Addis Ababa University,

College of Development Studies,

Center for Regional and Local Developmental Studies

PERCEPTIONS AND ACCEPTANCE OF MENSTRUAL TRACKING MOBILE APPLICATION AMONG ADOLESCENT GIRLS IN LAFTO SUB CITY, ADDIS ABABA

BY

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ADDIS ABABA

JULY, 2023

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Perceptions and Acceptance of Menstrual Tracking Mobile Application among Adolescent Girls in Lafto Sub City, Addis Ababa

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A Thesis Submitted to Addis Ababa University, Department of Regional and Local Developmental Studies in Partial Fulfillment of the Requirements for the Degree of Masters of Arts in Regional and Local Developmental Studies

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This is to certify that the thesis prepared by **Bernabas Petros Gemecho** entitled, **Perceptions and Acceptance of Menstrual Tracking Mobile Application among Adolescent Girls in Lafto Sub City, Addis Ababa**, which is submitted in partial fulfillment of the requirements for the degree of Masters of Arts in Regional and Local Developmental Studies (RLDS), complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

Approved by Board of Examiners

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Statement of the Author

I, the undersigned, declare that this thesis entitled "**Perceptions and Acceptance of Menstrual Tracking Mobile Application among Adolescent Girls in Lafto Sub City, Addis Ababa**", hereby submitted to Addis Ababa University for the degree of Masters of Arts in Regional and Local Developmental Studies is my original work, which has not been presented for the award of any other Degree or Diploma in any other university or institution.

Bernabas Petros Gemecho

Name

Signature

19/06/2023

Date

Acknowledgement

Firstly, I would like to thank, the Almighty God for giving me a dream, strength, health and other resources to successfully complete this thesis.

In addition, I would like to acknowledge the academic support and invaluable guidance and criticism that I received from my advisor, Dr. Yeshtila Wondemeneh throughout this thesis preparation stages. I would also like to express my gratitude to my father, mother, brothers and sisters for their valuable advice and encouragement.

My special thanks go to the Addis Ababa Public Health Research and Emergency Management Directorate; Nifas Silk Lafto Sub city Health Office, and the Directors, vice Directors, Unit Leaders, Teachers and all academic staffs at the seven private high schools at Jemo 1, wereda 13. Moreover, I am very grateful to Bethlehem Admasu, Mercy Abebayehw, and Selam Elias students at School of Redemption; Danawit Asmerom and Arsema Gezachew students at Felegeneway Academy; and Danawit Eyob a student from Abune Gorgorios School for facilitating the data collection process. Without their support, this research would not have been possible.

I am very grateful to all people who supported me in providing useful data and materials required for the research as well as for those who participated voluntarily. Last but not least, I would also like to thank all the academic staffs from Addis Ababa University, College of Development Studies.

Acronym

Apps	Applications
ATT	Attitude to Use
AfCFTA	African Continental Free Trade Area
AI	Artificial Intelligence
AR	Augmented Reality
BI	Behavioral Intention to Use
COVID 19	Corno-Virus Diseases
CU	Cues to Action
DH	Digital Health
DHTs	Digital Health Technologies
DHIS	District Health Information Software/System
EIC	Ethiopian Investment Commission's
E-Health	Electronic Health
E-Governance	Electronic Governance
FDRE	Federal Democratic Republic Ethiopia
FP	Family Planning
FABMs	Fertility Awareness-Based Methods
GSMA	Global System for Mobile Association
GBV	Gender Based Violence
H	Hypothesis
H2M	Human to Machine

HBM	Health Belief Model
HTMT	HeteroTrait–MonoTrait ratio
ICT	Information Communication Technology
IT	Information Technology
IOT	Internet of Things
IOE	Internet of Everything
KII	Key Informant Interview
M2M	Machine to Machine Communication
mHealth	Mobile Health
MI	Menstrual Irregularity
MInT	Ministry of Innovation and Technology
MoT	Ministry of Transportation
MoP	Ministry of Peace
MoH	Ministry of Health
NBE	National Bank of Ethiopia
OT	Operation Technology
PAHO	Pan American Health Organization
PHC	Primary Health Care
PU	Perceived Usefulness
PEU	Perceived Ease of Use
PSE	Perceived Self Efficacy
PBA	Perceived Barriers
PTHMI	Perceived Threat to Menstrual Irregularity

PTHTP	Perceived Threat to Teenage Pregnancy
RH	Reproductive Health
RCT	Randomized Clinical Trial
STT	Self-Tracking Motivation
SDGs	Sustainable Developmental Goals
SSA	Sub Saharan Africa
SC	Self-Care
SRH	Sexual Reproductive Health
T^o	Temperature
TAM	Technology Acceptance Model
TRA	Theory of Reason Action
UK	United Kingdom
UNIDO	United Nations Industrial Development Organization
UNCTD	United Nations Conference on Trade and Development
UNFPAs	United Nations Sexual and Reproductive Health Agency
UHC	Universal Health Coverage
VR	Virtual Reality
WHO	World Health Organization
WEF	World Economic Forum
WASH	Water Sanitation and Hygiene
WSSCC	Water Supply and Sanitation Collaborative Council
4IR or Industry 4.0	Fourth Industrial Revolutions
2G, 3G	Gigabytes

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Abstract

The world has been passing through the fourth industrial revolution and the traditional health system is evolving to a more digital health. The objective of this research is to examine perceptions of menstrual tracking mobile application acceptance among adolescent girls in Lafto sub city, Addis Ababa. I employed exploratory, cross-sectional design with integrated HBM and TAM to investigate the subject of the study. Additionally, the sample size was estimated using the inverse square root method and I adopted a combination of stratified and simple random sampling techniques. I also used the self administered questionnaires using Google doc and a total of 161 adolescent girls participated voluntarily. I used Stata version 17 for descriptive analysis and R studio software version 4.3 for PLS-SEM analysis. The finding of my 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 behavioral intention to use such apps except perceived threat to teenage pregnancy and menstrual irregularity. But, both had significant indirect effect. Based on the above findings, I recommend health software developers to increase the significant predictors (perceived usefulness, perceived ease of use, perceived self efficacy and cues to action) and to decrease perceived barriers which lead to positive attitude to use and self tracking motivations that ultimately impacts acceptance of such apps among adolescent girls.

Key Words: Menstrual Tracking Mobile Application; HBM; and TAM, PLS-SEM

Chapter 1

1. Introduction

1.1 Background of the Study

The world has been passing through the fourth industrial revolution -4IR (Snowdon, 2021). Developed countries are leading this new industrial era. However, according to some scholars, Africa seems unprepared not only for the current 4IR but also for the three previous revolutions. On the other hand, other scholars argue that the continent has a place and is ready for the 4IR with emphasis on sub-Saharan Africa-South Africa and other countries (Benyera, 2022; Dijkstal et al., 2019; Fox & Signe, 2021; Mamphiswana & Bekele, 2020; Njuguna & Landry, 2020). Ethiopia envisions creating a digital economy in 2025 to promote inclusive prosperity. As a result, the newly launched 5G network in Addis Ababa, the beginning of private telecom companies, and generally the reform movements display the country's progress towards this revolution (Federal Democratic Republic Of Ethiopia, 2020).

Furthermore, technology is the main driver and foundation of the 4IR. Thus, the typical features of this era are its usage of artificial intelligence- AI, health apps, virtual reality-VR, analytics, machine learning, etc. (Snowdon, 2021). In addition, this era has been transforming the traditional health system into digital health (Snowdon, 2021). Consequently, self-tracking technologies which promote client-centeredness are arriving in the arena of the healthcare delivery system. Menstrual tracking mobile applications are one of the self-tracking technologies, which are available in the play store or apple store and designed for women to track their menstrual progress.

Additionally, the major consumers of the digital world are the adolescent and youth population group. As a result, 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.

However, adolescent girls, who are engaged in the digital world eminently, have been suffering from menstrual irregularity, teenage pregnancy, and other sexual reproductive health rights issues (Admassu et al., 2022; Mamo et al., 2021; Mittiku et al., 2022). To begin with, menstrual irregularity is any changes that occur in frequency of onset, regularity of onset, volume of blood, and duration of flow from the regular menstrual cycle**.** Moreover, menstruation in adolescent girls is characterized by irregularities (longer or shorter cycle length) compared to adult women (Gazibara et al., 2020; Mittiku et al., 2022). This is because the unit (hypothalamic-pituitary-ovarian axis) that is responsible for regulating this activity in adolescent girls is immature. Additionally, literatures showed that it can take up to 1-3 years for adolescents to have regular cycles after menarche[1]. As a result, period irregularity 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). Additionally, studies revealed that period irregularity has a longer impact on women's health; such as cardiovascular diseases, type 2 diabetes, infertility etc (Mittiku et al., 2022).

Secondly, teenage pregnancy in Africa, SSA, East Africa, Ethiopia and Addis Ababa was 18.8% (G. M. Kassa et al., 2018a); 19.3% (G. M. Kassa et al., 2018a), 54.6% (Worku et al., 2021), 23.59% (Mamo et al., 2021), and 4.1% (Abita et al., 2022), respectively. Similarly, in 2022, in SSA unintended teenage pregnancies were 30.01% (Ayalew et al., 2022); whereas, in Ethiopia, it was 29.7% (Zeleke et al., 2021). Thus, adolescent girls are more likely to die during pregnancy and childbirth compared to girls in their twenties (Advocates for Youth, 2007). Having said this, some of the root causes for teenage pregnancy and unintended pregnancy are, not knowing family planning methods or lack of education concerning types of family planning methods, non-use of or ignorance of contraceptives, misconceptions about contraceptives, non-friendly adolescent SRH services, lack of privacy at clinics, lack of guidance and counseling on sexual health, negative attitudes of caregivers, to name a few. (Ayalew et al., 2022; Birhanu et al., 2019;

[1] https://my.clevelandclinic.org/health/articles/10132-menstrual-cycle

G. M. Kassa et al., 2018b; Maharaj, 2022; Mathewos & Mekuria, 2018; Mezmur et al., 2021; Worku et al., 2021; Yakubu & Salisu, 2018; Zeleke et al., 2021).

Consequently, it is recommended to adolescent girls to use menstrual tracking mobile apps as it allows them to prevent teenage pregnancy (as a natural contraceptive method); to know about contraceptives; to verify their menstrual experiences; to understand their body; to track their period cycle, pain etc and in general, to fill up the gaps created by the above root causes and to recognize their period as a normal healthy physiological process (Fowler et al., 2020).

In conclusion, despite the fact that there are lots of adolescent smartphone users in Ethiopia, little is known about the acceptance of menstrual tracking mobile apps. Thus, the key question of the study is: why adolescents have been suffering from teenage pregnancy and menstrual irregularity since the majority of them are consumers of digital technology. Accordingly, the purpose of this study is to examine perceptions of menstrual tracking mobile app acceptance among adolescent girls based on Technological Acceptance Model (TAM) and Health Belief Model (HBM) in Lafto sub-city, Addis Ababa. Here, I employed exploratory cross-sectional research design and sequential mixed research approach as well as combination of stratified and simple random probability sampling design. Also, the data was analyzed by Structural Equation Modeling-Partial Least Squares approach (PLS-SEM) using Stata version 17 and R studio software version 4.3. Hence, the study findings will stimulate the development of such technologies in the context of the community and contribute to achieve SDGs.

1.2 Statement of the Problem

Adolescent girls, who are engaged in the digital world eminently, have been suffering from menstrual irregularity, teenage pregnancy, and other sexual reproductive health rights (SRHR) issues (Admassu et al., 2022; Mamo et al., 2021; Mittiku et al., 2022). To begin with, menstrual irregularity is any changes that occur in frequency of onset, regularity of onset, volume of blood, and duration of flow from the regular menstrual cycle**.** Moreover, menstruation in adolescent girls are characterized by irregularities (longer or shorter cycle length) compared to adult women (Gazibara et al., 2020; Mittiku et al., 2022). This is because the unit (hypothalamic-pituitary-ovarian axis) that responsible for regulating this activity in adolescent girls is immature. Additionally, literatures showed that it can take up to 1-3 years for adolescents to have regular

cycles after menarche[2]. As a result, period irregularity is common in adolescents girl and this creates anxiety, depression, and in general emotional dissatisfaction, thus, it affects their quality of life (Mittiku et al., 2022). Additionally, studies revealed that it has a longer impact on the women's health; such as cardiovascular diseases, type 2 diabetes, infertility etc (Mittiku et al., 2022).

Secondly, the overall pooled prevalence of teenage/adolescent pregnancy in Africa, in 2018 was 18.8%; whereas in sub-Saharan Africa 19.3% (G. M. Kassa et al., 2018a). In addition, 6, 114, 000 (15-19 years old) and 332, 000 (10-14 years old) were the estimated number of births that occurred in SSA in 2021, which was the largest in the globe[3], and in East Africa, the rate was 54.6% (Worku et al., 2021). Similarly, the pooled prevalence of teenage unintended pregnancy in 2022 in SSA was 30.01% (Ayalew et al., 2022). Likewise, adolescents in Ethiopia continue to face a high burden of morbidity and mortality from multiple factors including, teenage pregnancy, unplanned pregnancy, unsafe abortion, and extra.

The pooled estimated prevalence of teenage pregnancy in Ethiopia was 23.59% in 2021, which is greater than in other African countries (Mamo et al., 2021). Additionally, other studies in the country showed that the prevalence of teenage pregnancy was 30.2% in eastern Ethiopia (Mezmur et al., 2021), 25.4% in Farta Wereda (B. G. Kassa et al., 2021), 7.7% in Arba Minch town (Mathewos & Mekuria, 2018) and 4.1% in Addis Ababa (Abita et al., 2022). And, according to Addis Ababa Health Bureau; DHIS report of facility based teenage pregnancy of the last 9 months of this year (Hamele 2014 E.C to Megabit 2015 E.C) showed that it was higher in Akaki Kaleti; Lemi Kura; Kolfe Keranyo and Nifas Silk Lafto sub cities than other sub cities. Moreover, 709-970 teenage girls were tested positive for pregnancy in the last 9 months in the four sub cities; whereas, in other sub cities it was less than 583. Also, the prevalence of unintended teenage pregnancy in 2021 was 29.7% of which 20.4% were mistimed and 9.3% unwanted (Zeleke et al., 2021). As a result, teenage girls are exposed to abortion, which leads to morbidity.

Hence, teenage pregnancy and unintended adolescent pregnancy are the leading cause of death for adolescent girls as they are more likely to die during childbirth compared to girls in their

[2] https://my.clevelandclinic.org/health/articles/10132-menstrual-cycle
[3] https://www.who.int/news-room/fact-sheets/detail/adolescent-pregnancy

twenties (Advocates for Youth, 2007). According to regional and national studies, some of the root causes for teenage pregnancy and unintended pregnancy are, not knowing family planning methods or lack of education concerning types of family planning methods, non-use of contraceptives, misconceptions and ignorance about contraceptives, non-friendly adolescent SRH services, lack of privacy at clinics, lack of guidance and counseling on sexual health, negative attitudes of caregivers, to name a few (Ayalew et al., 2022; Birhanu et al., 2019; G. M. Kassa et al., 2018b; Maharaj, 2022; Mathewos & Mekuria, 2018; Mezmur et al., 2021; Worku et al., 2021; Yakubu & Salisu, 2018; Zeleke et al., 2021). On top of this, the WHO regional office for Africa report (2021) on the assessment of barriers to adolescent health in Ethiopia indicated that the health service delivery neglected the adolescent population group; which in turn increases their vulnerability to different health threats.

Consequently, it is recommended to adolescent girls to use menstrual tracking mobile apps as it allows them to prevent teenage pregnancy (as a natural contraceptive method); to know about contraceptives; and in general, to fill up the gaps created by the above root causes and to recognize their period as a normal healthy physiological process (Fowler et al., 2020). Furthermore, the data generated by the apps helps them to prepare for the upcoming bleeding or menstruation; to track their period cycle, symptom; to verify period experiences and sensations; to inform healthcare professionals, and generally, to follow-up their health status as well as manage their fertility (to know their fertile and infertile periods, extra) (Levy et al, 2019).

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. For instance, (Christiansen et al., 2023; B. F. Endehabtu et al., 2019; Lund et al., 2016; Olusola Oladeji & Oladeji, 2022; Parellada et al., 2020; Shiferaw et al., 2016; Thomsen et al., 2019) to name a few. Moreover, among those studies, three of the studies were employed a randomized clinical trial (RCT) research design; while, three studies cross sectional and one study cohort, respectively. In addition, some studies focused on improving the antenatal and postnatal care services using text messages, voice call and even through smartphone apps (Medhanyie et al., 2015; B. Endehabtu et al., 2018; Z. Y. Kassa et al., 2019; Atnafu et al., 2017; A. S. Kebede et al., 2019; Little et al., 2013). Here, three of the studies were employed cross

sectional research design; whereas, two of the studies RCT and one study cohort, respectively. Thus, mobile health studies in our country weren't focused on self-tracking mobile applications, like menstrual tracking apps. Therefore, as to my understanding, acceptance of menstrual tracking mobile app among the adolescent girls in Ethiopia is understudied.

Therefore, the purpose of this study is to examine perceptions of menstrual tracking mobile apps acceptance among adolescent girls based on TAM and HBM in Lafto sub-city, Addis Ababa. As a result, I used exploratory cross-sectional research design in order to address the knowledge gaps. And also, sequential mixed research approach was employed, which involves collecting qualitative data after a quantitative phase is completed in order to explain the quantitative data in more depth (Creswell, 2014). In addition, the study population was estimated using the inverse square root method. Moreover, a combination of stratified and simple random sampling design was adopted to select the study participants and the inclusion criteria was all adolescent women, who are attending in secondary high schools at Jemo 01wereda 13.

1.3 Objective

1.3.1 General Objective

To examine perceptions and acceptance of menstrual tracking mobile application among adolescent girls in Nifas Silk Lafto Sub-city, Addis Ababa

1.3.2 Specific Objectives

The specific objectives of this study are:-

- To explore the effects of the factors on the self tracking motivation and behavioral intention to use menstrual tracking mobile app.
- To identify the impacts of the factors on the attitude to use menstrual tracking mobile app.
- To find out the effects of the factors on the perceived usefulness of menstrual tracking mobile app.
- To explore to what extent perceived self efficacy impacts the perceived ease of use of menstrual tracking mobile application.

1.4 Research Hypothesis

The hypotheses of this study are:

- **H1a:** cues to action, self tracking motivations and attitude to use have a positive significant effect on behavioral intention to use menstrual tracking mobile app.
- **H1b:** the adolescent girl's perceived usefulness of menstrual tracking mobile apps has a positive significant effect on self tracking motivations.
- **H2:** the adolescent girl's perceived usefulness, perceived ease of use, perceived self efficacy, perceived threat to teenage pregnancy and menstrual irregularity have a positive significant effect on attitude to use the app; but, perceived barriers has a negative effect.
- **H3**: the adolescent girl's perceived ease of use, perceived self efficacy, perceived threat to teenage pregnancy and menstrual irregularity have a positive significant effect on perceived usefulness of the menstrual tracking mobile app.
- **H4**: the adolescent girl's perceived self efficacy has a positive significant effect on perceived ease of use of menstrual tracking mobile apps.

1.5 Significance of the Study

Here, the significance of the study is explained at three levels: individual, community, and national level, respectively. At an individual level, the study will create the opportunity to know about the menstrual tracking mobile app, which will empower and satisfy adolescent women/girls through informed decisions and autonomy in their body. Likewise, the findings will stimulate the development of such technologies that don't deviate from the culture of the community.

As we are in 4IR, the result of the study will call health practitioners, particularly public health informatics, biomedical informatics, software developers, etc both at the individual level or national as well as international institutions to develop menstrual tracking mobile apps and other related adolescent friendly technologies in our contexts. Thus, it will give directions for app designers, software developers, etc. in the community. Similarly, it will motivate other researchers to make a further study on the issue from different perspectives. Moreover, its findings are essential for various stakeholders, decision-makers, health policymakers, and the like, so that they can prepare health policies that fit the country's contexts before such

technologies come to the ground. Accordingly, the findings will contribute to achieving SDG targets for health in 2030.

Therefore, the study will demonstrate that self-tracking technologies, such as menstrual tracking mobile apps are necessary and will contribute to narrowing the existing gaps in adolescent health and reaching the adolescent population group.

1.6 Scope of the Study

The scope of the study is on menstrual tracking mobile applications; thus, the study doesn't include other forms of self-care or digital health technologies. In addition, the study only measures acceptance of such apps among adolescent girls as an outcome variable. Also, the study populations are adolescent girls, who are students in high schools at Jemo 01 wereda 13, Lafto sub-city.

1.7 Limitations of the study

The study has several limitations related to the study area, sampling procedure, instruments used for self tracking motivation, unexplained differences in constructs and extra. Firstly, Nifas-silk Lafto sub city and Jemo 01 wereda 13 was selected purposefully; because I was limited to cost and time. Also, the study was focused only on adolescent girl private high school students, and the sample size was estimated by assuming minimum effect sizes of 0.11 to 0.2. Similarly, as the sample size per group is unequal, I didn't perform multi group analysis (because it decreases the statistical power). As a result, future studies should consider other sub cities, wereda and public or governmental high schools as the study area as well as different participants and sampling estimation method and procedure. Thus, equal or moderately unequal sample sizes should be considered in future studies in order to make multi group analysis. In addition, the instrument used to measure 3 of the self tracking motivations (STT)—Self entertainment, Self association and Self healing (Gimpel et al, 2013)—in this study should be revised and re-evaluated in the contexts and understanding of the adolescent girls as it had problems in establishing the indicator reliability and discriminant validity.

