0.224	-0.429	-0.137	0.160	-0.304	**0.842**				
CU	0.426	0.647	0.258	0.316	0.551	-0.310	**0.912**			
STT	0.365	0.471	0.320	0.242	0.489	-0.243	0.596	**0.794**		
ATT	0.621	0.643	0.239	0.212	0.655	-0.372	0.666	0.575	**0.857**	
BI	0.494	0.667	0.324	0.236	0.581	-0.309	0.713	0.704	0.768	**0.951**

Annex 3: AVE and Latent correlation matrix; Source: Author Construction

	PU	PEU	PBA	PSE	PTHTP	PTHMI	ATT	CU	STT	BI
pu1	**0.802**	0.426	-0.210	0.513	0.270	0.149	0.591	0.490	0.423	0.519
pu2	**0.709**	0.367	-0.227	0.386	0.261	0.159	0.531	0.419	0.355	0.439
pu3	**0.847**	0.538	-0.324	0.472	0.212	0.148	0.574	0.384	0.367	0.479
pu4	**0.870**	0.527	-0.357	0.544	0.234	0.110	0.615	0.571	0.463	0.576
pu5	**0.802**	0.464	-0.158	0.358	0.177	0.094	0.506	0.487	0.417	0.423
pu6	**0.769**	0.442	-0.112	0.320	0.232	0.127	0.363	0.375	0.391	0.379
pu7	**0.816**	0.505	-0.226	0.415	0.226	0.085	0.432	0.401	0.397	0.425
pu8	**0.816**	0.570	-0.296	0.492	0.262	0.048	0.558	0.401	0.334	0.467
peu1	0.400	**0.839**	-0.123	0.325	0.114	-0.089	0.446	0.263	0.176	0.302
peu2	0.524	**0.894**	-0.176	0.363	0.158	0.021	0.512	0.328	0.332	0.388
peu3	0.625	**0.924**	-0.265	0.620	0.308	0.175	0.652	0.492	0.414	0.567
pba1	-0.245	-0.211	**0.787**	-0.308	0.047	0.271	-0.309	-0.206	-0.123	-0.217
pba2	-0.280	-0.143	**0.848**	-0.386	-0.164	0.022	-0.333	-0.305	-0.243	-0.311
pba3	-0.228	-0.189	**0.852**	-0.418	-0.209	0.106	-0.295	-0.280	-0.244	-0.253
pba4	-0.267	-0.215	**0.879**	-0.331	-0.136	0.147	-0.313	-0.252	-0.207	-0.257
pse1	0.465	0.432	-0.357	**0.881**	0.340	0.098	0.559	0.493	0.290	0.489
pse2	0.515	0.487	-0.404	**0.900**	0.298	0.124	0.586	0.654	0.538	0.690
pthtp3	0.189	0.089	-0.044	0.224	**0.714**	0.171	0.154	0.174	0.228	0.225
pthtp4	0.251	0.174	-0.128	0.320	**0.911**	0.124	0.169	0.247	0.272	0.257
pthtp5	0.290	0.296	-0.157	0.352	**0.920**	0.193	0.268	0.235	0.310	0.331
pthmi3	0.145	0.070	0.059	0.147	0.234	**0.877**	0.205	0.322	0.258	0.260
pthmi4	0.087	0.091	0.194	0.127	0.103	**0.815**	0.172	0.262	0.170	0.154
pthmi5	0.112	-0.011	0.171	0.017	0.112	**0.777**	0.138	0.176	0.153	0.150
att1	0.521	0.477	-0.305	0.506	0.234	0.168	**0.841**	0.581	0.484	0.680
att2	0.605	0.581	-0.415	0.620	0.273	0.151	**0.870**	0.572	0.504	0.650
att4	0.555	0.536	-0.231	0.522	0.104	0.228	**0.859**	0.561	0.491	0.645
cu1	0.511	0.398	-0.323	0.680	0.269	0.298	0.635	**0.927**	0.545	0.699
cu2	0.493	0.379	-0.237	0.486	0.196	0.276	0.577	**0.896**	0.543	0.593
stt4	0.362	0.290	-0.108	0.356	0.338	0.169	0.354	0.422	**0.781**	0.468
stt6	0.420	0.353	-0.224	0.471	0.315	0.176	0.477	0.511	**0.781**	0.529
stt7	0.406	0.415	-0.184	0.423	0.273	0.120	0.440	0.417	**0.801**	0.543
stt8	0.314	0.204	-0.145	0.244	0.178	0.208	0.390	0.387	**0.765**	0.495
stt9	0.423	0.255	-0.268	0.385	0.195	0.178	0.521	0.525	**0.866**	0.681
stt10	0.393	0.226	-0.202	0.350	0.243	0.300	0.530	0.553	**0.768**	0.602
bi1	0.538	0.468	-0.292	0.641	0.350	0.184	0.699	0.665	0.639	**0.948**
bi2	0.566	0.472	-0.296	0.628	0.269	0.263	0.760	0.690	0.698	**0.955**