Additionally, the integrated model explained 23.9% of the variations in self tracking motivation (STT) by perceived usefulness (PU) and 26.7% variations in perceived ease of use (PEU) by perceived self efficacy (PSE), leaving 76.1% and 73.3% unexplained, respectively. Hence, to

address this unexplained difference, future research should extend the model with additional factors that affect menstrual tracking mobile applications acceptance. All in all, since the sample was collected in the urban city Addis Ababa, Ethiopia; there are limitations in generalizing the results to other areas, cities and countries due to differences in cultural beliefs and perceptions in terms of technology usage.

Finally, the study has limitations related to the integrated model in which the study didn't include data privacy, technology infrastructure (e.g. internet connectivity, power electricity consumption, etc), menstrual tracking technology proliferation or innovation in the city, technology sustenance, and other similar issues as factors that affect acceptance of such apps. Thus, future studies should focus on these factors, which can increase the overall predictive power of the model.

1.8 Organizations of the study

The study is divided into five chapters. The first is the introductory chapter: which consists of the background of the study, the statement of problems, significance, objectives, scope, and limitations of the study; whereas, the second chapter deals with the operational definition, theoretical literature review, and empirical studies relevant to the topic under investigation as well as the conceptual framework of the study, respectively. The next chapter focuses on the research design and methodology of the study. The data presentation, analysis, and interpretation are presented in the fourth chapter. The fifth chapter provides a summary of findings, conclusions and recommendations.

Chapter 2

2. Literature Review

2.1 Introduction

The reviewed literature mainly focuses on four points. The first section deals with the operational definition of concepts and terms; then the theoretical literature review follows. Next, the empirical studies are discussed and finally, the conceptual framework of the study is explained.

2.2 Operational Definition of Concepts and Terms

Adolescents/Teens: The World Health Organization (WHO) classifies 10-19 years of age as adolescents and it is a universal definition for adolescents[4].

Teenage/Adolescent Pregnancy: is a pregnancy that occurs under the age of 20[5].

Client: In this paper, I used the term 'client' repeatedly, rather than 'patient'. It is because of the paradigm shift in 4IR, which focused on self-care. In other words, in this era, the concept of healthcare emphasized a preventive, personalized, participatory healthcare system, not just curing diseases. Here, individuals' lifestyles and realities are taken into consideration−thus; it is a holistic and inclusive approach to individual health. But, the term patient refers to a person who is a sufferer or receives treatment in a hospital[6]. In this digital era, individuals are actively engaged and participating in managing their own health through DHTs and the focus is not on the absence of diseases, but rather on a life course and holistic approach to health. Hence, I prefer the term client− healthcare everywhere; rather than, the patient− hospital sensitive healthcare term. Likewise, the term 'consumer' or 'user' is preferred to 'patient', though I didn't use this term frequently. Therefore, nobody waits to be patient to receive healthcare in this digital era, and clients are actively participating to keep their health with or without the service provider and they are autonomous or sovereign on their health and body.

[4] Ibid
[5] Ibid
[6] https://www.oxfordlearnersdictionaries.com/definition/english/patient_1

Menstrual irregularity: it is any changes that occur in frequency of onset, regularity of onset, volume of blood, and duration of flow from the regular menstrual cycle[7].

Menstrual regularity: It can last from 2 to 7 days and can happen every 21–35 days[8].

Menarche: is the first menstrual cycle in a female adolescent[9].

2.3 Theoretical Literature Review

This section establishes the theoretical foundations for the research's objectives and hypotheses. First, the discussions start with the theories of self-care, its importance, and its role in achieving SDGs. Then, strategies for creating an environment to support self-care focusing on digital health will be examined. Moreover, literature concerning 4IR as well as digital health and our country's readiness for it will be surveyed. Additionally, the researcher examines self-tracking techs definitions with emphasis on menstrual mobile apps, and then, the debates on self tracking techs will be presented. Finally, this section concludes with the theories or models that explain the usage of self-tracking techs by clients.

2.3.1 Basic Concepts of Self-Care (SC)

The concept of SC is part of primary healthcare (WHO, 2009) which existed before formal health systems were formed (Narasimhan et al., 2020), and its interventions are the hopeful recommended method in order to improve health and well-being (WHO, 2021a). This promising approach is for both the client, who are benefited from the interventions and the general health systems. WHO (2021b), defined SC as "*the ability of individuals, families and communities to promote health, prevent disease, maintain health and cope with illness and disability with or without the support of a health worker*". Likewise, the self-care forum defines the term as "*the actions that individuals take for themselves, on behalf of and with others in order to develop, protect, maintain and improve their health, well-being or wellness"* (Self Care Forum, 2020). Moreover, the concept incorporates self-management (e.g self-administration of injections, medications, treatment, examination, etc); self-testing (e.g self-sampling, self-screening, self-diagnosis, monitoring etc); and self-awareness (e.g self-help, self-education, self-regulation, self-

[7] https://my.clevelandclinic.org/health/articles/10132-menstrual-cycle
[8] Ibid
[9] Ibid

determination) (Narasimhan et al., 2020; WHO, 2021b). Thus, SC is a client-centered or a right-based approach that empowers them to actively engage in their own health.

In addition, the Mitchell Institute define the term as an *"umbrella encompasses…both self-care capability (i.e. knowledge, skills and confidence to engage in effective self-care) and self-care activity (i.e. health behaviors and day-to-day activities that constitute self-care) of individuals"*(T et al., 2020).

The key principles of SC for health and well-being are holistic approach, human rights, life course, gender equality and ethics (WHO, 2021a). The concept is also a continuum starting at individual determinants (daily choices concerning menstruation, sexual health, hygiene etc; health literacy); moving on to the community and health systems determinants (Chambers, 2006; WHO, 2021a). In other words, there is no single cut-off point for SC; it is a spectrum of care among clients, the community as well as the general health system.

Besides, promoting sexual health is one of the recommendations of WHO (2021a) that SC interventions should consider. Consequently, SC in SRH will give opportunity to women/girls to fulfill their health desires, needs, concerns, values and realities (Hardon et al., 2019; WHO, 2021b); which in turn reduces the unmet need for SRH services if the SC interventions are cheap, acceptable and available (Remme et al., 2019).

Therefore, SC is an informed decision making by clients on their own behalf and it is a continuum. Hence, it is an inclusive and holistic life style approach to health of clients, by clients and for clients with or without clinical care or service provider.

2.3.1.1 People-Centered Approach for Health and Well-Being

People or client centered approach is the main focus of SC and it deals with the holistic environment, circumstance, needs and desires of each person across their life journey for their own health and well-being (WHO, 2021b). In other words, the concept takes in to consideration people preferences and holistic dimensions of their course of life for their own health, safety and well-being. Furthermore, people-centered approach sees clients as active participants and beneficiaries of SC interventions that respond to the health desire, needs and preferences of them. It also underlines the promotion of gender equality, gender transformative health services,

clients participation in their own healthcare and ensures that clients are empowered (WHO, 2021b). Thus, it considers clients as active agent of their health and focused on their health reality and imagination rather than disease management and control (WHO, 2021b).

2.3.2 Reasons for Self-Care

There are two major reasons for the rational of self-care. To begin with, when clients used SC out of positive reasons because the healthcare considers them as lay health worker to fulfill their own health related needs and realities (Remme et al., 2019). In other words, the existing healthcare system promotes and supports self-care through creating an enabling environment (WHO, 2021a). Thus, all the underling policy, social and economic factors and determinants that sit beyond clients are in alignment of self-care(T et al., 2020; WHO, 2021b). Consequently, it displays the following things.

Firstly, SC become part of the healthcare system; in another way, it is a component of primary healthcare (WHO, 2009; 2021a). Secondly, WHO (2021b) estimated a global shortage of 18 million health workforce in 2030; thus, SC contributes to solve this issue by seeing clients as a lay health worker (Remme et al., 2019). This means SC is a strategy to ensure universal health coverage(WHO, 2021a). All in all, it acknowledges clients autonomy and power on their own health. As a result, it indicates that they prefer these interventions for positive reasons; such as, convenience, cost, empowerment or because it fits with their values, lifestyles or realities of health (Narasimhan et al., 2020; WHO, 2021a).

Other point is, when clients used it for negative reasons because to avoid the health system. Moreover, the health system is characterized by poor quality services, like poor information or interventions; products are inappropriate, unaffordable, or inaccessible; lack of or no access (e.g humanitarian); discrimination from the healthcare providers and extra (Narasimhan et al., 2020; WHO, 2021b). Thus, clients are obligated to use SC.

Therefore, the reason for SC can be positive or negative. In the former case, it indicates the existing system or environment enables and priorities SC. Here, there will be cooperation between the user and the service giver. In the latter case, it displays that the existing system or environment isn't accessible, affordable and clients are vulnerable to diseases. This shows us that there is no cooperation between the client and service giver. In short, positive reasons depicted

that clients are engaging in SC as an option with, whereas, the negative reasons as an option to the traditional healthcare system.

2.3.3 SDGs and Self-Care

The SDGs are planned to achieve in 2030. In general, WHO (2021a) identified the following SDGs and targets that focused in SC interventions. These are;

- SDG 3 "Ensure healthy lives and promote well-being for all at all ages" (target 3.7 and 3.8)
- SDG 4 "Ensure inclusive and equitable quality education and promote life-long learning opportunities for all" (target 4.5 and 4.6)
- SDG 5 "Achieve gender equality and empower all women and girls" (target 5.6)
- SDG 9 "Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation"(target 9.5)
- SDG 10 "Reduce inequality within and among countries" (target 10.3 and 10.4)
- SDG 12 "Ensure sustainable consumption and production patterns" (target 12.7 and 12.a)
- SDG 16 "Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels" (target 16.6).

Therefore, the concept of SC plays a great role in achieving SDGs. Moreover, SDG 3, 4 and 5 envisions for the universal coverage of quality services in health, SRH education and generally in empowering women. Likewise, SDG 9 and 12 leads us to anticipate the development of SC products or technologies as well as its distribution throughout the world. This will contribute to the reduction of inequalities (SDG 10), and promotion of inclusive societies at all levels (SDG 16). Hence, it will promote "*better health for all through better SC by all*" (T et al., 2020).

2.3.4 Declaration of Astana and Self-Care

The Astana Declaration, which was the 40th anniversary of the Alma-Ata declaration, was a global conference on primary healthcare, which held in 2018 in Astana, Kazakhstan to reaffirm the commitments and declaration of Alma-Ata of 1978 and the 2030 agenda of SDG (Rasanathan & Evans, 2020; WHO, 2018). This declaration focused on the primary healthcare as a way to health for all and emphasized the installation of primary care services as a furculum of the health systems (Rasanathan & Evans, 2020). Moreover, the three components of primary care as it is

described in the declaration are, (a) integration of primary care and essential public health functions as the fundamental of comprehensive health services in order to meet people's needs throughout the course of life; (b) empowering of clients and communities as self careers and caregivers; (c) addressing multi-sectoral determinants of health (Rasanathan & Evans, 2020; WHO, 2018; 2021a).

Therefore, this declaration states health services should be delivered as possible to where clients live through a people-centered approach and the need for integration of essential public health functions as a fundamental part of primary care (self-care) (Rasanathan & Evans, 2020; WHO, 2021a). It also focused on the right of clients to be autonomous and sovereign of their own health realities and needs. After all, self-care plays crucial role in achieving SDGs and UHC targets.

2.3.5 Experience and Lessons of COVID 19

The experience with the pandemic COVID 19 calls nations for promotion of and support for SC in all healthcare system (T et al., 2020). In other words, the current experience of social isolation and self-protection to prevent transmission of COVID-19 has emphasized the importance of self-care measures such as physical distancing, wearing masks and good hygiene (T et al., 2020; WHO, 2021a). Similarly, the response shows that the existing health systems in most countries are not oriented towards primary healthcare (e.g self-care) to be mobilized in such cases (Rasanathan & Evans, 2020). Furthermore, it demonstrates the role of clients informed decision to provide protection for the health of others and community. Hence, health and healthcare have to be considered as co-designed, co-implemented and co-evaluated by healthcare providers and clients in the community (T et al., 2020).

Additionally, PAHO/WHO director Dr. Carissa F. Etienne said that the pandemic "*has exposed the need for the health systems to be more resilient, interdisciplinary, inter-sectoral and interconnected than ever*" (PAHO, 2021). According to her, in order to achieve SDGs and UHC targets, we have to know where our client is and what social and health status has. Besides, she also said that we have to know the state of our health systems and their ability to respond to the particular needs of clients up to communities (PAHO, 2021). Hence, the only way to know this, as to her, is "*if we have information systems capable of capturing and processing critical and disaggregated data and making it available to the entire health system without exceptions*"

(PAHO, 2021). Therefore, the pandemic awakened various stakeholders in the health arena to build a client-centered healthcare system to achieve SDGs and UHC targets; and the role of digital technologies are eminent (Ajadi, 2020; PAHO, 2021; UNIDO, 2019; UNCTD, 2021).

2.3.6 Strategies for Creating an Environment to Support Self-Care

It is noted that a safe and supporting environment is essential for SC interventions. Its effectiveness and successfulness requires integrations of different aspects of the health system building blocks (WHO, 2021a). In addition, these strategies are focused to improve and promote the access, uptake and scale-up of SC interventions for health; not a replacement for the direct interaction in the health system (WHO, 2021a). As a result, the following are six WHO's (2021a) health system building blocks in order to create an enabling environment for the SC interventions to be safe and appropriate.

- Service Delivery:- deals with the inputs in to the health system which should be organized according to clients' needs and preferences in a holistic manner, not the diseases.
- Health Workforce: - deals with the attitude and behavior of the service provider to be inclusive, non-discrimination and non-stigmatization, which promotes clients autonomy, safety and reality on their own health. They should also acknowledge and support a people-centered healthcare.
- Health Information:- deals with the available and accessible of health information for both clients and service providers to make an informed decision. Here, mobile phones, tablets and other ICT devices will give the opportunity to deliver information at any time and place needed.
- Medical Products, Vaccines and Technologies:-deals with the health technology regulation, assessment and management.
- Financing:- deals with the affordability and accessibility of SC services and interventions.
- Governance:- deals with the regulatory environment that enable or inhibit SC interventions and products.

Hence, digital/self-care technologies are crucial in delivering health services, in giving health information etc. The next part will focus on this issue.

2.3.6.1 Fourth Industrial Revolution (4IR) and The Health Delivery System

In this section, the following points–the typical features of 4IR and the pace of Africa, particularly Ethiopia; evolution and birth of DH; views and examples of DH predominantly on menstrual application–will be discussed.

2.3.6.1.1 Fourth Industrial Revolution (4IR)

The world is in the fourth industrial revolution (4IR) or Industrial 4.0; which refers to the marriage or integration of physical assets and digital technologies(Deloitte, 2020);in other words, it is the amalgamation of cyber-physical systems or integration of IT and OT (Bloem et al., 2014) or it is the cooperation of the virtual and the physical systems (Bloem et al., 2014; Schwab, 2016); or as the World Economic Forum puts, it is a fusion of the physical, digital, and biological worlds (Schwab, 2016). Some even called it the second machine age and it is believed the concept was emerged first in Germany as Industrial 4.0 and later spread as 4IR by WEF (Schwab, 2016). Hence, it is an era where integration and merging of different worlds and realties (physical, virtual/ digital/ cyber, biological) takes place.

Furthermore, its typical features are usage of internet of things (IOT), artificial intelligence (AI), robots, drones, autonomous vehicles, 3D printing, cloud/quantum computing, nanotechnology, biotechnology, materials science, energy storage, augmented and virtual reality, etc (BEIS UK, 2019; Bloem et al., 2014; Deloitte, 2020; Schwab, 2016; Snowdon, 2020; UNIDO, 2019; WHO, 2021). Additionally, Schwab (2016) believed that 4IR is different from the previous revolutions in three ways, in velocity; breadth and depth; systems impact, respectively. Thus, technology is the furculum of this era (Benyera, 2022) and silent revolution is taking place (Bloem et al., 2014) with technologies that are innovative, fast-growing, deeply interconnected and interdependent (UNIDO, 2019).

On top of this, machine to machine communication (M2M) between internets of everything is the leading paradigm of the 4IR and will improved human to machine interaction (H2M) (Bloem et al., 2014). M2M system is an interaction or a communication between technologies without human intervention (Bloem et al., 2014). These systems uses sensors and meters to communicate events via a communications network, to application software that converts the raw data into

meaningful information (Bloem et al., 2014). Thus, M2M interaction within IOT devices and human is the distinctive nature of this era.

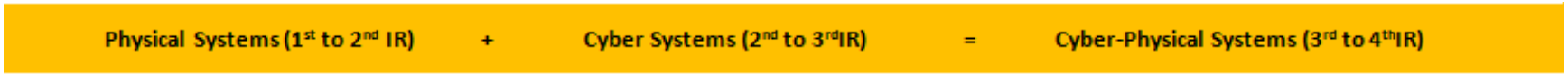
Besides, the four industrial revolutions across history can be summarized as follows.

Table 1: The 4IR across history

	1st IR	2nd IR	3rd IR	4th IR
Period	Started at 1784 up to the beginning of 20th century (Bloem et al., 2014); others like Schwab (2016) and Snowdon(2021) stated that it was 1760-1840; 1784-1850 respectively.	Started at the beginning of 20th century up to 1970's (Bloem et al., 2014); others said late 19th century to early 20th century (Schwab, 2016) or 1870-1950 (Snowdon, 2021).	Started at 1970's to early 21th century (Bloem et al., 2014); other said 1960's to 1990's (Schwab, 2016)or 1969 to early 21th century (Snowdon, 2021)	Present-
Characteristics or typical features	Mechanical production, rail roads, and stem power or engine. It is a transitional period from muscle power to mechanical power (Bloem et al., 2014; Schwab, 2016; Snowdon, 2021).	It is the "*introduction of the conveyor belt and mass production, to which the names of icons such as Henry Ford and Frederick Taylor are linked*" (Bloem et al., 2014). In other words Schwab (2016) and Snowdon (2021) characterized it was a "*mass production fostered by the advent of electricity and the assembly line*".	It is the "*digital automation of production by means of electronics and IT*" (Bloem et al., 2014; Snowdon, 2021). Moreover, it is called "*the computer or digital revolution because it was catalyzed by the development of semiconductors, mainframe computing (1960s), personal computing (1970s and 80s) and the internet (1990s)*" (Schwab, 2016).	It builds on the digital revolution of the 3IR. Its basic features are mobile internet, more powerful sensors that have become cheaper, artificial intelligence, machine learning and more to come (Bloem et al., 2014; Schwab, 2016; Snowdon, 2021).

Source: (Bloem et al., 2014; Schwab, 2016; Snowdon, 2021)

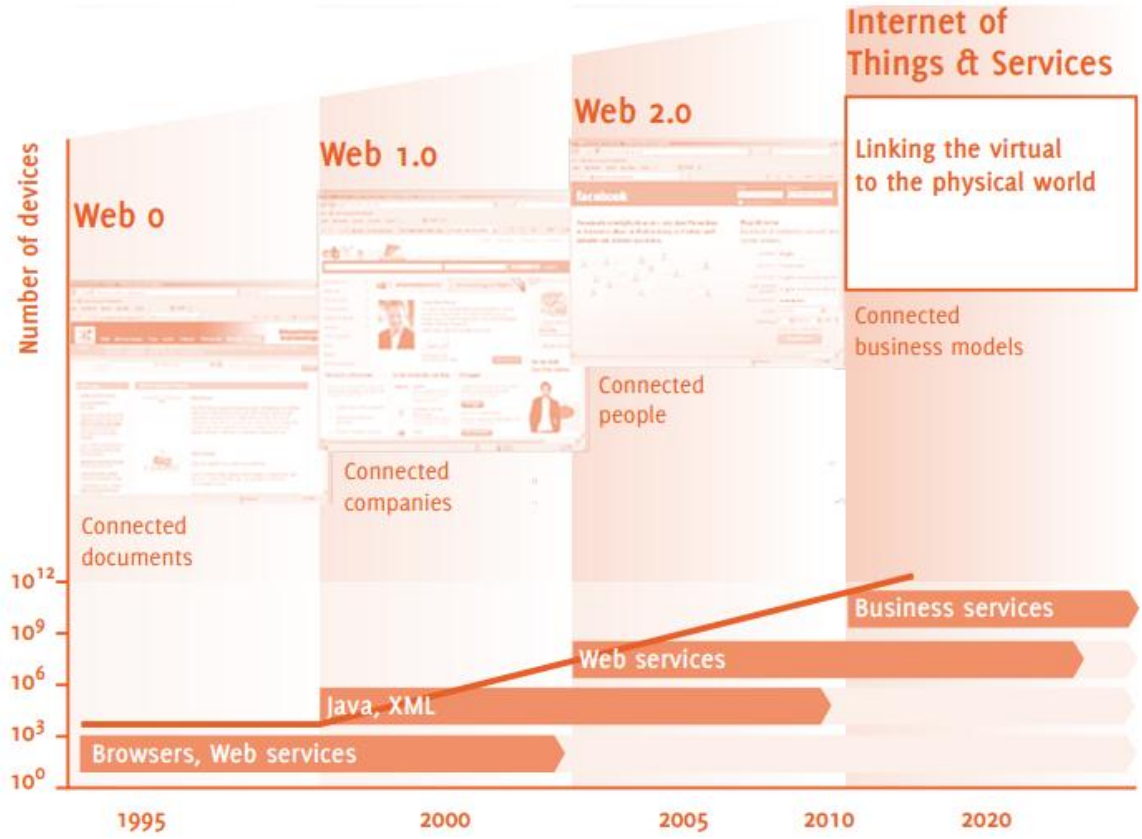
Figure 1: The four industrial revolution in terms of cyber to physical relationship



Source: (Bloem et al., 2014)

Also, these four revolutions from cyber to physical internet perspective can be summarized as following.

Figure 2: Industrial Revolutions from the cyber-physical Internet perspective



Source: (Bloem et al., 2014)

This fig shows that the IOT or IOE is responsible for the 4IR. This means, new business services and models are now being and will be developed by integrating or linking the physical and virtual/cyber worlds (Bloem et al., 2014). Therefore, a convergence between OT (industrial process automation and factory automation) and IT (business process automation and office automation) are its characteristics of this industrial age (Bloem et al., 2014).

2.3.6.1.2 Evolution of ICT in the Health System and Emergence of Digital Health (DH)

It is noted that the 4IR shifts the traditional health system to a more digital health (Snowdon, 2021). The term digital health has no universal definition (Fatehi et al., 2020; Snowdon, 2021)

instead variety of terms like mobile health, e-health, health IT, virtual care, telehealth, AI, genomes and extra are used (Fatehi et al., 2020; Rowlands, 2019; Snowdon, 2021; WHO, 2017). However, Rowlands (2019) defined the concept as a paradigm shift in "*the evolutionary path of ICT in healthcare but constituting a great leap forward and transcending technologies rather than just the next technological step*". In other words, he believes the term is more than the next step of technological innovations and he views it as an era of the fourth industrial revolution in which analytics, artificial intelligence, health apps or software, virtual reality and things like that are evolved in/transformed the health care system (Rowlands, 2019; Snowdon, 2021; WHO, 2017). Moreover, Rowlands (2019) described the evolution of the ICT in the healthcare system as follows.

Table 2: Evolution of ICT in the healthcare system

	1st wave	**2nd wave**	**3rd wave**	**4th wave**
Period	Early 1950's-1960's	Mid 1960's-2000's	2000's-2020's	2020's-
Era of	IT in health	ICT in health	E-health	Digital health
Description	Introduction of mainframe computers, and code written in machine and assembly languages. It was so expensive and used in industries in order to automate highly standardized, process-intensive functions.	Introduction of higher level programming languages such as FORTRAN and COBOL. Also, integrated circuits and microprocessors hold memory, logic, and control circuits on single chips enabling personal computers.	-Introduction of advanced telecommunications (3G, 4G, 5G…); e-commerce to the healthcare and pharmaceuticals. -The healthcare system required more ICT because of chronic conditions, quality and safety issues, and in general to deliver satisfactory client-centered services.	-Introduction of data analytics, AI, machine learning, robotics, health apps, AR, VR and generally expansions of IOT as well as IOE devices. -Introduction of ICT in digital societies, so that clients can actively participate and control their own health and well-being. -It is about more than tech.

Its focus	Little impact on the core functions of the healthcare (The role of C in ICT is limited and it was industry agnostic–not health specific)	Its focus was the healthcare organization. It was provider-centric, and focused on corporate applications for healthcare. Thus, it was more about healthcare logistics and performance management than about clinical and patient/citizen needs.	Its focus was on health information sharing and structured communication (EHR) in the health system as well as healthcare interoperability and connectivity. Thus, it was more about the healthcare delivery system, not on clients. Although it described as client-centric, its practices depicted it was not and the vast bulk of healthcare data was still provider-associated and controlled.	The focus is on health, not on the delivery system; in other words, it is client-centric–they are the sovereign or autonomous on their own health and service providers are participants. Thus, it will improve PHC, and help to achieve UHC and SDG targets.

Source: (Rowlands, 2019; Snowdon, 2021; WHO, 2017)

In addition, Rowlands (2019) identified seven characteristics of digital health. These are, (a) citizen or consumer centricity–client centered healthcare model (which will be discussed next); (b) new entrants–digital disruption with non-healthcare companies; (c) industry convergence–overlapping between the boundaries of health service delivery, pharma and other non-healthcare sectors; (d) role convergence–merging and diverging of the boundaries of clinical professional roles and practices(Gibson et al., 2015); (e) origin of data–new types of health data will be generated through sensors, apps etc.; (f) analytics and algorithms–new modes of care and knowledge will be generated; (g) broader than health–it focuses on clients daily lifestyles and wellness, respectively.

Therefore, DH is an emerging concept in the healthcare system in the 4IR era for digital societies. Moreover, ICT in the health system is evolved from paper recording to DH (Fernandes et al., 2022). Here, it is noted that the concept is more than tech, which concerned on the client's lifestyles as well as self-care and considers the provider and the health system as participants.

Hence, it is concluded that the improving and transforming of the health care system as well as the client care as the result of digital health is inevitable.

2.3.6.1.2.1 Client-Centered Health Delivery System

The 4IR promises the health system a 'client-centered' or 'consumer-enabled' health delivery system. This term defined by Snowdon (2021) as the focus "*of a health system on meeting and delivering on the consumer's individual needs, values, and personalized health goals. It recognizes the value and importance of connectivity between consumers and their care teams, creating a partnership based on consumer needs and choice. It leverages digital options (such as online tools, handheld devices for "care anywhere" approaches, or apps that enable on-demand health and wellness care), to support self-management of personal health and wellness goals, shaped by the unique life circumstances, preferences, health needs and choices of the consumer*". Thus, digital tools and technologies support client's to manage their own health as well as connecting them in meaningful ways to the health system (service provider) by offering choices for how, when, and where care is delivered. In short, DH will focus on SC as part of the healthcare delivery system.

2.3.6.1.3 Africa and 4IR with a focus on Ethiopia

Africa can't isolate itself from the 4IR. To put it in another way, as part of the global community the continent can't escape the 4IR (Fox & Signe, 2021). Besides, it promises the continent high productivity in agriculture, labor, mining, etc., economic transformation, trade improvement, food security, poverty reduction, self-employment, job opportunities, and cheap consumer goods to name a few (Benyera, 2022; Dijkstal et al., 2019; Fox & Signe, 2021; Mamphiswana & Bekele, 2020; Njuguna & Landry, 2020).However, some scholars argue whether the continent is ready or not ready for the 4IR. Moreover, Saidi (2022) questioned not only of the preparedness for the current IR, but were the continent ever ready for the 1st, 2nd, and 3rd IR. Likewise, Benyera (2022) took it further and argued that 4IR is a "*cure which kills the patient*"; by which he believes that it doesn't solve the problem of Africa as the context and ideologies of 4IR is not changed.

Others believed that the 4IR will free the continent from underdevelopment and contributes to achieve SDGs if African countries "*turning a curse into resources*" (Benyera, 2022; Dijkstal et

al., 2019) and takes lessons from china (Benyera, 2022). That means, African countries should use the opportunities in the 4IR and adopt strategies like remittances; knowledge and technology transfer; technological leapfrogging; African continental free trade area (AfCFTA) etc. to unfold technological advances (Benyera, 2022; Dijkstal et al., 2019). Likewise, Fox and Signe (2021) identified three solutions to capitalize the 4IR in Africa; these are (a) revise regulatory frameworks, improve business environments, and policies; (b) increase access to technology and close the gap in physical and digital infrastructure, especially in sectors with high-quality employment potential; (c) close the skills gap and increase human capital.

Additionally, China was not benefited from the 1st and 2nd IR, but they effectively used opportunities presented in the 3rd IR and became the global powerhouse (Benyera, 2022). Similarly, the previous IR in Africa characterized by slavery, colonialism, neocolonialism and globalizations, which affected the continent's development pace (Benyera, 2022; Dijkstal et al., 2019).But, the continent should take lessons from China and India (Benyera, 2022; Dijkstal et al., 2019). In addition, Wessels and Van Wyk (2022) argued that the continent is ready and in the rightful place for the 4IR with a great emphasis on south Africa (Njuguna & Landry, 2020).

The foresight Africa 2020 report showed that majority of the firms in Africa prepared moderate to low for five key 4IR technologies (AI/robotics; IOT; big data; 3D printing; Block chain) (Njuguna & Landry, 2020). Moreover, the GSMA (2021) report showed that 4G adoption increases in SSA and it will double to 28% in 2025 as well as it indicated seven commercial 5G networks are operating in the region and by the end of 2025, 3% of mobile connections in the region will be 5G. Also, it identified that in SSA the youthful population are the higher subscriber of mobile services and in 2025, it is projected 50% of the region population will subscribe mobile services as well as more than 170 million people will have started mobile internet for the first time. Likewise, in 2025, percentage of populations connected in SIM and mobile internet users will be 90% and 39%, respectively.

Therefore, a silent revolution is going on in our world (Schwab, 2016). What would be better for Africa, maintain the status quo and miss or leapfrog directly to the 4IR? (Dijkstal et al., 2019) Literatures show us that different policy and implementation guidelines as well as roadmaps for the ICT infrastructures in order to fit 4IR are generated at different levels.

2.3.6.1.3.1 Ethiopia in 4IR

Ethiopia as part of the global community embraces the 4IR and envisions a 'digital Ethiopia 2025'–a strategy to build an inclusive, knowledge based and prosperous society (FDRE, 2020). Moreover, the digital strategy concluded that IT is a cross cutting sector which could no longer considered as a separate sectorial categories and all sectors must embrace and engage with; because, it is the enabler of all sectors (FDRE, 2020). In addition, the strategy focuses on four frameworks for digital transformation; in other words, the readiness of the country for the 4IR described in four ways, in infrastructure (internet coverage, mobile subscription, electricity power, etc.); enabling systems (cyber security, digital ID, payment etc.); applications–digital interactions among government, private sector and societies (E-Governance apps, health apps, social media apps); and the broader ecosystem (finance, people, policy and regulations, extra) (FDRE, 2020).

Although digital transformation in the country is at the infant stage, there are initiatives that demonstrate the country's progress in the 4IR era. For instance, "*the efforts by the Ministry of Innovation and Technology (MInT) to upgrade and modernize 'WoredaNet'; the move by the Ministry of Transportation (MoT) to digitalize the national fleet management system; Ethiopian Investment Commission's (EIC) provision of online licensing services and digitalization of records; the experiment with Digital ID by the Ministry of Peace (MoP); and E-Payment systems by the National Bank of Ethiopia (NBE)*"; also, the liberalization of the telecom sector, the newly launched 5G network, the newly built science museums and AI institutions, smart city, and extra depicts the country's progress to fit in the 4IR era (FDRE, 2020). Hence, the new technologies incorporated in bank, security, telecom, transport industries depict the country's progress and leapfrog to 4IR era (Tesfachew, 2022).

Concerning DH, MoH (2021) formulated the 'digital health blueprint' as a means to achieve SDGs and UHC. And, there are different initiative in the health sector in integrating DH technologies (John Snow Inc., 2021); but, our country lacks client-centered/self-centered technologies.

2.3.6.1.4 Self-Tracking Technologies

Nowadays, the paradigm of health and healthcare are shifting to the concept of preventive, personalized, participatory, and in general, towards self-care, away from 'curing disease' (Flores et al., 2013; Sharon, 2017; Swan, 2013). It is moving as a response to the public health crisis (e.g pandemic, cost, shortage of physicians, etc.) that the world has been faced (Sharon, 2017; Swan, 2012). Self tracking techs are part of SC and lots of digital technologies are invented (apps, wearable's, software's etc.) and it will be increased. In fact, these techs will change the old paradigm and belief 'my health is the responsibility of the physicians' to 'my health is the responsibility of myself and I have self-care technologies'(Sharon, 2017; Swan, 2012).

According to Lupton(2016b), self-tracking techs involves practices that "*people knowingly and purposively collect information about themselves, which they then review and consider applying to the conduct of their lives*". These techs are also called as self-monitoring, lifelogging, the quantified self, personal analytics, and personal informatics; which, aimed at regularly monitoring, recording and measuring, elements of client's behaviors or bodily functions (Lupton, 2016c). In general, client's used these tools, so as to remember aspects of their life, to know their body, or as goal oriented in order to improve their health, physical fitness, emotional well- being, social relationships, work productivity etc. (Lupton, 2016c).

2.3.6.1.5 Menstrual Cycle and Menstrual Health

Menstruation is the release of blood by the uterus and vagina once a month (Critchley et al., 2020). According to UNFPA (2021a) first day of menstruation could be between 8 to 16 years old; but this is different for some girls. It is noted that menstruation cycle is a turning point for girls from childhood to adulthood (WSSCC, 2018). The normal range of menstrual cycle length is usually considered as anywhere between 21 and 35 days (WSSCC, 2018). Periods have an end time at some point in a woman's life, which is called menopause (WSSCC, 2018). Additionally, there are four phases for menstrual cycle; these are, (1) menstrual phase; (2) proliferative/follicular (estrogen) phase; (3) ovulation phase and (4) secretory/ luteal (progesterone) phase (Haroun, 2016; WSSCC, 2018).

Furthermore, according to UNFPA (2021a), menstrual health is a state of complete physical, mental and social well-being (not only the absence of disease) with regards to the menstrual

cycle. This includes a positive and respectful environment, which is free from stigma (negative stereotype) and psychological distress (Chau et al., 2021b; UNICEF, 2022). Also, it embraces resources that they need in order to make informed decisions to care for their bodies in their life course (Chau et al., 2021a). Hence, menstrual health includes the broader systemic factors that link menstruation with health, gender equality, well-being, education, empowerment, equity, and human rights (Chau et al., 2021b; House et al., 2012). In order to promote and improve menstrual health, it is essential that adolescent girls should have access to water and sanitation. And, UNICEF's (2017) Water, Sanitation and Hygiene (WASH) program, which is focused on menstrual hygiene management (MHM), and aims in eliminating inequalities in WASH services, plays crucial role. The last but not the least ways to manage menstrual health is through exercise, diet, sanitary pads or modes, talking with female teachers or family members, menstrual tracking mobile applications to name a few (Chau et al., 2021a).

2.3.6.1.6 Menstrual Challenges and Gender Stigma

Even though the menstrual cycle is a natural physiological process, adolescent girls have been experiencing gender inequality, stigma, and discrimination in relation to menstruation (Chau et al., 2021a). To begin with, menstrual stigma, as to UNFPA (2021a), "*manifests as restrictions on bathing, handling food, swimming, participating in religious gatherings, eating certain foods, or sleeping in the same household as non-menstruating family members*". This affects their daily lives and freedom. On top of this, discrimination in schools is a manifestation of a stigma in which adolescent girls are unable to manage their period safely, with dignity and privacy (Chau et al., 2021b; House et al., 2012). Hence, this will negatively influence their feelings towards menstruation and body image. Moreover, most forms of gender-based violence (GBV) are specifically related to menstruation (Chau et al., 2021b; House et al., 2012). For instance, bullying or teasing in school is a common experience faced by adolescent girls. Also, inadequate WASH infrastructure and limited access to affordable as well as effective period related products, contribute to the risk of adolescent girls to experience GBV (Chau et al., 2021b; House et al., 2012).

Likewise, adolescent girls enter menarche with very little information; but with high misconception about menstruation; which makes them to experience a menstrual cycle with shock, shame, fear and embarrassment (Chau et al., 2021b; House et al., 2012). The quantity and

quality of menstrual information provided to adolescent girls before menarche is so crucial. It is also noted that socio-cultural factors (religion, culture, education, socio-economic status etc) have an effect on the adolescent girls' experience of menstruation in some way or another (Chau et al., 2021b; Gesselleen, 2013). Because period is considered as taboos (a disease, infection, dirty, evil spirit, shameful or impure) in most communities, it prevents adolescent girls from articulating their needs (Chau et al., 2021a; Gesselleen, 2013; House et al., 2012). In addition, many adolescent girls will experience period symptoms such as pain, dysmenorrheal, anxiety, depression, irritability, fatigue, moodiness, headaches, premenstrual syndrome, acne, breast tenderness, and extra; which contribute to school absenteeism (Chau et al., 2021a; Critchley et al., 2020; Gesselleen, 2013; House et al., 2012). Some even reported severe abdominal pain and backache which all affects their menstrual health and quality of life (Chau et al., 2021b; Gesselleen, 2013).

2.3.6.1.7 Menstrual Tracking Mobile Application and Its Importance

Having said this; out of the self-tracking techs, this study deals with the menstrual tracking mobile apps. Moreover, these apps are designed for women to track their menstrual progress, which helps them in identifying their bleeding, cycle length, etc.; to track menstrual symptoms; to get awareness about the menstrual tracking and etc. For instance, the followings apps−Flu, Ovia, Glow, Kindara, Natural Cycles and extra−are few of them that found in Google play or app store. Additionally, some apps are purposefully designed for women as a fertility awareness-based methods (FABMs) of contraception, which helps them in identifying their fertile and infertile periods (standard days method/calendar rhythm method), as well as to record there T^{o} daily to identify their infertile periods (Basal Body Temperature), and extra. In all the cases it rely on women input data and use algorithms to predict bleeding days, ovulation, fertile period, etc. (Dudouet, 2022). Thus, clients use these apps for different purpose in order to achieve healthier habits and lifestyle.

- Importance of menstrual tracking mobile application for adolescent girls

There are eight benefits in using menstrual tracking mobile apps; these advantages are, (1) to track period cycle length and regularities, (2) to prepare for upcoming bleeding, (3) to know

menstrual cycles and body, (4) to verify menstrual experiences and sensations, (5) to inform healthcare professionals, (6) to track health, (7) to get or prevent pregnant (natural contraception), and (8) to identify changes in tracking (Levy & Romo-Aviles, 2019). In addition, good menstrual hygiene is crucial for the health, education, and dignity of adolescent girls. It is noted that girls have been tracking their cycles using memory, counters, and calendars for millennia (Hohmann-Marriott et al., 2022). But, in this digital era, a newest form of tracking by using a mobile app is developing. Therefore, equipping adolescent girls with adequate information and skills on menstrual hygiene as well as teenage pregnancy and menstrual managements helps in empowering them with knowledge which enhances their self-esteem (Chau et al., 2021a). This will have a positive impact on their academic performance, and achievement of SRHR as well as gender equality (Chau et al., 2021b; House et al., 2012). Thus, menstrual tracking mobile apps enable the adolescent girls to control their bodies, and improve their cognitive about fertility-related education and care.

2.3.6.1.8 Debate on Self-Tracking Technologies

In general, DH techs and in particular SC as well as self tracking techs, has been advocated in health literatures. To make it more specific, existing medical and public health literatures are optimistic to this paradigm shift. But, some of social science literatures are pessimistic towards to it. Let me start with the optimistic argument.

- Optimistic Argument

There are two key argument that encourages digital health transformation as well as the utilization of digital technologies; these are the utilitarian and empowerment argument (Marent & Henwood, 2021). The former considers "*digital technologies as a way to increase the efficiency, effectiveness and quality of health services"*; and the latter considers, "*digital technologies provide patients and citizens with personal health data and timely feedback by which they can gain a better understanding of their medical condition and are better placed to manage and participate in their health"* (Marent & Henwood, 2021). Likewise, Snowdon et al (2014) identified seven optimistic arguments for digital health and self tracking behaviors. These are, (1) to learn and better understand health and wellness; (2) to engage and connect to other digital consumers; (3) to take control of their body; (4) to self-manage health information and

data; (5) to ensure accuracy; (6) to collaborate with health providers, not be simply recipients of care; and (7) drive towards consumer engagement—to access expertise and health information from around the globe. This encourages clients to take actions for themselves, with or without a service provider, to prevent, maintain and improve their health and wellbeing. Therefore, the optimistic argument focuses on the improvement of universal health coverage (UHC) and client-centered care.

- Pessimistic Argument

Benjamin et al (2021), in their analysis on DH, stated that the pessimistic argument are at two levels; societal and practical level. In the former case, they said that social theory has focused on the implications and disruptions of techs in the society in terms of "*power and inequalities, capitalization of economic interests and the penetration of personal privacy*" (Swan, 2013). In other words, these techs didn't conceptualize as a way to empower clients rather as an evolutionary stage to disrupt the society. Such disruption, they called, the growth of a 'health data economy' which becomes a threats to 'health data privacy' (Lupton, 2016b; Swan, 2013). According to their analysis, digital health are based on hidden aims to transform client data into financial commodities by persuading clients to upload their personal data either for personal gain or for the good of society at large (Lupton, 2013, 2016c; Swan, 2013). Likewise, Lupton (2016b) called self tracking techs as of tracking of the self by others, in which clients are coerced into using such digital health technologies in the interests of other actors and agencies.

Likewise, digital or body capitalism and politics, digital bodies, body and data sovereignty are some of the issues raised by the advocators of this argument (Gurumurthy, 2022; Lupton, 2016d). Moreover, Lupton (2016a) considered digital health as the neoliberal 'soft' politics, in which lay people are encouraged to engage in practices of self-care in their own interests. According to her, digital technologies are developed for surveillance purposes and the data generated by the apps forms data capitalism. Gurumurthy (2022) also agrees with the above prepositions and she stated that some self tracking mobile apps company shares sensitive private information to third-party firms. Hence, they argued that client data are extracted for private profit and it is transformed into a commercial profit by other actors and agencies. In short, the crucial issues in digital health are the health data economy and the privacy of the client; as a result, scholars argue clients must know concerning their data usage and emphasis on data governance, security and quality;

informed consent, sovereignty, transparency, privacy etc. regarding the health data (Marent & Henwood, 2021; Privacy International, 2019).