Annex 4: Item level discriminant validity; Source: Author Construction

Constructs	PEU	PSE	PTHTP	PTHMI	PU	PBA	CU	STT	ATT
PEU									
PSE	0.611								
PTHTP	0.254	0.453							
PTHMI	0.143	0.177	0.231						
PU	0.649	0.657	0.331	0.167					
PBA	0.246	0.535	0.194	0.236	0.332				
CU	0.489	0.827	0.316	0.392	0.639	0.369			
STT	0.397	0.571	0.379	0.284	0.539	0.273	0.705		
ATT	0.717	0.823	0.282	0.264	0.745	0.439	0.822	0.669	
BI	0.536	0.814	0.375	0.273	0.634	0.351	0.838	0.782	0.896

Annex 5: HTMT Discriminant Validity Measure Source: Author Construction

Variable	PU	PEU	PBA	PSE	PTHTP	PTHMI	ATT	CU	STT
PU		1.37		1.489	1.18	1.042			
ATT	1.84	1.7	1.32	1.866	1.19	1.119			
BI							1.975	2.047	1.701

Annex 6: VIF Test; Source: Author Construction

PU1/ Using menstrual tracking mobile apps (MTMAs) enable me to accomplish tasks quickly (e.g. in tracking my period cycle dates as well as identifying my fertile, infertile and upcoming periods).
PU2/ Using (MTMAs) in preventing pregnancy naturally will increase my productivity.
PU3/Using (MTMAs)will improve my performance to track my period.
PU4/ MTMAs will make it easier to verify my menstrual sensations and experiences.
PU5/Using MTMAs will enhance my effectiveness in informing healthcare professionals concerning my health status.
PU6/MTMAs will give me access to information on contraceptives, and menstruation related ideas.
PU7/Using MTMAs will give me greater control over my body.
PU8/I would find MTMAs will be useful in tracking my period and identifying changes in it.
PEU1/Learning to operate a menstrual tracking mobile application would be easy for me.
PEU2/I would find it easy to get menstrual tracking mobile applications to do what I want it to do.
PEU3/My interaction with the menstrual tracking mobile application would be clear and understandable.
PBA1/Using a menstrual tracking mobile app will be difficult and uncomfortable.
PBA2/Menstrual tracking mobile application will consume my time.
PBA3/Using menstrual tracking mobile application is prohibited in my cultural and religious beliefs.
PBA4/My family didn't allow and support me to use a menstrual tracking mobile application.
PSE1/I can download a menstrual tracking mobile application when I want to.
PSE2/A reminder notification on my smartphone to log in each day would be important to my use of MTMAs.
PTHMI3/My feelings about myself would change if my period is irregular.
PTHMI4/When I think about menstrual irregularities I feel nauseous.
PTHMI5/Menstrual irregularities would threaten my daily activities.
PTHTP3/ The thought of teenage pregnancy scares me.
PTHTP4/If I were pregnant, my education would be endangered.
PTHTP5/Teenage pregnancy would threaten my relationship with my family and relatives.
ATT1/I have positive feelings towards the use of menstrual tracking mobile application technologies.
ATT2/Using a menstrual tracking mobile application is a wise idea.
ATT3/I have no objection to using a menstrual tracking mobile app if available.
CU1/If I see my friends using a menstrual tracking mobile app, it reminds me to use it.
CU2/Routine educational talks regarding teenage pregnancy and MI awareness would help me to get a MTMAs.
STT4/I like MTMAs because I want to manipulate factors that affect my period regularity.
STT6/I like MTMAs becauseI'm interested to know how my period cycle works.
STT7/I like MTMAs because it helps me to optimize my menstrual health.
STT8/I like MTMAs because it motivates me to keep on working for a goal (e.g. to prevent teenage pregnancy naturally).
STT9/I like MTMAs because it motivates me to avoid period irregularity.
STT10/I like MTMAs because it facilitates my self-discipline.
BI1: I intend to continue to use a menstrual tracking mobile app in future.
BI2: I plan to use a menstrual tracking mobile app in future.

Annex 7: Survey items; Source: Author Construction

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