In the latter case, they argued that empirical theories challenges overarching claims, languages of promises and its practices regarding the intersection of digital technologies and healthcare. Here, they illustrated three central aspects of digitalization; these are, (a) quantification and reconfiguration of knowledge (what forms of knowledge are eclipsed by digital data concerning our body as well as quantified data leads to a reductionist understanding of the self); (b) connectivity and shifting of face to face interactions between the provider and client; (c) instantaneity and the reconfiguration of control through instant feedback and alerts; as to them this shows, self tracking techs create passive clients that are being controlled by the technical device (Marent & Henwood, 2021).

Therefore, as Sharon (2017) puts it the debates on digital health and self tracking technologies are focused on 'empowerment Vs surveillance and discipline'; 'improved overall health Vs the disintegration of state and collective responsibility for health'; and 'greater (self) knowledge Vs reductionism and the non-impartiality of numbers'.

2.3.6.1.9 Theories on the Usage of Self Tracking Techs

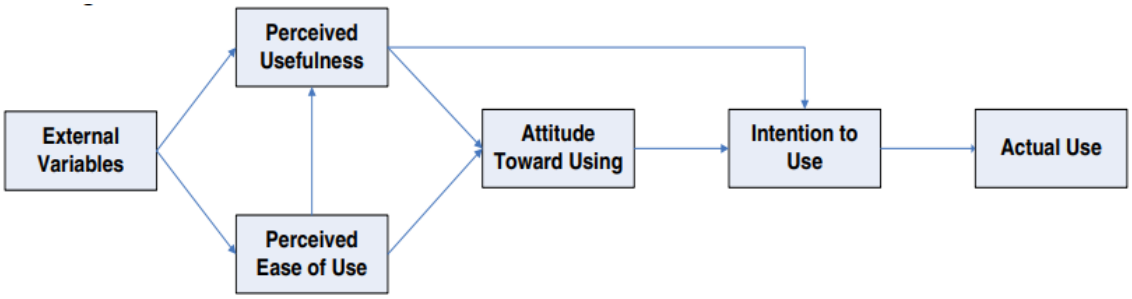
Here, I discuss two key models concerning the usages of self tracking technologies and both are the foundations for the study's theoretical framework.

2.3.6.1.9.1 Technological Acceptance Model (TAM)

TAM is created by Davis to identify client's acceptance to techs and it is based on TRA (Ahlan & Ahmad, 2014; Ammenwerth, 2019; Ma & Liu, 2011; Zaineldeen et al., 2020). In other words, it deals with the factors that affect the acceptance of innovation, the intention to use techs, or an attitude towards using self-tracking techs. In general, TRA considers people as decision makers, who consciously choose based on costs and benefits attached to it (Ketikidis et al., 2012). Accordingly, Davis hypothesized "perceived usefulness and perceived ease of use" as factors that affect clients acceptance to techs (Ahlan & Ahmad, 2014; Ammenwerth, 2019; Ma & Liu, 2011; Zaineldeen et al., 2020). Moreover, as it is demonstrated below in fig 3 actual use is impacted by intention to use which is impacted by attitude towards using and perceived

usefulness. Also, attitude towards using directly impacted by perceived usefulness and ease of use. Finally, perceived usefulness is directly impacted by perceived ease of use; and both are impacted by external variables (Ahlan & Ahmad, 2014; Ammenwerth, 2019; Ma & Liu, 2011; Zaineldeen et al., 2020).

Figure 3: Technological Acceptance Model



Source: (Ahlan& Ahmad, 2014; Zaineldeen et al., 2020)

Later, TAM revised to TAM 2, TAM 3 etc. with different variables added, but TAM is the general theory that is used to describe client's acceptability of health related techs (Kim & Park, 2012a). Hence, the model plays crucial role in identifying factors that affect acceptance of new emerging techs by clients and other expanded model of it considers cultural and social background contexts (Kim & Park, 2012a).

Therefore, the independent variables in the model are the perceived usefulness and ease of use; while, the dependent variable are the actual usage of the tech. Thus, the advantage of the model is to investigate and predict client's behavioral intention to use various techs. To say it differently, it determines the acceptance and utilization of techs or identifies client's readiness and attitude towards a behavior that accepts as well as consumes techs.

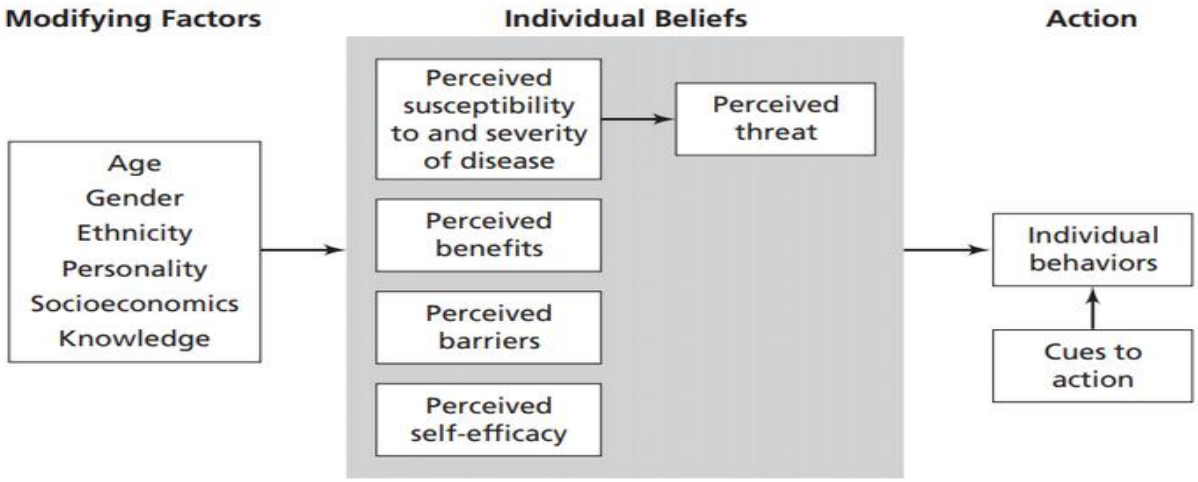
2.3.6.1.9.2 Health Belief Model (HBM)

The HBM was developed by the American social psychologists in order 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 (Champion, V. L., & Skinner, 2005). Moreover, perceived susceptibility and seriousness as well as perceived benefits and barriers are the key structures of the model (Abraham & Sheeran, 2014a). But, later,

it was modified and includes variables like cues to action, and self-efficacy (Abraham & Sheeran, 2014b; Champion, V. L., & Skinner, 2005).

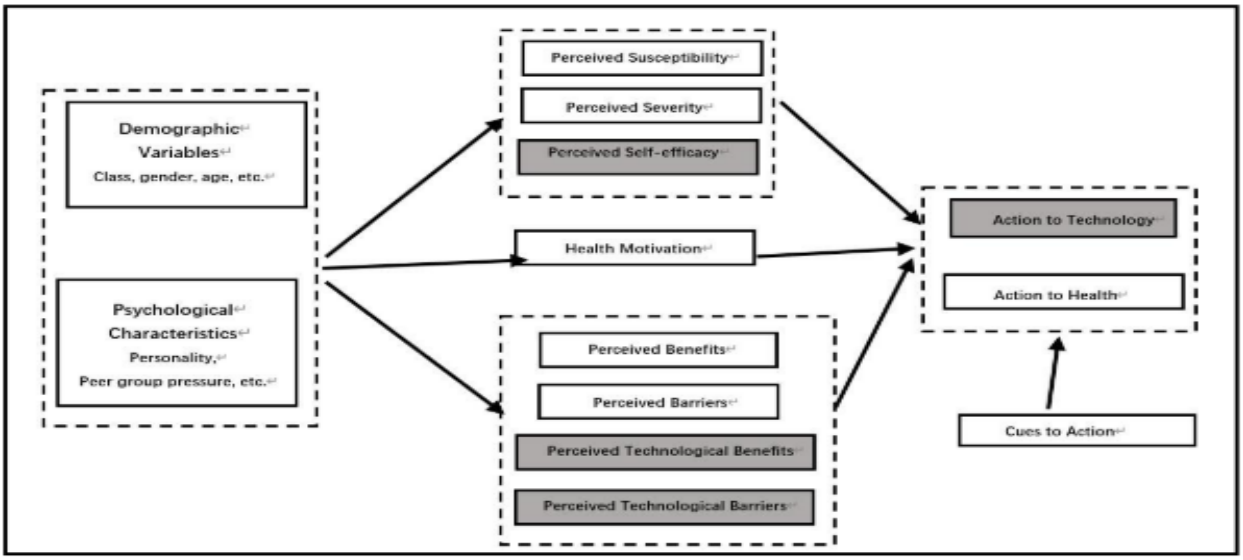
These variables can be defined as follows. (a) Perceived susceptibility refers to vulnerability or the likelihood of getting a disease. (b) Perceived severity refers to feelings about the seriousness of an illness or a condition−it specifies medical and clinical consequences as well as possible social consequences (Champion, V. L., & Skinner, 2005). Here, it is noted that both are perceived threat to the clients. (c) Perceived benefits refer to beliefs concerning various available strategies for reducing the perceived threat or the occurrence of disease. (d) Perceived barrier refer to the potential negative aspects (cost, difficulty etc.) of a particular health strategy to apply in life. And, the newly added variables (e) Cue to action and (f) Self- efficacy refers to exposure to factors that prompt action and confidence in one's tended ability to perform the new health behavior; respectively (Champion, V. L., & Skinner, 2005).

Figure 4: Health Belief Model



Source: (Bhatt et al., 2022)

Figure 5: Health Belief Model Related to Technology



Source: (Wu et al., 2020)

Therefore, it determines health behavior by client's beliefs or perceptions about a disease and methods available to decrease its occurrence/incidence (Abraham & Sheeran, 2014b). In other words, it considers individuals as decision makers, which will take actions either to prevent, control, or treat a health problem if they perceive themselves vulnerable to a problem, and their beliefs on the severity of the problem; in addition, if they perceive an action will benefit them and produce a desirable outcome as well as if they perceive few barriers, self-confidence and factors that triggered to take that action.

2.3.7 Theoretical Conclusion

So far, I discussed theories on SC, DH and self tracking techs. Moreover, the concept of SC is not a replacement or substitute to the traditional healthcare system. In other words, what defines SC is neither the absence nor the annihilation of the traditional health systems. SC is part of PHC and it is crucial to achieve SDGs. It is noted that there was nothing like a COVID-19 that awakened the globe to incorporate SC as part of their health delivery system and DH is one of the strategies of SC for the digital societies. Besides, the promise of the 4IR is the transformation of the health delivery system to a client-centered care. And, we are witnessing this; consequently, various forms of self tracking techs like apps, software's, wearable etc. have been developing. The key debates on self tracking techs are focused on whether the promises of DH

are real and benefit the client or it is just a political and market based system to exploit the client. Lastly, I overviewed two models or theories that explain the usage of emerging technologies by the client.

2.4 Empirical Review

In this part, I present first empirical studies from an international perspective followed by national empirical studies.

2.4.1 International Experience

Here, I discuss empirical studies related to self-tracking motivation, menstrual tracking mobile app as well as HBM and TAM related studies.

To begin with, a study on 'the motivation of patients to track their own health', Gimpel et al (2013) identified five factor frameworks of self-tracking motivations in an exploratory survey of 150 self-trackers. These factors are, self-entertainment (motivated due to the fun, enjoyment etc. aspects of the tech); self-association (deals with the person's relationship to the community); self-design (motivated by self-optimization and to control their lives), self-discipline (motivated due to self-gratification possibilities like obtaining reward, achieving goal etc.) and self-healing (motivated to avoid the healthcare system). Finally, they concluded that emerging techs offers new ways to know oneself in a fact-based understanding of collected self-related data, which in turn empowers clients.

Another study on "the role of ignored motivators: intrinsic motivations' effects on intention of using mobile health apps" in Kocaeli, in 2018 had tested the above five factor frameworks with 214 respondents by the use of Structural Equation Model (SEM). And, the findings revealed that self-design, self-discipline and self-entertainment motivations were found to affect behavioral intention to use mobile app positively. However, the other two motivations: self-association and self-healing do not have any effect on the behavioral intention to utilize the mobile health applications (Apps & Alan, 2018).

On top of this, a study by Orji et al (2012) to extend the HBM and to design an effective health interventions design in Canada using 7 point Likert scale format with 576 sample size and PLS-SEM approach in 2012, identified that PSE was the dominant significant determinant and CU

was insignificant. Also, they identified that PBA had a significant negative impact on intention to use.

In addition, a study on determinants of internet usage for health related purposes in Malaysia, by integrating HBM and TAM with 293 sample size using PLS-SEM identified that perceived threat or risk fully mediated by PU and ATT (Ahadzadeh et al., 2015). Besides, they concluded that women who perceived their health as vulnerable to diseases were concerned about their health, which in turn prompted cognitive beliefs in using the internet and in developing an attitude towards health related internet usage. Another study by Kim et al (2012) to develop a health information technology acceptance model by integrating HBM, TRA and TAM with 728 sample size using PLS-SEM in Korea, identified that perceived threat, PU, and PEU significantly affected health consumers' ATT and BI. Moreover, they found out that PSE had a strong indirect impact on ATT and BI through the mediators of perceived threat, PU and PEU.

Additionally, factors affecting user's acceptance of mobile health services study in UAE in 2015 and Cario in 2014, concluded that PU and PEU had an impact on ATT as well as PSE had an impact on PEU, respectively. Moreover, the former study held on with 144 sample sizes using SEM approach and the latter with 302 using the PLS-SEM approach (Alloghani et al., 2015; El-Wajeeh et al., 2014).

Likewise, TAM related studies in different disciplines have consistent results. For instance, Mayar et al (2022) identified that PSE had an impact on PU and PEU as well as both had a mediation effect in the relationship between PSE and intention to use online education in Egypt by using PLS-SEM and 202 participants. Similarly, Buabeng-andoh (2018) studied the ability of the integration of TAM and TRA in explaining student's BI to use mobile learning in Ghana with 487 students using PLS-SEM in 2018. The integrated model used in the study explained 23.0 percent of the variance in BI, 33.8 percent in PU and 47.6 ATT.

Finally, Gazibara et al (2020) studied on 'high school girls and smart phone applications to track menstrual cycle' in Belgrade, Serbia. The study included 394 high school girls from Belgrade, Serbia, who used smart phones. And, the result revealed that approximately one third of adolescent girls in Belgrade highs schools who had had smart phones used menstrual tracking applications.

2.4.2 National Experience

In our country, empirical studies on mobile health were focused on improving the health care system and the performance of the healthcare worker (Medhanyie et al., 2015); or to make it more specific, to improve the maternal healthcare service delivery systems (Little et al., 2013). In addition, a systemic review by Tsegahun et al (2021) on the potential of DHTs in African context, tracking Ethiopia as a node, studied 47 publications based on their inclusion criteria out of which 26 deals with the mobile health. Moreover, 15 were focused on the potential use of mobile Health for maternal, child and RH services; whereas, the rest dealt on infectious diseases (11). In addition, they stated the outcomes of interest in those publications were effectiveness (7), usability (5), feasibility (4), quality (4), willingness (5) and knowledge (1). According to them in 9 of the publications healthcare professionals were the target. Thus, mobile health studies in our country weren't focused on self-tracking mobile applications, like menstrual tracking apps. Therefore, as to my understanding, acceptance of menstrual tracking mobile app among the adolescent women in Ethiopia is understudied.

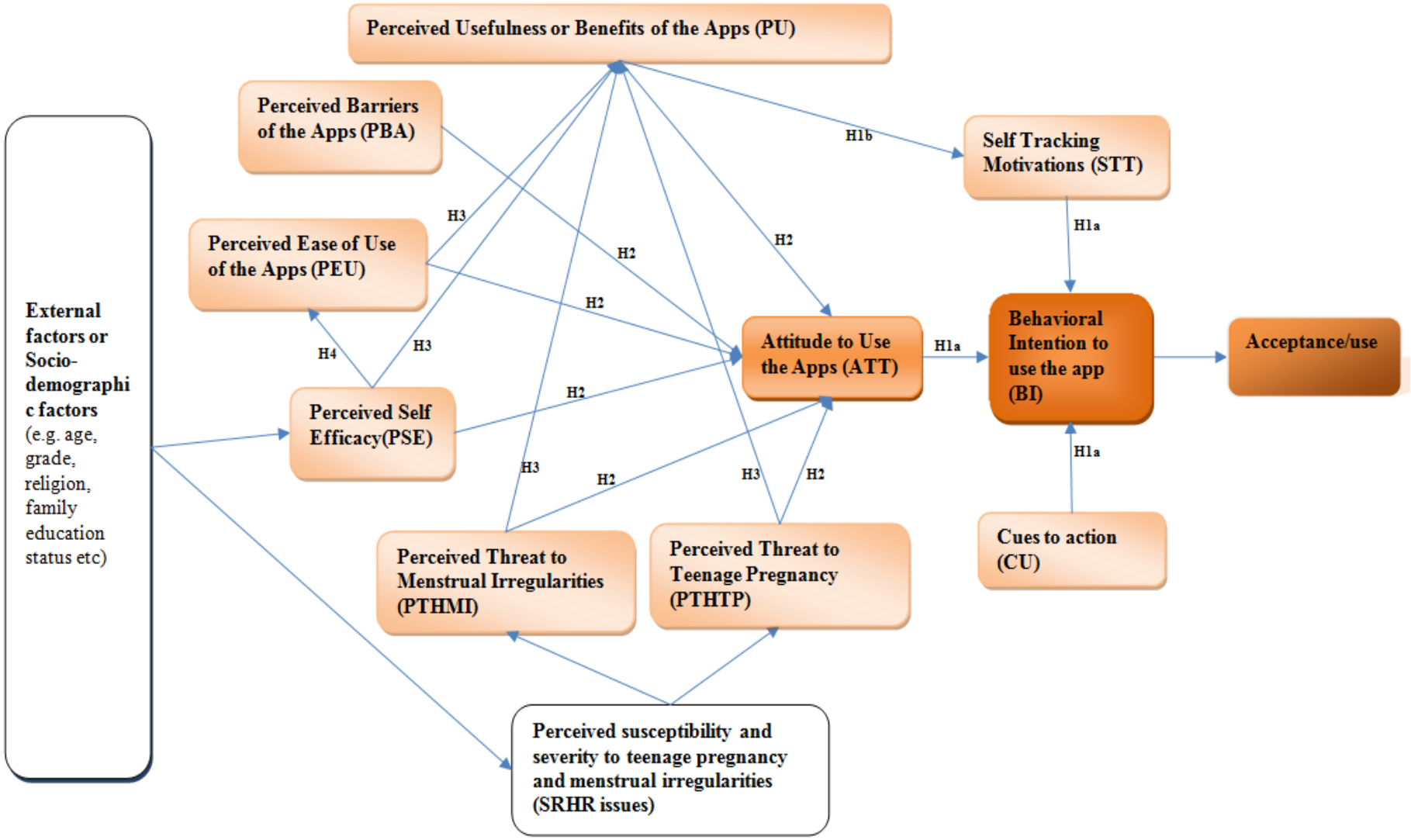
2.5 Conceptual Framework and Research Hypothesis

In this section, I explain the conceptual framework of the study based on TAM and HBM as well as related empirical studies. Hence, figure 6 is the integrated conceptual framework of the study. This framework consists of different variables. These are perceived usefulness of the app; perceived ease of use of the app; perceived self efficacy; perceived barriers, perceived threat to teenage pregnancy and menstrual irregularities; attitudes towards to use the app; self tracking motivation; cues to action and behavioral intention to use the app or the acceptance of the app among adolescent girls.

Moreover, in the proposed framework, I assumed several hypotheses. To begin with, acceptance/behavioral intention to use the menstrual tracking mobile app are directly affected by the adolescent girls' CU, STT, and ATT (H1a). Similarly, the adolescent girls' STT is directly affected by the PU (H1b). Secondly, ATT is directly affected by the PU, PEU, PBA, PSE, PTHTP and PTHMI (H2). Thirdly, the PU is affected by the PEU, PSE, PTHMI and PTHTP (H3). Finally, the perceived ease of use is influenced by the perceived efficacy (H4).

In addition, the external factors in the proposed framework are (a) socio-demographic factors (age, adolescent grade, average grade point, experience of using the app, religion, family educational background, monthly income of parents). Therefore, the purpose of the study is to examine perceptions of menstrual tracking mobile application acceptance among adolescent girls based on TAM and HBM.

Figure 6: Conceptual framework of the study



Source: Own Sketch based on TAM and HBM

Chapter 3

3. Research Methodology

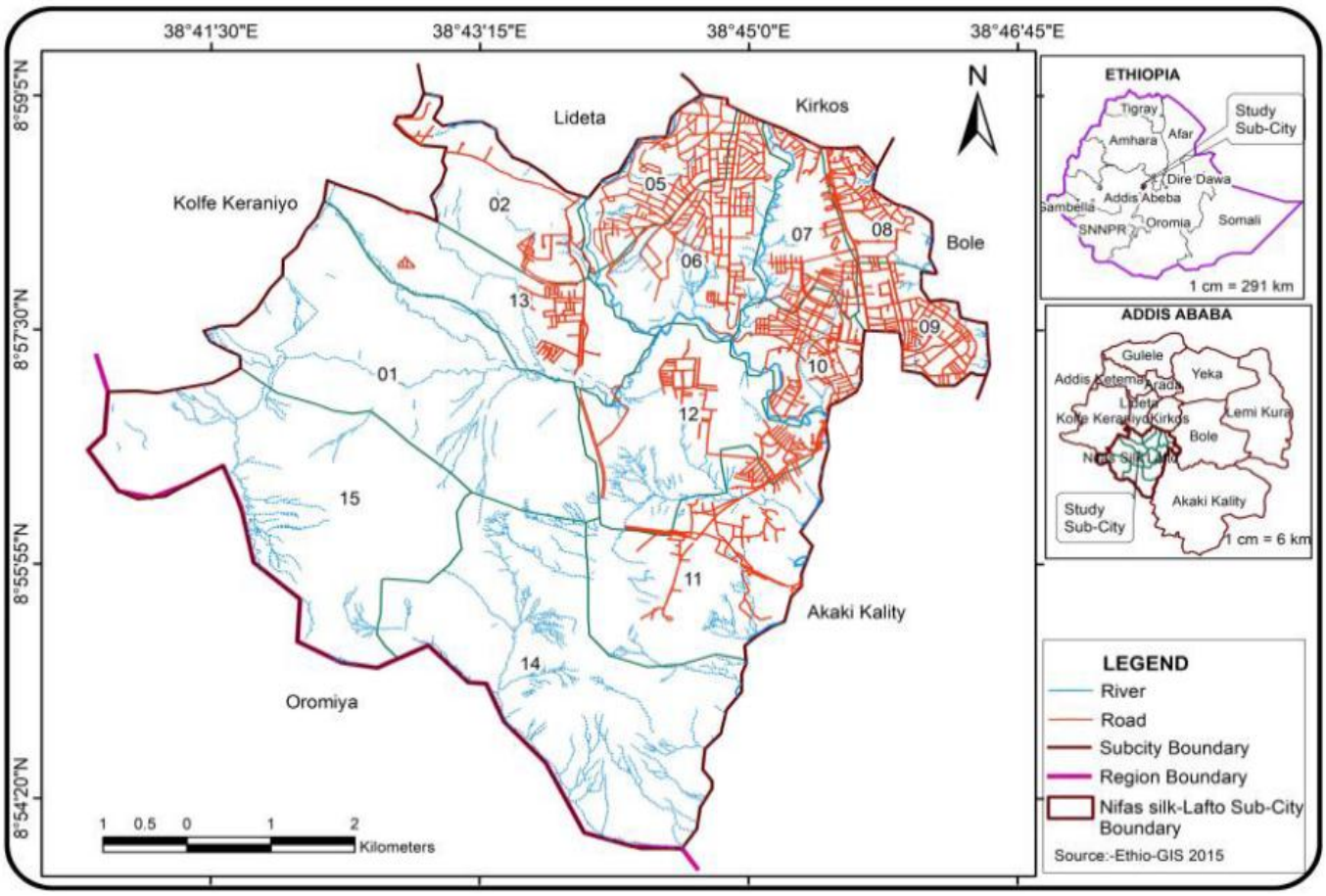
In this section, I discuss how the study is designed and the specific steps that are taken to test the research hypotheses. Thus, this chapter explains the research design, research approach, source of data, sampling design as well as how reliability and validity tests performed to name a few.

3.1 Description of Study Area

Addis Ababa is the capital city of Ethiopia with over 10 sub-cities and Nifas Silk Lafto sub-city is the focused area of the study. Furthermore, according to Addis Ababa Health Bureau; DHIS report of facility based teenage pregnancy of the last 9 months of this year (Hamele 2014 E.C to Megabit 2015 E.C) showed that it was higher in Akaki Kaleti; Lemi Kura; Kolfe Keranyo and Nifas Silk Lafto sub cities than other sub cities. Moreover, 709-970 teenage girls were tested positive for pregnancy in the last 9 months in the four sub cities; whereas, in other sub cities it was less than 583. Therefore, the researcher selected Lafto Sub city in order to minimize cost.

In addition, the sub-city covers 5876.02 hectares, which is 11.31% of the total area, and is located in the South Western part of the city (Tadesse, 2016). Besides, it borders the sub-cities of Kolfe Keranio, Akaki Kaleti, Lideta, Kirkos, and Bole. Totally, it has 11 weredas (Nifas Silik Lafto Sub City health report), out of which Jemo 01 wereda 13 is chosen purposefully to select the study participants.

Figure 7: Map of Nifas Silk Lafto sub-city



Source: adapted from (Serbessa et al., 2023)

3.1.1 Demographic Status

The total population of the sub-city was 393, 027 (188, 653 M and 204, 374 F). In the study area, the total population was 39, 821 (Nifas Silik Lafto Sub City health report).

3.1.2 Description of Study of Population

Kebede (MD) et al (2021) identified 13.75 (±1.30) and 13 years as the mean and median ages at menarche in Addis Ababa city, respectively. As a result, I took the median age (13) as the minimum age to participate in the study. In addition, teenage pregnancy is defined by WHO as a pregnancy that occurs under the age of 20. Hence, the maximum age to participate in the study is 19 years of age. Therefore, the study populations were all adolescent girls, who were attending secondary high schools (grade 9-12) at Jemo 01 wereda13.

Inclusion Criteria

All adolescent girl students, who were attending secondary high schools at Jemo 01 wereda

3.1.3 Duration of the study

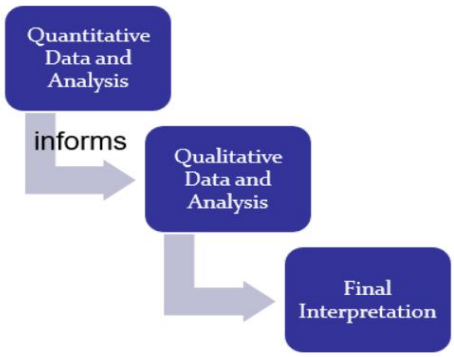
The study period was from 6th May 2023 to 14th May 2023.

3.2 Research Design

Research design is the overall structure or the map or blueprint of the study. It focuses on what type of study is planned and what kinds of results are expected from the research. In general, it is a plan to answer the research question and pave the way for the research to be conducted appropriately (Creswell, 2014). In this study, the researcher used exploratory cross sectional research design. In such design, data are collected at a specific point in time in the lives of the respondents. In addition, the main purpose for the research design was to explore determinants of menstrual tracking mobile application acceptance. Because, little is known on the underlying relationships between constructs in impacting user acceptance of such apps in the wereda. Also, I want to extend the TAM with HBM constructs in order to explore predictors of menstrual tracking mobile acceptance among adolescent girls.

3.3 Research Approach

Figure 8: Sequential Mixed Approach (QUAN-qual)



Source[10]

The study will employ sequential mixed approach, which will involve collecting qualitative data after a quantitative phase in order to explain the quantitative data in more depth (Creswell, 2014). In other words, in this type of research approach the quantitative data and analysis performed first, followed by qualitative data (Quan⇒qual).

In the first quantitative phase of the study, PU; PEU; PSE; PBA; PTHMI; PTHTP; CU; STT; ATT and BI instrument of data were collected from adolescent girls who are attending in secondary high schools at Jemo 01, wereda 13 in order to test the proposed hypotheses, which examines perceptions of the menstrual tracking mobile apps acceptance in adolescent women.

[10] https://research.library.gsu.edu/c.php?g=1050115&p=7622501

The second qualitative phase was conducted in order to explore their experiences, concerns, and opinions in more depth in order to further explain and build upon the initial quantitative results. Moreover, in this exploratory follow-up, I asked 21 qualitative questions concerning PTHMI and PTHTP with the snowball sampling method.

3.4 Source of Data/Data Collection Methods

3.4.1 Primary Source of Data

Primary data was collected from adolescent women through online surveys or questionnaires prepared in Google doc. Also, unstructured in-depth interviews were conducted via phone call and text.

3.4.2 Secondary Source of Data

Secondary data was collected from various sources, such as, health reports, government documents as well as books, published and/or unpublished local health center documents or reports, journals, articles etc.

3.5 Data Gathering Instrument

Here, two types of data gathering instruments or tools were designed: questionnaires and interview questions.

Self Administered Adolescent Survey Questionnaires: the survey tools were used to collect quantitative data on socio-demographic characteristics of the participants and to gather quantitative information on the PU; PEU; PSE; PBA; PTHMI; PTHTP; CU; STT; ATT and BI. The questionnaires are prepared in Seven-point Likert scale, ranging from “strongly disagree” (1) to “strongly agree” (7) in which participants were asked to indicate an appropriate response. And, it was conducted in Google doc (online). Thus, the questionnaires were used to test the proposed hypotheses, which examine the perceptions of menstrual tracking mobile application acceptance among adolescent women.

Moreover, each of the questionnaires was prepared or developed by taking lessons from previous TAM and HBM studies in different disciplines as it is shown below in table 3.

Table 3: Definition of the latent construct

Key Variables	Explanations	Hypothesis	Scale	Reference
Behavioral Intention to use the app (BI)	Behavioral intention refers to the degree to which adolescent girls had formulated conscious plans to accept and utilize or not to accept and utilize menstrual tracking mobile apps in future.	**H1a:** cues to action, self tracking motivations and attitude to use have a positive significant effect on behavioral intention to use menstrual tracking mobile app.	2	(Buabeng-andoh, 2018; Davis & Davis, 1989)
Self tracking motivation to use the app (STT)	Self tracking motivation refers to the adolescent girls' reasons to consume menstrual tracking mobile apps and what motivates them to accept and utilize these apps. Gimpel et al (2013) identified five behavioral motivating factors to consume self tracking mobile apps. These factors are, (1) self-entertainment: motivated due to the fun, enjoyment etc. aspects of the Menstrual tracking apps; (2) self-association: deals with the person's relationship to the community or with one's relation towards a community and to understand their health status by comparing with others; (3) self-design: motivated by self optimization and to control their lives or for autonomy, (4) self-discipline: motivated due to self gratification possibilities like obtaining reward, achieving goal etc. and generally for informed decisions and (5)	**H1b:** the adolescent girl's perceived usefulness of menstrual tracking mobile apps has a positive significant effect on self tracking motivations.	6	(Gimpel et al., 2013)

	self-healing: motivated to avoid the healthcare system because of poor services.			
Cues to action (CU)	It refers to a reminder or trigger that leads adolescent girls to behavioral intentions to use menstrual tracking mobile apps. Thus, they are people, events, or things that move client's to change their behavior. It is influenced by the printed and non-printed media campaigns, advice from others, reminders from physicians, teachers, friends etc.		2	(Hossain et al., 2021; Mohamed et al., 2019; Wall, 2009)
Attitude towards to use the app (ATT)	Attitude toward using is defined as the degree of evaluative effect that adolescent girl's associate with using the menstrual tracking mobile app in her job. In other words, it depicts the adolescent girls' positive or negative feelings about using the menstrual tracking mobile app.	**H2:** the adolescent girl's perceived usefulness, perceived ease of use, perceived self efficacy, perceived threat to teenage pregnancy and menstrual irregularity have a positive significant effect on attitude to use the app; but, perceived barriers has a negative effect.	3	(Buabeng-andoh, 2018; Davis & Davis, 1989)
Perceived usefulness of the app (PU)	It is the degree to which adolescent girls believe that using menstrual tracking mobile apps would enhance their menstrual and reproductive health. Moreover, Levy and Romo-Aviles (2019) identified eight benefits of menstrual tracking mobile apps. these are, (1) to track period cycle	**H3**: the adolescent girl's perceived ease of use, perceived self efficacy, perceived threat to teenage pregnancy and	8	(Davis et al., 1989; Levy & Romo-Aviles, 2019)

	length and regularities, (2) to prepare for upcoming bleeding, (3) to know menstrual cycles and body, (4) to verify menstrual experiences and sensations, (5) to inform healthcare professionals, (6) to track health, (7) to get or prevent pregnant (natural contraception), and (8) changes in tracking.	menstrual irregularity have a positive significant effect on perceived usefulness of the menstrual tracking mobile app.		
Perceived ease of use of the app (PEU)	It refers to the degree to which adolescent girls believe that using menstrual tracking mobile apps would be free of effort or effortless. A client may perceive a technology useful and at the same time, they may perceive barriers or difficulty to use. Thus, the perception of the client on the ease of use of the app is crucial.	**H4**: the adolescent girl's perceived self efficacy has a positive significant effect on perceived ease of use of menstrual tracking mobile apps.	3	(Davis et al., 1989; Levy & Romo-Aviles, 2019)
Perceived Barriers of the app (PBA)	It refers to the adolescent girl's feelings on the obstacles to using a menstrual tracking mobile app. Hence, perceived barriers are related to understandability, inconvenience, time consuming, religious and cultural beliefs etc.		4	(Champion, V. L., & Skinner, 2005; Mohamed et al., 2019; Niculaescu & Landa-avila, 2021a; Wall, 2009)
Perceived self efficacy (PSE)	PSE is the degree to which adolescent girl's believe or perceive that she has the ability to perform specific tasks related to menstrual tracking mobile apps. In other words, it is the confidence that they can successfully execute menstrual tracking mobile apps.		2	(Mohamed et al., 2019; Niculaescu & Landa-avila, 2021b; Wall, 2009)

Perceived threat to teenage pregnancy (PTHTP) and menstrual irregularities (PTHMI)	Perceived threat refers to the adolescent girl's perception of their susceptibility or vulnerability to menstrual irregularity and teenage pregnancy. Also, it refers to the degree to which they believe that both menstrual irregularity and teenage pregnancy is severe and affects their life. Hence, the greater the PTHMI and PTHMI, the greater the likelihood of engaging in behaviors to decrease the threat.	3 3	(Champion, V. L., & Skinner, 2005; Mohamed et al., 2019; Niculaescu & Landa-avila, 2021a; Wall, 2009)

Source: Own Computation

Key Informant Interview Questions: the purpose of the interview questions were to explain or build upon the initial quantitative results in more depth. As a result, a total of 21 unstructured in-depth interviews were conducted via phone call (17) and text (4) as per the adolescent women preference until saturation point reached. The questions are open ended, and were formulated and employed after the quantitative phase had completed.

3.6 Sampling Design

In this study, since the PLS-SEM approach was used, I employed the inverse square root method proposed by Kock and Hadaya (2018) for estimation of the sample size. Assuming a common power level of 80% and significance levels of 1%, 5% and 10%, the minimum sample size (n_{min}) is given by the following equations, respectively (Hair et al., 2021).

Figure 9: Inverse square root sampling design

$$\text{Significance level} = 1\%: \; n_{min} > \left(\frac{3.168}{|p_{min}|}\right)^2.$$

$$\text{Significance level} = 5\%: \; n_{min} > \left(\frac{2.486}{|p_{min}|}\right)^2.$$

$$\text{Significance level} = 10\%: \; n_{min} > \left(\frac{2.123}{|p_{min}|}\right)^2.$$

Source: Hair et al (2021)

p_{min} is the value of the path coefficient (β) with the minimum magnitude in the PLS path model.

As I had limited information concerning the expected effect sizes, I adopted the recommendation of Hair et al (2021), which stated to consider ranges of effect sizes rather than specific values for estimation of the sample size.

Accordingly, as it is shown below, they estimated the minimum sample size required for different significance levels and varying ranges of path coefficient (p_{min}).

Figure 10: Minimum sample size estimations based on inverse square root method

p_{min}	Significance level		
	1%	5%	10%
0.05–0.1	1004	619	451
0.11–0.2	251	155	113
0.21–0.3	112	69	51
0.31–0.4	63	39	29
0.41–0.5	41	25	19

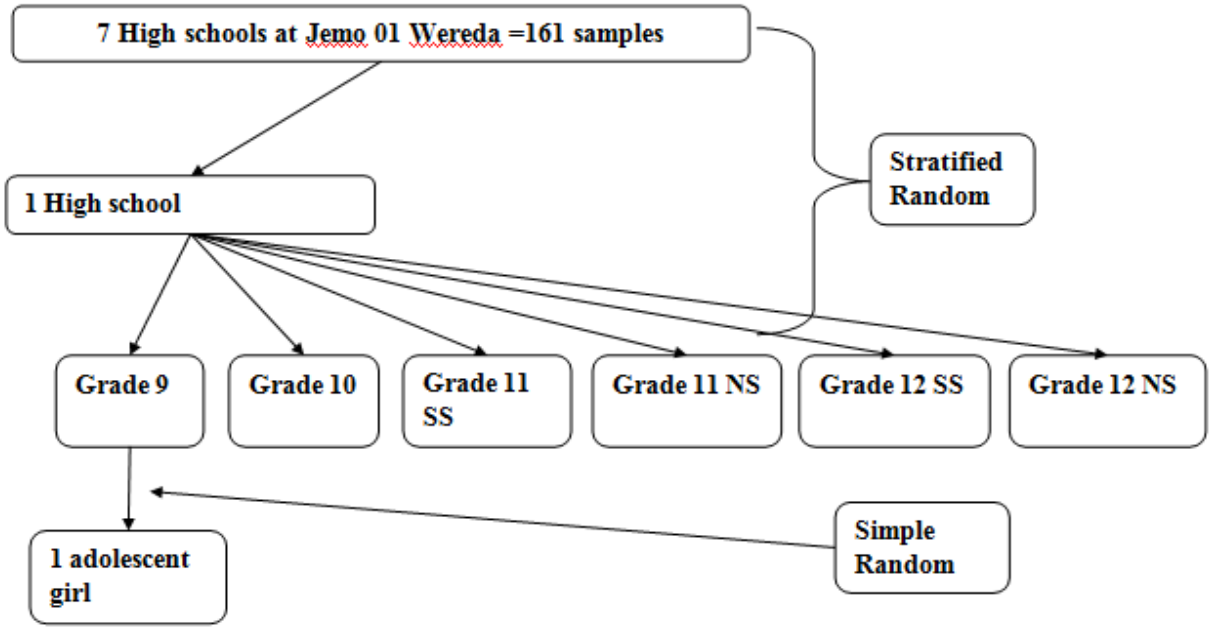
Source: Hair et al (2021)

Thus, I assumed the minimum path coefficients between 0.11-0.2, and with 5% significance level, I get $(2.486/0.2)^2$ = 155. So, an approximate minimum sample of 155 was required in the study. However, carelessness, non-response, and other conditions might happen during data collection; as a result, I included another 6 samples. Hence, I collected 161 samples.

The sampling frame was a student roaster, which contains lists of active students enrolled in the school. In addition, there are 7 private secondary schools in the wereda, and all of them have classes from grade 9-12, except two schools.

Furthermore, I employed a combination of stratified random and simple random sampling techniques/procedures in order to select 161 respondents. It is noted that secondary school constitutes heterogeneous groups; as a result, I subdivided each school into smaller homogeneous groups based on education level in order to get more accurate representation. Thus, I stratified each school into six groups or classes (grade 9, 10, 11 natural sciences as well as social sciences, 12 natural sciences as well as social sciences) as shown below. Then, the adolescent girls were selected based on a simple random sampling method.

Figure 11: Sample size procedure



Source: Own Computation

Initially, I planned to collect equal data from each school and class. But, the total number of students in the class as well as in the school, and the willingness of the students to participate in the study affected my expectations. As a result, I collected unequal number of adolescent girl students from each class and school. The summary of the sampling technique is presented as shown below in the table.

Table 4: Summary of sampling techniques

School	Sampling technique	
School of Indiana	Simple random	The unit leader of the school selected girl students randomly and opened a telegram group. Then, I shared the link of the questionnaires as well as key information's about the study in the telegram group.
South West Academy		The nurse of the school selected randomly girl students from each class and I shared the purpose of the research for randomly selected students at the library. Then, girls who wanted to participate in the study gave their social media accounts and I shared the link. In addition, students opened 1 telegram groups to facilitate the data collection process.
Felegenewa y Academy		I shared the purpose of the research at each class and students who wanted to participate gave their social media accounts and I shared the link. In addition, students opened 2 telegram groups to facilitate the data collection process.
Dream Success Academy		The grade 9-12 unit director of the school selected girl students randomly from each class and I shared the purpose of the research for the selected students at library. Then, students who wanted to participate in the study gave their social media account and I shared the link.
School of Redemption		The vice director of the school selected girl students randomly from each class and I shared the purpose of the research at his office. Then, students who wanted to participate in the study gave their social media account and I shared the link. In addition, students opened 4 telegram groups to facilitate the data collection process.
Abune Gorgorios		The unit leader of the school selected girl students randomly and I shared the purpose of the research for the selected students at library. Then, girls

School	who wanted to participate in the study gave their social media accounts and I shared the link. In addition, students opened 1 telegram groups to facilitate the data collection process.
Dynamic Academy	I shared the purpose of the research at each class and students who wanted to participate gave their social media accounts and I shared the link.

Source: Own computation

In addition, the selection of KII strictly followed a non-probability sampling technique. Moreover, key informants were selected for in depth analysis through snowball sampling technique and interviews were held until saturation point reached. Thus, I conducted a total of 17 KII via phone call and 4 via telegram chat after the quantitative phase had completed.

3.7 Data Analysis Methods

Here, the quantitative data was analyzed using descriptive analysis. I employed descriptive analysis to illustrate the demographic characteristics of the respondents using charts, tables, percentages, frequency etc. Then, I used Structural Equation Modeling (SEM) to Partial Least Squares approach to analyze the questionnaires prepared in 7-point Likert scale format. For qualitative data I used thematic analysis techniques; so that it was presented with the result of the quantitative data. In general, I used two statistical soft ware's−Stata version 17 for data cleaning and descriptive analysis as well as R studio version 4.3 for PLS-SEM analysis.

3.7.1 Justification for PLS-SEM Data Analysis

Hair et al (2021) described ample justifications for using PLS-SEM; for instance, it is suitable to overcome issues related to small sample size; it can handle non normal data. Also, they stated that it is an appropriate approach if the structural model is complex and includes many constructs, indicators, or model relationships, and extra. Wold (1980), the inventor of PLS, justified its usefulness for exploratory research and stated that "the researcher designs the arrow scheme on the joint basis of his rudimentary theoretical knowledge, his experience and intuition about the problems explored, and the data that are at his disposal," and, "the arrow scheme is usually tentative since the model construction is an evolutionary process".

In addition, both agree with its usefulness in complexity of the problems explored and scarcity of prior theoretical knowledge. To sum up, Henseler (2021) concluded that PLS-SEM is justified technique for exploratory studies "if researchers look for a quick, graphic-supported indication of whether there might be a relation between two proxies," and "the analyst's focus will predominantly lie on the path coefficients".

3.8 Reliability Test

Reliability test is concerned with the repeatability of the study or the consistency across the parts of a measuring instrument (Drost, 2004; Kothari, 2004). Thus, a test is said to be reliable if repeat measurement made by it under constant conditions will give the same result. Here, the study used indicator reliability and internal consistency reliability measures.

3.9 Validity Test

Validity test indicates the degree to which an instrument measures what it is supposed to measure (Drost, 2004; Kothari, 2004; SÜRÜCÜ & MASLAKÇI, 2020). In other words, it deals with the meaningfulness of research components (Taherdoost, 2017). In this study, I employed three types of validity tests.

First, content validity, which is the extent to which a measuring instrument provides adequate coverage of the topic under study (Fitzpatrick, 1983; Kothari, 2004; Taherdoost, 2017). Thus, I made exhaustive literature reviews and ensured that the questionnaires were representative of all aspects of the construct theories. In addition, I ensured that the survey questionnaires included all the items that were essential and eliminated undesirable items. And also, I discussed with experts about the questionnaires.

Secondly, construct validity was used in the study to test the measurement tools. Moreover, it is the "degree to which scores on a test can be accounted for by the explanatory constructs of a sound theory" (Drost, 2004; Kothari, 2004). In other words, it refers to how a concept, idea, or behavior is translated or transformed into a functioning and operating reality. In addition, there are two types of construct validity; these are Convergent and Discriminant. Moreover, if a measure confirms the correlations of theoretical propositions in its constructs, it is called Convergent. While, if the measure confirms the divergence of theoretical propositions in its

constructs, it is called Discriminant validity (Drost, 2004; Kothari, 2004). Furthermore, to ensure the construct and content validity as well as reliability of the developed 61 measured items, pilot test was performed. Here, the questionnaires were tested with twenty one respondents chosen randomly for the pilot test, which was conducted at Bright Side International Academy. And, the results showed that 15 of the items weren't reliable and valid. As a result, I removed 15 items and modified the rest of 46 questionnaires. The pilot test result analysis was performed using Stata Version 17.

Thirdly, face validity, which "refers to researchers' subjective assessments of the presentation and relevance of the measuring instrument as to whether the items in the instrument appear to be relevant, reasonable, unambiguous and clear" (Drost, 2004). Thus, I evaluated each of the questionnaires based on feasibility, readability, understandability, consistency of style and formatting, and the clarity of the languages used.

3.10 Ethical Considerations

This study was approved by Addis Ababa Public Health Research and Emergency Management Directorate as well as Addis Ababa University, Institutional Review Board. Moreover, as most of the participant's age is less than 18 years, I discussed with each of the school's parent committees, directors, teachers and other delegates. Moreover, oral and written permissions were obtained from Lafto health office as well as the school's parent committees, and director's.

I also ensured that the rights, privacy and confidentiality of the participants were protected and respected. The participants were informed about the nature of the study. Participation was on a voluntary basis. Thus, I introduced the purpose of the study as a fulfillment of a Masters Degree program and not for any other hidden agenda and requested the respondents to participate in the study on a voluntary basis and while refusal or abstaining from participating was permitted. However, I ensured that the results of the study will be disseminated to Addis Ababa Public Health Research and Emergency Management Directorate. I also assured the respondents of confidentiality of the information given and protection from any possible harm that could arise from the study since the findings would be used for the intended purposes only.

Chapter4

4. Result and Discussion

4.1 Introduction

This chapter has four main sections. Firstly, the descriptive analysis part will be discussed followed by PLS-SEM analysis. Moreover, PLS-SEM analysis has two basic steps—the measurement models and the structural models 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. As a result, the second section presents the measurement models assessment using four steps. Similarly, the third section presents the structural models assessment using four steps. Finally, the last section presents the discussions of the findings.

4.2 Descriptive Analysis of Respondents

Descriptive statistics is one of the techniques used to summarize the data collected from a sample representative of a given population. Descriptive statistics such as mean, standard deviation, frequency and others were used during data analysis. It is used to compare and contrast different categories of sample units with respect to the desired characteristics so as to draw some important implication of the data. Moreover, the data were collected for 1 week (from May 6/2023 to May 14/2023). And, I shared the link of the questionnaires to 9 telegram groups created by students who wants to participate in the study. The group consists of a minimum of 8 members to maximum of 35. Besides, I also shared the link to 46 girl students by email and for 56 by text. In short, I shared the questionnaires for a total of 288 students. But, I didn't reach all of them as 30 emails were bounce back, 40 text messages weren't delivered and 51 telegram messages weren't seen. Thus, out of 167 girl students that I reached successfully, 161 participated voluntarily. So, the response rate was 96%. In addition, I used Stata version 17 to clean and to assess the data as well as to describe the data. Hence, 161 observations were usable and included in the analysis.

Table 5: Descriptive analysis

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

Source: Own Computation

School Name: from a sample respondents of 161, 10.56% (17) of them were from school of Indiana, 13.66% (22) of them were from South West Academy, 11.8% (19) of them were from Felegeneway Academy, 14.91% (24) of them were from Dream Success Academy, 21.12% (34) of them were from School of Redemption, 22.98% (37) of them were from Abune Gorgorios School and 4.97% (8) of them were from Dynamic Academy.

Grade: from a sample respondents of 161, 14.29% (23) of them were grade 9, 29.19% (47) of them were grade 10, 13.66% (22) of them were grade 11 Natural Science, 10.56% (17) of them were grade 11 Social Science, 20.5% (33) of them were grade 12 Natural Science, 11.8% (19) of them were grade 12 Social Science.

Average Grade Point in the First Semester: from a sample respondents of 161, 33.54% (54) of them had an average grade point of 90-100, 40.37% (65) of them had an average grade point of 80-89, 22.98% (37) of them had an average grade point of 70-79, 2.48% (4) of them had an average grade point of 60-69, and 0.62% (1) of them had an average grade point of 50-59.

Religion: from a sample respondent of 161, 67.7% (109) of them were Orthodox Christians, 19.25% (31) of them were Protestants, 9.94% (16) of them were Muslims, and 3.11% (5) of them were other religion followers.

Parent Education: from a sample respondents of 161, 34.78% (54) of the respondent parents completed graduate degree, 29.19% (47) of respondent parents completed secondary education,

22.98% (37) of respondent parents completed undergraduate degree, 7.45% (12) of respondent parents completed primary education, and 5.59% (9) respondent parents completed technical or vocational education.

Menstruation: from a sample respondent of 161, 98.14% (158) of them were menstruating and the rest of them were not (1.86% or 3). In addition, the mean menarche age, according to menstruating girls, were 12.58. And, 54.66% (88) of them reported a regular cycle, but 43.48% (70) of them reported an irregular cycle.

Smartphone: from a sample of respondents of 161, 88.82% (143) have a smartphone and the rest of them do not have (11.18% or 18). In addition, 27.33% (44) have been using smartphones for 0-2 years, whereas 38.51% (62) and 22.98% (37) have been used for 3-5 years and over 5 years, respectively.

Self Tracking Mobile Application: from a sample respondent of 161, 21.12% (34) of them have an experience of self tracking mobile app usage, whereas, 78.88% (127) of them didn't have an experience. Additionally, 19 of self tracking mobile app users used a menstrual tracking mobile app and the rest of them used other types of self tracking mobile app.

Menstrual Tracking Mobile App: from a sample respondent of 161, 38.51% (62) of them knows menstrual tracking mobile app; out of which 14.91% (24) of them have been using menstrual tracking mobile app for 0-2 years (11.8% or 19), 3-5 years (1.86% or 3) and over 5 years (1.42% or 2), respectively. But, 61.49% (99) of them didn't.

Finally, the average age of respondents in this study is 16.75, whereas the average menarche age, according to girls who are menstruating, is 12.58.

Descriptive Statistics of the Construct Items

The descriptive statistics for each construct item are shown in table 6. All indicator means are greater than 5, ranging from 5.006 to 5.957 (standard deviation 1.45 to 2.282), except for perceived barriers (means: 1.944 to 2.242; standard deviation: 1.717 to 1.825) and perceived threat to menstrual irregularity items (means: 2.422 to 3.516; standard deviation: 1.788 to 2.242). Moreover, each of the items standard deviations indicates a narrow dispersion.

Table 6: Descriptive statistics of the construct items

Indicator	Mean	Sd	Median	Min	Max	N
Perceived Usefulness 1	5.516	1.747	6	1	7	161
Perceived Usefulness 2	5.019	1.811	5	1	7	161
Perceived Usefulness 3	5.652	1.678	6	1	7	161
Perceived Usefulness 4	5.634	1.653	6	1	7	161
Perceived Usefulness 5	5.509	1.663	6	1	7	161
Perceived Usefulness 6	5.447	1.635	6	1	7	161
Perceived Usefulness 7	5.658	1.570	6	1	7	161
Perceived Usefulness 8	5.888	1.658	7	1	7	161
Perceived Ease of Use 1	5.447	1.665	6	1	7	161
Perceived Ease of Use 2	5.453	1.616	6	1	7	161
Perceived Ease of Use 3	5.522	1.647	6	1	7	161
Perceived Barriers to Use 1	2.242	1.717	1	1	7	161
Perceived Barriers to Use 2	2.050	1.717	1	1	7	161
Perceived Barriers to Use 3	1.994	1.825	1	1	7	161
Perceived Barriers to Use 4	1.944	1.751	1	1	7	161
Perceived Self Efficacy 1	5.950	1.687	7	1	7	161
Perceived Self Efficacy 2	5.702	1.724	6	1	7	161
Perceived Threat to Menstrual Irregularity 3	3.379	2.208	3	1	7	161
Perceived Threat to Menstrual Irregularity 4	2.422	1.788	2	1	7	161
Perceived Threat to Menstrual Irregularity 5	3.516	2.242	3	1	7	161
Perceived Threat to Teenage Pregnancy 3	5.006	2.282	6	1	7	161
Perceived Threat to Teenage Pregnancy 4	5.764	1.919	7	1	7	161
Perceived Threat to Teenage Pregnancy 5	5.733	2.079	7	1	7	161
Attitude to Use 1	5.441	1.713	6	1.	7	161
Attitude to Use 2	5.832	1.550	6	1	7	161
Attitude to Use 4	5.379	1.789	6	1	7	161
Cues to Action 1	5.484	1.711	6	1	7	161
Cues to Action 2	5.317	1.741	6	1	7	161
Self Tracking Motivation 4	5.739	1.641	6	1	7	161
Self Tracking Motivation 6	5.957	1.485	7	1	7	161
Self Tracking Motivation 7	5.845	1.547	6	1	7	161
Self Tracking Motivation 8	5.068	1.854	5	1	7	161
Self Tracking Motivation 9	5.814	1.450	6	1	7	161
Self Tracking Motivation 10	5.559	1.561	6	1	7	161
Behavioral Intention to Use 1	5.807	1.575	6	1	7	161
Behavioral Intention to Use 2	5.770	1.542	6	1	7	161

Source: Own Computation

4.3 Reflective Measurement Model/ Outer Model Assessment

In this section, I discuss the reflective measurement model part of the PLS-SEM analysis using four steps. The first two steps deals with the reliability of the measurements; whereas, the last two with the validity of the measurements.

4.3.1 Reliability

A test is said to be reliable if repeat measurement made by it under constant conditions will give the same result. Here, factor loading, Cronbach Alpha (CA), composite reliability (CR) and reliability coefficient rho_A was used to measure the reliability of the items prepared in 7-point Likert scale format.

4.3.1.1 Indicator Reliability

Assessing indicator reliability is the first step in the reflective measurement model part of the PLS-SEM. It indicates how much of each indicator's variance is explained by its construct. This also shows the communality of an indicator. According to Hair et al (2021) indicator loading above 0.708 or indicator square loadings above 0.5 are recommended to ensure indicator reliability. However, for indicators less than 0.708, there are three considerations. Firstly, for indicator loadings between 0.40 and 0.708 removal of an indicator is recommended merely when deleting it leads to an improvement in the internal consistency reliability and convergent validity above the threshold value (Hair et al., 2021). Secondly, it should be examined whether removal of an indicator affects content validity. Hence, indicators with weaker loadings are sometimes retained. Finally, indicator loadings with less than 0.4 should always be removed from the measurement model (Hair et al., 2021).

Based on the above criteria, out of the 46 items, 36 were reliable as it is shown in table 7 and the rest 10 items weren't. Moreover, 2 problematic items were found in perceived threat to menstrual irregularity (PTHMI1 and PTHMI2); 2 in perceived threat to teenage pregnancy (PTHTP1 and PTHTP2); 1 in perceived self efficacy (PSE3), 1 in behavioral intention to use (BI3) and 4 (STT1, STT2, STT3 and STT5) in self tracking motivation. Thus, these items were removed in order to improve the convergent, internal consistency reliability and discriminate validity of the measurement model.

Table 7: Indicator and internal consistency reliability

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: …enable me to accomplish tasks quickly (e.g. in tracking my period cycle dates as well as identifying my fertile, infertile and upcoming periods).	0.802	0.644	0.922	0.936	0.648	0.927
PU2: ... .in preventing pregnancy naturally will increase my productivity.	0.709	0.503				
PU3: ….will improves my performance to track my period.	0.847	0.717				
PU4: …will make it easier to verify my menstrual sensations and experiences.	0.87	0.756				
PU5: ... .will enhance my effectiveness in informing healthcare professionals concerning my health status.	0.802	0.643				
PU6: …will give me access to information on contraceptives, and menstruation related ideas.	0.769	0.591				
PU7: …will give me greater control over my body.	0.816	0.666				
PU8: …will be useful in tracking my period and identifying changes in it.	0.816	0.666				
PEU1: Learning to operate a menstrual tracking mobile application would be easy for me.	0.839	0.703	0.866	0.916	0.785	0.92
PEU2: I would find it easy to get menstrual tracking mobile applications to do what I want it to do.	0.894	0.799				
PEU3: My interaction with the menstrual tracking mobile application would be clear and understandable.	0.924	0.854				
PBA1: Using a menstrual tracking mobile app will be difficult and uncomfortable.	0.787	0.619	0.863	0.907	0.709	0.864
PBA2: Menstrual tracking mobile	0.848	0.719				

application will consume my time.						
PBA3: Using menstrual tracking mobile applications is prohibited in my cultural and religious beliefs.	0.852	0.726				
PBA4: My family didn't allow and support me to use a menstrual tracking mobile application.	0.879	0.773				
PSE1: I can download a menstrual tracking mobile application when I want to.	0.881	0.777	0.74	0.885	0.794	0.744
PSE2: A reminder notification on my smartphone to log in each day would be important to my use of menstrual tracking mobile app.	0.9	0.811				
PTHMI3: My feelings about myself would change if my period is irregular.	0.877	0.769	0.766	0.863	0.679	0.795
PTHMI4: When I think about menstrual irregularities I feel nauseous.	0.815	0.664				
PTHMI5: Menstrual irregularities would threaten my daily activities.	0.777	0.604				
PTHTP3: The thought of teenage pregnancy scares me.	0.714	0.510	0.811	0.888	0.729	0.87
PTHTP4: If I were pregnant, my education would be endangered.	0.911	0.829				
PTHTP5: Teenage pregnancy would threaten my relationship with my family and relatives.	0.92	0.847				
ATT1: I have positive feelings towards the use of menstrual tracking mobile application technologies.	0.841	0.708	0.819	0.892	0.734	0.82
ATT2: Using a menstrual tracking mobile application is a wise idea.	0.87	0.757				
ATT3: I have no objection to using a menstrual tracking mobile app if available.	0.859	0.738				
CU1: If I see my friends using a menstrual tracking mobile app, it reminds me to use it.	0.927	0.859	0.798	0.908	0.831	0.813
CU2: Routine educational talks regarding teenage pregnancy and menstrual irregularity awareness would help me to get a menstrual	0.896	0.803				

tracking mobile app.						
STT4…I want to manipulate factors that affect my period regularity.	0.781	0.61	0.883	0.911	0.631	0.89
STT6…I'm interested to know how my period cycle works.	0.781	0.609				
STT7…it helps me to optimize my menstrual health.	0.801	0.642				
STT8…it motivates me to keep on working for a goal (e.g. to prevent adolescent pregnancy naturally).	0.765	0.585				
STT9...it motivates me to avoid period irregularity.	0.866	0.75				
STT10…it facilitates my self-discipline.	0.768	0.59				
BI1: I intend to continue to use a menstrual tracking mobile app in future.	0.948	0.898	0.895	0.95	0.905	0.899
BI2: I plan to use a menstrual tracking mobile app in future.	0.955	0.912				

Source: Own Computation

4.3.1.2 Internal Consistency Reliability

Assessing internal consistency reliability is the second step in the reflective measurement model part of PLS-SEM. It assesses whether indicators measuring the same construct are associated with each other or not. Hence, it ensures the repeatability of the study measuring instrument (Drost, 2004; Kothari, 2004). Moreover, reliability values above 0.7 are considered appropriate (0.6 in exploratory research); while, values above 0.95 are problematic since it indicates that the indicators are redundant as well as it suggests the possibility of undesirable response patterns (Hair et al., 2021). Having said this, there are three types of reliability measures used in PLS-SEM.

These are composite reliability rhoc (CR), cronbach's alpha (CA) and reliability coefficient rho_A. Table 7 shows that CA values exceeded the acceptable level of 0.7. Similarly, the threshold value for composite reliability (CR) is > 0.7 and the table shows that CR of a construct exceeds the acceptable level. However, as CA is the lower bound and CR is the upper bound for internal consistency reliability, reliability coefficient rho_A, which lies between these two bounds, is also recommended as a good representation of a construct's internal consistency

reliability. Moreover, the above table shows that the rho_A value is within the acceptable range. Hence, the items in the scale are related to each other and the measurements are reliable.

4.3.2 Validity Test

Validity test indicates the degree to which an instrument measures what it is supposed to measure (Drost, 2004; Kothari, 2004; SÜRÜCÜ & MASLAKÇI, 2020). In other words, it deals with the meaningfulness of research components (Taherdoost, 2017).

4.3.2.1 Convergent Validity

Assessing convergent validity of the latent construct is the third step in the reflective measurement model part of PLS-SEM. It indicates the extent to which the construct converges to explain the variance of its indicators (Hair et al., 2021). As a result, average variance extracted (AVE) was used to evaluate a construct's convergent validity. AVE indicates the grand mean value of the squared loadings of the indicators associated with the construct. In other words, it is the sum of the squared loadings divided by the number of indicators. It is also equivalent to the communality of a construct (Hair et al., 2021). Thus, the threshold value of AVE is greater than or equal to 0.50 and higher values indicate that the latent construct explains 50% or more of the indicator variance that make up the construct. Similarly, as it is shown above in table 7 AVE exceeded the acceptable level of 0.5, which confirms the convergent validity of the proposed constructs.

4.3.2.2 Discriminant Validity

Assessing discriminant validity of the latent constructs is the final step in the reflective measurement model part of PLS-SEM. It indicates the extent to which a construct is empirically distinct from other constructs in the structural model. There are three types of discriminant validity measures.

Firstly, Fornell and Larcker (1981) suggested that each latent's construct AVE should be compared to the squared inter-construct correlation of that same latent construct as well as with all other latent constructs in the structural model. Hence, the correlation between all model constructs should not be larger than their AVEs. In other words, a latent construct should explain

the variance of its own indicators (items) adequately than the variance of other latent constructs in the model.

Below, the table shows the square roots of each AVE in the diagonal with the correlation coefficients (off-diagonal) for each construct in the relevant rows and columns. Therefore, 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.

Table 8: AVE and latent correlation matrix

	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**

Source: Own Computation

The second type of discriminant validity measures is called cross loading or item-level discriminant validity. Here, it compares the factor loading of each item or indicator within a latent construct and the loading of an item on another construct (Hair et al., 2021). Thus, an item must be correlated with its own latent construct rather than with other latent construct in order to ensure discriminant validity at indicator level (Hair et al., 2021). Therefore, as it is shown below in table 9, each of the outer loading indicator values exceeds the cross-loading values, which establishes the item level discriminant validity.

Table 9: Cross loading/item level discriminant validity

	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**

Source: Own computation

The last type of discriminant validity measure is called heterotrait–monotrait ratio (HTMT). HTMT is a new developed measure, which is recommended by most scholars, as a response to a

critique on the above validity assessment types. Hair et al (2021) defined it as the mean value of the indicator correlations across constructs relative to the mean of the average correlations for the indicators measuring the same construct. Hence, discriminant problem are present when HTMT values approaches to 1. And, the threshold value presented in two ways, firstly, for conceptually similar latent constructs, HTMT should less than 0.9; while, for conceptually different constructs, HTMT should less than 0.85. Therefore, as it is shown below in table 10, all of the constructs HTMT values are less than 0.85, except ATT and BI (0.896). However, as both constructs are conceptually similar and their correlation is less than 0.9, it is concluded that discriminant validity of the measurement model is established.

Table 10: HTMT discriminant validity measure

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

Source: Own Computation

4.4 Structural Model/ Inner Model Assessment

This section describes the assessment of collinearity issues; the significance and relevance of bootstrap path relationships; the model's explanatory power; and the model's predictive power, respectively. Here, I used standardized bootstrap method with 10, 000 subsamples as per Hair et al (2021) recommendations in order to determine the path coefficients and I also used t value > 1.96 to decide the significance relationship.

4.4.1 Multicollinearity Test of the Structural Model

Table 11: VIF test

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

Source: Own Computation

According to Hair et al (2021) recommendations, vif is not an issue if it is less than 3, and the above table shows that vif of the latent construct is less than 3.

4.4.2 Assessment of the Significance and Relevance of the Path Coefficients

The study 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 this criteria, as it is shown below in table 12, cues to action (β=0.287) and adolescent girl's self tracking motivation (β=0.251) has a medium positive impact on behavioral intention to use the app; whereas, attitude to use has a strong positive impact (0.439). In addition, perceived usefulness of the app has a strong positive impact on the adolescent girl's self tracking motivation (β=0.474), and a medium positive impact on attitude to use the app (β=0.208). Likewise, perceived ease of use of the app has a strong positive impact on perceived usefulness (β=0.373) and medium positive impact on attitude towards using the app (β=0.245). Moreover, perceived barriers have a medium negative effect on attitude to use the app (β= -0.204). Similarly, perceived self efficacy has a strong positive effect on perceived usefulness of the app (β=0.344), attitude to use the app (β=0.359) and on perceived ease of use of the app (β=0.568). Lastly, perceived threat to teenage pregnancies has weak (low) positive effects on perceived usefulness (β=0.1), and attitude to use the app (β=0.085). Similarly, perceived threat to menstrual irregularities has weak (low) positive effects on perceived usefulness (β=0.073), and attitude to use the app (β=0.088).

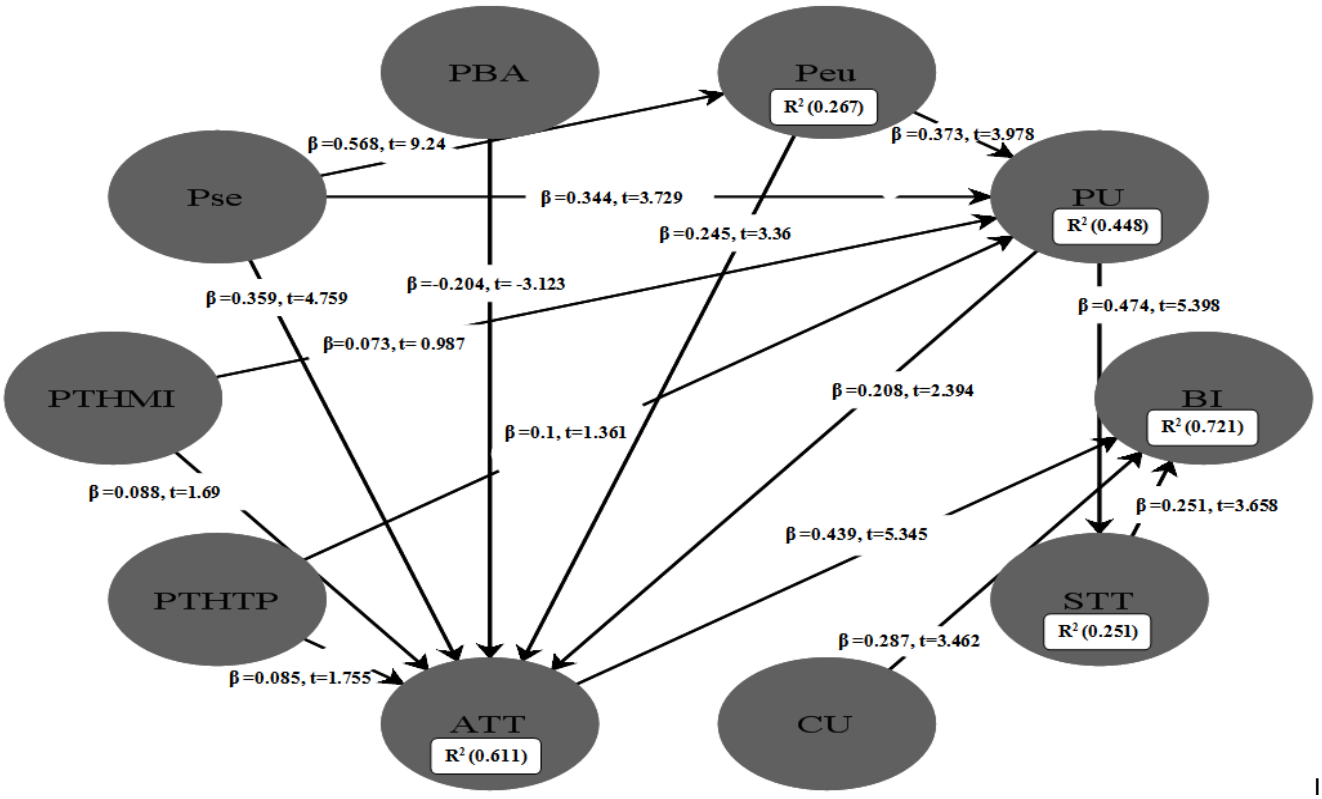
Table 12: Bootstrap path coefficient

Relationship	Original Est.	Bootstrap Mean	Bootstrap SD	T Stat.	2.5% CI	97.5% CI
CU➔BI	0.287	0.281	0.083	3.462	0.121	0.442
STT ➔BI	0.251	0.258	0.069	3.658	0.132	0.395
ATT ➔BI	0.439	0.439	0.082	5.345	0.281	0.613
PU➔STT	0.474	0.477	0.088	5.398	0.294	0.637
PU➔ ATT	0.208	0.212	0.087	2.394	0.053	0.382
PEU ➔PU	0.373	0.371	0.094	3.978	0.190	0.549
PEU➔ATT	0.245	0.240	0.073	3.360	0.104	0.387
PBA➔ATT	-0.204	-0.209	0.065	-3.123	-0.338	-0.083
PSE➔PU	0.344	0.344	0.092	3.729	0.155	0.518
PSE➔ATT	0.359	0.354	0.076	4.759	0.205	0.504
PSE➔PEU	0.568	0.572	0.062	9.240	0.441	0.681
PTHTP➔PU	0.100	0.097	0.073	1.361	-0.048	0.241
PTHTP ➔ATT	0.085	0.082	0.048	1.755	-0.009	0.176
PTHMI➔ PU	0.073	0.083	0.074	0.987	-0.064	0.218
PTHMI ➔ATT	0.088	0.088	0.052	1.690	-0.010	0.193

Source: Own Computation

Additionally, at 5% significance level, the bootstrapping statistical significance is defined based on the criteria that the value of T should exceed 1.96. And, below this threshold value are insignificant. Moreover, as it is shown in table, most of the relationships are statistically significant (CU➔BI, t=3.462; STT➔BI, t=3.658; ATT➔BI, t=5.345; PU➔STT, t=5.398; PU➔ ATT, t=2.394; PEU➔ PU, t=3.978; PEU➔ATT, t=3.360; PBA➔ATT, t= -3.123; PSE➔PU, t=3.729; PSE➔ATT, t=4.759; PSE➔PEU, t=9.240); but four of the relationships are not statistically significant (PTHTP➔PU, t=1.361; PTHTP ➔ATT, t=1.755; PTHMI➔ PU, t=0.987; PTHMI ➔ATT, t=1.690).

Figure 12: Structural model



Source: Own Computation

Furthermore, it is important to consider the total effects of the latent constructs on the outcome constructs. It is noted that the direct effect of an independent variable on a dependent variable is described by the path coefficient which connects one determinant to another; whereas, an indirect effect is a sequence of relationships with at least one intervening construct involved. Hence, the total effect is the sum of direct and indirect effects. And, the total indirect effect is discussed under mediation analysis.

Table 13: Bootstrap total effects

Relationship	Original Est.	Bootstrap Mean	Bootstrap SD	T Stat.	2.5% CI	97.5% CI
PEU → PU	0.373	0.371	0.094	3.978	0.190	0.549
PEU → STT	0.177	0.177	0.056	3.164	0.077	0.300
PEU → ATT	0.322	0.319	0.065	4.939	0.191	0.441
PEU → BI	0.186	0.185	0.042	4.405	0.107	0.278
PSE →PEU	0.568	0.572	0.062	9.240	0.441	0.681
PSE → PU	0.556	0.557	0.069	8.031	0.425	0.691
PSE → STT	0.263	0.267	0.065	4.028	0.143	0.399
PSE → ATT	0.614	0.610	0.053	11.562	0.504	0.715
PSE → BI	0.336	0.338	0.057	5.854	0.228	0.449
PTHTP → PU	0.100	0.097	0.073	1.361	-0.048	0.241
PTHTP → STT	0.047	0.045	0.035	1.360	-0.024	0.119
PTHTP → ATT	0.105	0.103	0.052	2.044	0.005	0.197
PTHTP → BI	0.058	0.057	0.030	1.969	0.006	0.120
PTHMI → PU	0.073	0.083	0.074	0.987	-0.064	0.218
PTHMI → STT	0.034	0.041	0.037	0.920	-0.028	0.118
PTHMI → ATT	0.103	0.107	0.050	2.061	0.012	0.205
PTHMI → BI	0.054	0.057	0.026	2.099	0.009	0.107
PU →STT	0.474	0.477	0.088	5.398	0.294	0.637
PU → ATT	0.208	0.212	0.087	2.394	0.053	0.382
PU → BI	0.210	0.217	0.060	3.486	0.106	0.338
PBA → ATT	-0.204	-0.209	0.065	-3.123	-0.338	-0.083
PBA → BI	-0.090	-0.092	0.033	-2.687	-0.164	-0.035
CU→ BI	0.287	0.281	0.083	3.462	0.121	0.442
STT → BI	0.251	0.258	0.069	3.658	0.132	0.395
ATT → BI	0.439	0.439	0.082	5.345	0.281	0.613

Source: Own Computation

The above table depicted that at 5% significance level, perceived self efficacy has strongest positive total effects (β =0.614, t=11.562) on attitude to use, (β =0.568, t =9.24) on perceived ease of use and (β =0.556, t =8.031) on perceived usefulness. And, the relationship is statistically significant. Likewise, perceived usefulness has a strong positive impact on adolescent girl's self tracking motivation (β=0.474, t =5.398) and the relationship is statistically significant. In addition, attitude to use has a strong positive impact on behavioral intention to use apps (β=0.439, t =5.345) with statistical significance. Lastly, perceived ease of use has a strong positive total effect on perceived usefulness of the app (β=0.373, t =3.978) and their relationship is statistically significant.

In addition, perceived self efficacy has a medium, indirect, positive total effect on behavioral intention to use the app (β=0.336, t =5.854) and on self tracking motivation (β=0.263, t =4.028) with statistical significance. Similarly, perceived ease of use has a medium positive total effects on attitude to use (β=0.322, t =4.939); whereas, cues to action and self tracking motivation has a medium positive total effects on behavioral intention to use (β=0.287, t =3.462); (β=0.251, t =3.658), respectively, with a statistically significant relationship. Likewise, perceived usefulness has a medium positive total effect on attitude to use (β=0.208, t =2.394) and indirect total effect on behavioral intention to use (β=0.21, t =3.486). Also, perceived ease of use has medium positive, indirect, total effects on behavioral intention to use (β=0.186, t =4.405) and self tracking motivation (β=0.177, t =3.164).

Finally, perceived barriers have a weak negative, indirect effect on behavioral intention to use (β= -0.09, t = -2.687) and direct total effects on attitude to use (β= -0.204, t = -3.123), with statistically significance. Besides, both perceived threat to teenage pregnancy and perceived threat to menstrual irregularity has weak positive, total effects on attitude to use (β=0.105, t =2.044); (β=0.103, t =2.061), as well as indirect total effects on behavioral intention to use (β=0.058, t =1.969); (β=0.054, t =2.099), respectively, with a statistically significant relationship. However, both constructs aren't significantly related to perceived usefulness (β=0.1, t =1.361); (β=0.073, t =0.987), as well as self tracking motivation (β=0.047, t =1.36), (β=0.034, t =0.92), respectively.

4.4.3 The Model Explanatory Power (R2)/In sample predictive power

Table 14: Coefficient of determination (R2)

	PU	PEU	ATT	STT	BI
R^2	0.448	0.267	0.611	0.239	0.721
AdjR^2	0.434	0.263	0.596	0.234	0.715

Source: own computation

In addition, the model explanatory power was determined using the coefficient of determination, R^2. And, the table 14 shows that the model explained 44.8% of the variance in perceived usefulness of the app, 26.7% in perceived ease of use, 61.1% in attitude to use the app, 23.9% in adolescent girl's self tracking motivation and 72.1% in behavioral intention to use.

This means that the four constructs (PEU, PSE, PTHMI and PTHTP) moderately explain 44.8% of the variance in perceived usefulness. Similarly, perceived self efficacy weakly explains 26.7% of the variance in perceived ease of use, and six of the constructs (PU, PEU, PSE, PBA, PTHMI and PTHTP) moderately explain 61.1% of the variations in ATT. Also, the latent perceived usefulness construct weakly explains 22.1% of the variations in adolescent girl's self tracking motivation. Finally, four of the constructs (PU, CU, STT and ATT) substantially explain 72.1% of the variations in behavioral intention to use apps.

Table 15: Effect sizes (f2)

	PEU	**PU**	**STT**	**ATT**	**BI**
PEU		0.233		0.115	
PSE	0.365	0.108		0.115	
PTHTP		0.007		0.008	
PTHMI		0.007		0.051	
PU			0.314	0.115	
PBA				0.034	
CU					0.1
STT					0.21
ATT					0.33

Source: own computation

Additionally, effect sizes (f^2) of the constructs shows that the latent construct's perceived self efficacy has a strong effect size on perceived ease of use (0.365). But, it has medium effect sizes on attitude to use the app (0.115) and perceived usefulness of the app (0.108). Similarly, perceived ease of use has medium effect sizes on perceived usefulness (0.233) and attitude to use the app (0.115). Also, perceived usefulness has medium effect sizes on self tracking motivation (0.314); but, it has medium effect sizes on attitude to use the app (0.115). On the contrary, perceived barriers have low effect sizes on attitude to use the app (0.034). In addition, effect sizes of the attitude to use the app, self tracking motivation, and cues to action are strong and medium on behavioral intention to use (0.33, 0.21, 0.1), respectively. However, both perceived threat to menstrual irregularities and teenage pregnancies have low effect sizes on attitude to use the app (0.051 and 0.007) as well as on perceived usefulness of the app (0.007 and 0.008), respectively.

4.4.4 The Model Predictive Power/Out of sample predictive power

The 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. Moreover, for a model to have high predictive power, Hair et al (2021) stated that the root mean square error (RMSE) or mean absolute error (MAE) values produced by PLS –out of sample should less than with those produced by linear regression model (LM) for all indicators. In addition, they stated that if the majority of the indicators prediction error (RMSE or MAE) values produced by PLS- out of sample is less than LM, it indicates a medium predictive power (Hair et al., 2021). But, if minority of indicators prediction errors values produced by PLS-out of sample are less than LM, it indicates that the model has low predictive power. Finally, if none of indicators prediction error values produced by PLS-out of sample is not less than LM, it indicates that the model lacks predictive power. Besides, if the prediction error is symmetric and not highly skewed, RMSE is recommended. If it is not, MAE is recommended (Hair et al., 2021).

Based on the above guidelines, I used RMSE approach and the result shows that the majority of the indicator error values produced by PLS–out of sample were less than those produced by linear regression model (LM). As it is shown below, more than 85% of the indicators predicted error values were smaller compared to LM; thus, out of the 22 latent endogenous construct indicators, pu4, pu8, and bi2 have high RMSE values compared to LM; but the rest of the indicator RMSE values are smaller compared to LM. Therefore, the model has medium predictive power (86.36%).

Figure 13: Model predictive power

```
PLS out-of-sample metrics:
       pu1   pu2   pu3   pu4   pu5   pu6   pu7   pu8  peu1  peu2  peu3  att1  att2  att4  stt4  stt6  stt7
RMSE 1.520 1.682 1.507 1.413 1.576 1.567 1.451 1.471 1.610 1.529 1.329 1.495 1.225 1.535 1.555 1.370 1.448
MAE  1.169 1.366 1.143 1.089 1.243 1.270 1.084 1.060 1.296 1.184 1.000 1.158 0.940 1.202 1.236 1.075 1.102
      stt8  stt9 stt10   bi1   bi2
RMSE 1.808 1.363 1.477 1.176 1.135
MAE  1.467 1.059 1.183 0.829 0.870

LM out-of-sample metrics:
      pu1   pu2   pu3   pu4   pu5   pu6   pu7   pu8  peu1  peu2  peu3  att1  att2  att4  stt4  stt6  stt7
RMSE 1.661 1.782 1.524 1.377 1.621 1.734 1.596 1.438 1.728 1.697 1.422 1.543 1.232 1.576 1.698 1.516 1.518
MAE  1.235 1.358 1.103 1.003 1.201 1.372 1.162 1.026 1.374 1.253 1.036 1.092 0.907 1.140 1.240 1.049 1.079
     stt8  stt9 stt10   bi1   bi2
RMSE 1.919 1.379 1.488 1.242 1.068
MAE  1.437 1.045 1.114 0.867 0.818
```

Source: Own Computation

4.4.5 Mediation Analysis

Mediation effect occurs when a latent construct intervenes between two constructs. Hair et al (2021) described three types of mediation; these are, complementary mediation (both the direct and indirect effect are significant and they are in the same direction), competitive mediation (both the direct and indirect effect are significant and they are in opposite direction), and indirect-only mediation (when the indirect effect is significant, and the direct is not). In addition, they also described two types of non-mediation; these are direct-only non mediation (when the direct is significant, and the indirect is not), and no-effect non-mediation (when both effects are insignificant).

Moreover, the direct effect of perceived self efficacy to attitude to use was significant at 5% level (β=0.359, t=4.579). Similarly, the indirect effect of perceived self efficacy through the mediator of perceived usefulness as well as perceived ease of use was also significant as it is shown below. In addition, as both of the effects are in positive directions, we can conclude that the relationship between perceived self efficacy to attitude to use is complementary mediated by perceived ease of use and perceived usefulness. Likewise, perceived self efficacy has a significant direct effect on perceived usefulness with 5% significance level (β=0.344, t=3.729). Also, its indirect effect is significant and both are in the same direction. As a result, we can conclude that perceived ease of use acts as a complementary mediator in the relationship between perceived self efficacy and perceived usefulness. Lastly, both perceived threat to teenage pregnancy and menstrual irregularity have significant indirect effect on ATT through PU, but, insignificant direct relationship to attitude to use the app. Thus, perceived usefulness acts as a full mediator in the relationships of both constructs to ATT.

Table 16: Mediation analysis

	Original Est.	Direction	Bootstrap Mean	Boot strap sd	T Stat.	2.5% CI	97.5% CI	Mediation Type
PSE—>PEU —>ATT	0.142	0.041 (+ve)	0.142	0.05	2.827	0.048	0.247	Complementary/Partial
PSE—>PU —>ATT	0.087	0.0247 (+ve)	0.089	0.042	2.059	0.023	0.183	Complementary/Partial
PSE—>PEU —>PU	0.219	0.006 (+ve)	0.219	0.051	4.276	0.124	0.323	Complementary/Partial
PTHTP—> PU—>ATT	0.105	-	0.103	0.052	2.044	0.005	0.197	Indirect total effect only
PTHMI—> PU—>ATT	0.103	-	0.107	0.05	2.061	0.012	0.205	Indirect total effect only

Source: Own Computation

4.5 Discussion

The aim of the study is to examine perceptions of menstrual tracking mobile application acceptance among adolescent girls in Lafto sub city, Addis Ababa. The proposed model was based on the Technological Acceptance Model (TAM) and Health Belief Model (HBM). This integrated model has (86.36%) a medium predictive power. And the overall acceptance of the menstrual tracking mobile app was great, that more than 80% (82.3%) of the high school adolescent girl's agreed to use this application in future; whereas, 10.25% disagreed and 7.45% were neutral. Moreover, 14.91% of high school adolescent girls reported users of this application, which is less than from a study performed in Serbia in 2020 (29.7%) (Gazibara et al., 2020). This is because 61.49% of high school adolescent girls in the wereda reported that they didn't know menstrual tracking mobile app and 78.88% of them responded that they don't have experience of self tracking mobile app usage. Besides, the total number of participants in the present study is smaller compared to the study in Serbia (394). As a result, there is a difference in menstrual tracking mobile application usage in two places. Moreover, the discussions of the findings will be presented in four sections as follows.

4.5.1 Self Tracking Motivation and Behavioral 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 behavioral intention to use menstrual tracking mobile app*.

Furthermore, attitude to use is defined as the degree of evaluative effect that the adolescent girl's associate with using the menstrual tracking mobile app in their job. In other words, it depicts the adolescent girls' positive or negative feelings about using the menstrual tracking mobile app. Thus, the study revealed that ATT has a strong, positive and significant effect on BI *(β=0.439, t =5.345, p=0.05).* Also, ATT has effect sizes of 0.33 (f2), which indicates that removing the construct from the model has a 33.3% effect on BI.

Likewise, self tracking motivation refers to the adolescent girls' reasons to consume menstrual tracking mobile apps and what motivates them to accept and utilize these apps. Hence, the study depicted that STT has a direct, positive and moderate significant effect on BI *(β=0.251, t =3.658, p=0.05).* Also, STT has effect sizes of 0.21 (f2), which indicates that removing the construct from the model has a 21% effect on BI.

On the contrary, out of the five Gimpel et al (2013) self tracking motivating factors, self design and self discipline were the only included variables in the present study as the three of them were invalid and reliable. Additionally, the present study combined these two motivating factors as a single construct called STT. Thus, these two motivating factors have a significant effect on BI to use menstrual tracking mobile apps. However, a study on intrinsic motivations' effects on intention of using mobile health apps in Kocaeli, in 2018 with 214 respondents by using SEM concluded that self-design, self-discipline and self-entertainment motivations were found to affect behavioral intention to use mobile app positively (Apps et al, 2018). Their findings aren't consistent from the present study. And, a possible explanation 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.

On top of this, hypothesis 1b stated that *the adolescent girl's perceived usefulness of menstrual tracking mobile apps has a positive significant effect on self tracking motivations*. And, the study revealed that PU had a strong, positive and significant impact on self tracking motivation (*β=0.474, t=5.398, p=0.05).* And, PU explains 23.9% (R2) of the variations in STT and it has effect sizes of 0.314, which signifies that removing the construct from the model has effects of 31.4% on STT. Consequently, the low R2 may be due to that the study didn't include other key predictors of STT.

Additionally, cues to action refer to a reminder or trigger that leads adolescent girls to behavioral intentions to use menstrual tracking mobile apps. As a result, the study revealed that CU has a moderate, positive and significant impact on BI *(β=0.287, t =3.462, p=0.05).* Also, CU has effect sizes of 0.1, which indicates that removing the construct from the model has 10% effects on BI. However, the findings contradicted a study performed by Orji et al (2012). They identified that CU had weak or no effect (with *β=0.03, p≤ 0.01, f2 = 0%*) on behavioral intention to use. And, one explanation they mentioned for the low or no effect of the construct was inappropriateness in filling out the questionnaires by the participants.

In conclusion, the study revealed that behavioral intention−the degree to which adolescent girls had formulated conscious plans to accept or not to accept menstrual tracking mobile apps in future has a significant impact on menstrual tracking mobile apps acceptance. In addition, 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; whereas, Buabeng-andoh (2018) integrated TRA and TAM. In short, the attitude to use the app, self tracking motivations and cues to action have a significant, positive and direct effect on behavioral intention to use the app, which supports the proposed hypothesis.

4.5.2 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 have a positive significant effect on attitude to use the app; but, perceived barriers has a negative effect*.

Moreover, perceived usefulness is the degree to which adolescent girls believe that using menstrual tracking mobile apps would enhance their menstrual and reproductive health. The study revealed that perceived usefulness has a medium, positive and significant impact on attitude to use the app (*β=0.208, t=2.394, p=0.05)*. In addition, removing PU from the model has effects of 11.5% on ATT ($f^2 = 0.115$). The study is also revealed that PU acts as a complementary mediator in the relationship between PSE and ATT. This mediating effect enabled the adolescent girls to develop the attitude to use the app as they are confident and believe it will enhance their performance to track their cycle, to verify menstrual experiences, to prevent pregnancy and extra.

This finding is in line with previous empirical studies performed using TAM in different disciplines. To begin with, Kim et al (2012a) identified that PU had a significant impact on ATT to consume health related technologies by adopting TAM, HBM and TRA with PLS-SEM and 728 sample size in Korea. Secondly, Alloghani et al (2015) identified PU had a significant impact on ATT mobile health related services in UAE by using TAM with 144 sample size. The last study, which was performed to predict mobile learning usage among students by adopting TAM and TRA with 487 participants using PLS-SEM approach in Ghana, concluded that PU had a significant positive impact on ATT (Buabeng-andoh, 2018). Regarding the mediating effect, a similar study to identify factors that affect online learning in Egypt by using TAM with PLS-SEM and 202 participants concluded that PU had a mediating effect in the relationship between self efficacy and intention to use (Farrag et al, 2022). Thus, it is consistent with the present study findings and it supports hypothesis2.

Likewise, perceived ease of use refers to the degree to which adolescent girls believe that using menstrual tracking mobile apps would be free of effort. The study showed that PEU has a medium, positive and significant effect on attitude to use the app (*β=0.245, t=3.36, p=0.05)*. In addition, removing PEU from the model has effects of 11.5% on ATT. The study is also revealed that PEU acts as a complementary mediator in the relationship between PSE and ATT. This mediating effect enabled the adolescent girls to develop the ATT as they were confident and believed that the easier the menstrual tracking mobile app to use, the more accepted and useful it can be. Furthermore, this finding is in agreement with previous TAM related studies of Buabeng-andoh (2018), Kim et al (2012a), and Alloghani et al (2015), which all identified that PEU had a significant positive and direct impact on ATT. Regarding the mediating effect, a similar study by Farrag et al, (2022) concluded that PEU had a mediating effect in the relationship between self efficacy and behavioral intention to use. Thus, it supports hypothesis2.

On the contrary to PU and PEU, PBA refers to the adolescent girl's feelings on the obstacles to using a menstrual tracking mobile app. Hence, perceived barriers are related to understandability, inconvenience, time consuming, religious and cultural beliefs etc. The study showed that PBA has a medium, significant negative impact on ATT (*β= -0.204, t= -3.123, p=0.05)*. Also, it has effect sizes of 0.034, which indicates that removing the construct from the model has an effect of 3.4% on ATT. Moreover, a study performed to extend the HBM in Canada in 2012 with 576

participants by using the PLS-SEM approach concluded that perceived barriers had a significant negative effect on developing health related behavior (Orji et al., 2012). In addition, the path coefficient of PBA (-0.204) of the study does not significantly differ from their finding (-0.2). Thus, the present findings are consistent with their studies and supports hypothesis2.

Additionally, perceived self efficacy is the degree to which adolescent girl's believe or perceive that they have the ability to perform specific tasks related to menstrual tracking mobile apps. In other words, it is the confidence to utilize the mobile apps. The study revealed that PSE has the strongest positive and significant effects on ATT (*β=0.359, t=4.759, p=0.05)*, and it is the dominant determinant in the model with a total effects of (*β=0.614, t=11.562, p=0.05)* on ATT. In addition, it has an effect size of 0.115, which indicated that removing PSE from the model has 11.5% effects on ATT. Furthermore, this finding is in agreement with previous HBM and TAM related studies. To begin with, Orji et al., (2012) identified that PSE was the strongest and the most significant determinant of all the ten variables they used (with *β=0.39, f2=21%, p≤ 0.01*) in consuming mobile based health related technologies. However, the present study identified its effect in three dimensions—ATT, PEU and PU. As a result, the findings are differing. Similarly, a systematic review study on TAM in healthcare concluded that PSE had a significant impact on ATT to consume health related technologies. Hence, it supports hypothesis2.

On top of this, perceived threat is the adolescent girl's perception of their susceptibility or vulnerability to menstrual irregularity and teenage pregnancy. It refers to the degree to which they believe that both menstrual irregularity and teenage pregnancy is severe and affects their life. The study revealed that PTHTP has insignificant relationship to ATT *(β=0.085, t=1.755, p=0.05)*; and also it has an effect size of 0.007, which indicates that removal of the construct from the model has 0.7% effect on ATT. Similarly, PTHMI has insignificant relationship to ATT *(β=0.088, t=1.69, p=0.05)*; and its effect size of 0.05 indicates that removal of the construct from the model has 5.1% effect on ATT. However, both constructs have a medium, positive, indirect and significant total effects on ATT (*β*=0.105, *t* =2.044, *p=0.05*) by PTHTP and (*β*=0.103, *t* =2.061, *p=0.05*) by PTHMI. This shows that these two constructs didn't support the proposed hypothesis.

Moreover, one possible explanation according to Champion et al (2005) is that if perceived threat and barriers are low, it indicates that the benefits are perceived to be very high. And, the

interview analyses are consistent with this theoretical explanation. Here are the two themes that supports Champion et al (2005) reasoning's. To begin with, teenage pregnancy was seen as a threat among participants and perceived it as having severe psychological, spiritual, social, and health related consequences on their personal and family life. Moreover, one participant believed "**ሰውነታችን ልጁን ለመሸከም አይችልም**". Here, she said that teenager's body isn't mature for pregnancy. Similarly, other participant said "**በእኛ ማህበረሰብ ያንን ሰው እንደ መጨረሻ የቆሸሸ ነገር አድርጎ ገፍቶ ነው** የሚጥለው", which means that if adolescent girl is pregnant, she believed that our society will discriminate such individuals as filthy. She also said that being pregnant at adolescent age is—"**ያሳፍራል፣ ውርደት ነው፣ ከቤተሰብም ሊያሰውጣ ይችላል**"—so embarrassing, shameful and it may be a cause for the separation of the girl from her parents.

Secondly, participants emphasized three ways to reduce this threat—abstinence, contraceptive usage and abortion. Furthermore, one participant believed that "**በቤተሰብ ተቀባይነት አይኖረውም በዚህም ምክንያት እንድታስወርደው ሊያደርጓት ይችላሉ**", while the other believed that "**ይሄ እድሜ ግንኙነት ማድረጊያ ጊዜ** አይደለም". Here, the former assumed that teenage pregnancy isn't acceptable by the parents, therefore, they may make her to abort the pregnancy; whereas, the latter stated that adolescent age is not the time to date a boy friend. On the contrary, one participant concluded that—"**አሁን በዚህ ትውልድ ዴት አለማድረግ ከባድ ነው…ስለዚህ የእርግዝና መከላከያ መጠቀም አስፈላጊ ነው**"—nowadays, it is difficult not to date a boy friend; as a result, it is important to use contraceptives. Thus, participants had high PTHTP, but low PBA, which indicates that the health related activities to decrease the threats are perceived increasingly (in other words PU is high).

On the other hand, participants perceived MI as a threat is merely if it is persistent and recurrent. Moreover, one respondent said that "**የመጀመሪያ አከባቢ ያስደነግጠኝ ነበር…በቆይታ ግን ኖርማል እንደሆነ አስባለው**". Here the participant considers MI as a threat during the first few cycles and then she perceived it as normal. Likewise, another participant believed that —"ከ3ት **ወር ከበለጠ ያስፈራኛል ከዛ ውጪ ግን ኖርማል ነው**"—if MI is more than three months she will perceived it as a threat. But, the other participant believed that—"**በተደጋጋሚ ከተዛባ ወደ ሆስፒታል ቶሎ መሄድ አስፈላጊ ነው**"—if the irregularity is recurrent and repeated she will look for medical doctors. In general, participants considers MI as a normal physiological process and

stated that stress during exam period, poor diet, being teenager, substance abuse, family history as a cause for irregularity. Finally, participants stated that online, family and medical counseling; peer support; awareness on MI; lifestyle adjustment; menstrual tracking mobile apps; balanced nutrition and extra as a solution to MI. Here, one participant also said that "**ሙቅ ውሃ አፍልቶ ጀርባን ማሸት**" or massaging the back or the abdomen with hot water as a solution to MI. Thus, participants PTHMI and PBA are low, which indicates that the health related activities/behaviors to decrease the threats are perceived increasingly (PU is high).

To sum up, according to the interview and the findings, the insignificant direct effect of the constructs on ATT could be as a result of high perception of the adolescent girls on the usefulness (f2= 11.5%), ease of use (f2= 11.5%) and self efficacy (f2= 11.5%) of the app and other related strategies to decrease the threat. In addition, the perceived barriers to use the app are low (f2= 3.4%), which all may contribute for this insignificant direct relationship.

Additionally, the medium indirect only effect of PTHMI and PTHTP on ATT through the mediator of PU wasn't hypothesized initially. But, it is consistent with the study by Kim et al (2012b). They identified that perceived threat had an indirect significant effect on attitude to use and behavioral intention to use. Likewise, a study on determinants of internet usage for health related purposes in Malaysia, by integrating HBM and TAM with 293 sample size using PLS-SEM identified that perceived threat was fully mediated by PU (Ahadzadeh et al., 2015). Hence, this implies that adolescent girls', who perceive teenage pregnancy and period irregularity as a threat as well as wanting to decrease the threat, will develop a positive attitude to use menstrual tracking mobile apps through the mediator of usefulness of the apps. This also shows that perception of threat to teenage pregnancy and menstrual irregularity alone is not enough to develop an attitude to use the app or beliefs on the usefulness of the app.

In conclusion, the study shows that six constructs together (PU, PEU, PBA, PSE, PTHMI and PTHTP) explains moderately 61.1% (R2) of the variations in ATT. In addition, four of the constructs (PU, PEU, PBA and PSE) supports the proposed hypothesis, but the rest two constructs didn't (PTHTP and PTHMI). In general, this finding is consistent with a study performed by Buabeng-andoh (2018). But, in his studies, attitude had 0.476 coefficient of determination (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.

4.5.3 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 have a positive significant effect on perceived usefulness of the menstrual tracking mobile app*.

The study revealed that PEU has a strong, positive and significant impact on PU (*β=0.373, t=3.978, p=0.05)*; and it has effect sizes of 0.233, which signifies that removing the construct from the model has an effect of 23.3% on PU. It also 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 (2012a), and Alloghani et al (2015). Additionally, the study showed that PSE has a strong, direct, positive and significant impact (*β=0.344, t=3.729, p=0.05*) and a total effects (*β=0.556, t=8.031, p=0.05)* on PU. It has also an effect size of 0.108, which indicates that removing PSE from the model has 10.8% effects on PU. This finding is in agreement with a systematic review study on TAM, which identified that PSE had an impact on PU (AlQudah et al., 2021). Farrag et al, (2022) also showed that PSE had a direct impact on PU.

In contrast, the study revealed that PTHTP has insignificant relationship to PU *(β=0.1, t=1.361, p=0.05)*; and it has an effect sizes of 0.008 which indicates that removal of the construct from the model has 0.8% effect on PU. Similarly, PTHMI has insignificant relationship to PU *(β=0.073, t=0.987, p=0.05;* and it has an effect sizes of 0.007, which indicates that removal of the construct from the model has 0.7% effect on PU. Consequently, these two constructs didn't support the proposed hypothesis. This shows that the perception of threat to teenage pregnancy and menstrual irregularity alone is not enough to develop perceived beliefs or 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 in contrast to the former study.

4.5.4 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*) and it has a total effects (*β=0.568, t=9.24, p=0.05*) on PEU. In addition, it has an effect size of 0.365, which indicated that removing PSE from the model has 36.5% effects on PEU. This finding is consistent with a study performed to explore factors that influence mobile health technologies using TAM in Egypt with 302 participants, which identified that PSE had a significant effect on PEU (El-Wajeeh et al., 2014); likewise, Farrag et al, (2022) identified that PSE had an impact on PEU. The study is also revealed that 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.

Chapter 5

5. Conclusion and Recommendation

5.1 Conclusion

A silent industrial revolution is going on in our world. The traditional health system is evolving to a more digital health−a client centered, self care and personalized health delivery system. Self tracking digital technologies like menstrual tracking mobile applications have been promised to meet adolescent girls' health goals, needs, wants and realities. Therefore, it is necessary to examine their perceptions on menstrual tracking mobile apps.

This paper presented a conceptual model for menstrual tracking mobile applications acceptance based on TAM and HBM. There are nine factors in the model: perceived usefulness of the app, perceived ease of use, perceived barriers of the app, perceived self efficacy, perceived threat to teenage pregnancy, perceived threat to menstrual irregularity, attitude to use the app, self tracking motivation and cues to action.

Moreover, perceived usefulness of the app significantly affects the adolescent girls attitude to use the app and their self tracking motivation reasons, which indirectly leads to a behavioral intention to use menstrual tracking mobile app. The second factor, perceived ease of use, directly impacts the girls' attitude to use the app as well as their perception on the usefulness of the app. This implies that health application developers should focus on the usefulness as well as on the ease of use of the app. In addition, if they perceive that they are confident and able to download and install the menstrual tracking mobile application, it significantly affects their perception and belief on the usefulness as well as ease of use of the menstrual tracking mobile app. Also, their belief on their ability directly impacts a positive attitude to use the app, which ultimately leads to behavioral intention to use menstrual tracking mobile apps.

The adolescent girls' perception of their ability is the key factor, predictor of acceptance of such apps. Similarly, their perceived self efficacy has a mediating impact on attitude to use through the partial mediators of perceived usefulness and ease of use of the app. In general, the girls' belief and confidence to perform tasks related to menstrual tracking mobile apps significantly

affects the other factors of acceptance. Hence, this indicates that any interventions that are design to increase the adolescent girls' self efficacy and confidence will have direct and indirect impact on their perception of usefulness, ease of use, attitude to use and to behavioral intention.

On the contrary, their perception on the barriers to use such apps directly affects their attitude to use the apps. This negative effect implies that whenever the adolescent girls' perception on the barriers to use the app increases, it leads them to develop a negative attitude towards using the app. Thus, application designers should focus on the ease of use of the app in order to reduce the adolescent girls' perceived difficulties associated with menstrual tracking mobile apps. Besides, public health intervention strategies should focus on developing the self efficacy and confidence of the adolescent girl to keep their reproductive health through such apps, which will directly reduce the perceived difficulty associated with such apps.

In addition, adolescent girls' perception and belief of threat to teenage pregnancy and menstrual irregularity has an insignificant direct effect on attitude to use the apps as well as on perceived usefulness of the apps. But, both are fully mediated through perceived usefulness of the app and have an indirect only effect on attitude to use such apps. This implies that adolescent girls', who perceive teenage pregnancy and period irregularity as a threat as well as wanting to decrease the threat, will develop a positive attitude to use menstrual tracking mobile apps through the mediator of usefulness of the apps. Hence, increasing the usefulness of the app will have a mediating effect in attracting adolescent girls' to develop the attitude to use the app in order to decrease the perceived threat to teenage pregnancy and period irregularity.

Finally, adolescent girls' positive attitude to use, their self tracking motivation reasons and cues that triggers to use such apps significantly affects behavioral intention to use menstrual tracking mobile apps. Furthermore, their positive feelings and attitude towards it is a key factor of acceptance of such apps. Also, adolescent girls' motivational reasons to track their reproductive health through mobile apps have a significant impact on acceptance of such apps. Lastly, internal or external triggers that remind them to utilize the apps have also a direct effect on behavioral intention to use menstrual tracking mobile apps.

In short, using this integrated model to investigate adolescent girls' intention to utilize menstrual tracking mobile apps has helped to understand the key predictors that affect their acceptance of

such apps. The model helped to explain the relationship between the independent and dependent variables. Also, the study contributes to the existing knowledge on self tracking technologies and specifically, on menstrual tracking mobile apps by using PLS-SEM for the analysis instead of linear method. This is because PLS-SEM measures the direct and indirect effects among the independent and dependent variables compared to the linear model. In addition, it is suitable to overcome issues related to small sample size and normality assumptions since PLS-SEM is a non parametric technique. All in all the model has a moderate predictive power as the majority (86%) of the indicator error values produced by PLS–out of sample were less than those produced by linear regression model (LM).

5.2 Recommendations/ Implication For Practice

Menstrual tracking mobile applications are believed as it will contribute to improving the healthcare service delivery, especially in reaching the adolescent group. Consequently, in order to increase its acceptance, I recommend the following actions with their strategies.

Menstrual tracking mobile applications are believed as it will contribute to improving the healthcare service delivery, especially in reaching the adolescent group. Consequently, in order to increase its acceptance, I recommend the following actions with their strategies.

1. Health software developers should focus on increasing the perceived usefulness of menstrual tracking mobile application. To make it more specific, the application designer should consider the following strategies:-
    - Ensuring the application algorithms to calculate fertile and infertile days are accurate.
    - Ensuring the application has features to track period cycle daily and to identify changes in it.
    - Ensuring the application has features to prevent pregnancy in a natural way.
    - Ensuring the application has features to track period symptom.
    - Ensuring the application has reproductive health log/diary feature.
    - Ensuring the application has features to transfer their data to inform healthcare professionals concerning their health status
    - Ensuring the applications has access to information on contraceptives, and menstrual related ideas.

2. Health software developers should focus on increasing the perceived ease of use of menstrual tracking mobile application. This can be done by:-
   - Ensuring the application operating systems are easy which doesn't require any mental effort.
   - Ensuring the application language is clear and understandable.
   - Ensuring the application is flexible for interaction and adolescent friendly.
3. Health software developers should consider the cues to action and the following strategies are so useful.
   - Ensuring the application have notification on upcoming period, cycle length, fertile days, infertile days so that adolescents can check their menstrual health status.
   - Preparing routine educational talks regarding teenage pregnancy and menstrual irregularity in the school as well as in podcast.
   - Preparing short trainings on the health benefits of tracking and personalized care.
   - Advertising the menstrual tracking mobile app.
4. Health software developers should consider in developing the adolescent girls perceived self efficacy to consume such apps. I further forwarded the following strategies:
   - Ensuring the application have reminder to log in each day.
   - Ensuring the application has easy to follow guidelines and steps to download/install.
   - Providing clear instructions with FAQs and video tutorials.
   - Providing online chat support.
5. Health software developers should consider on decreasing the perceived barriers to use menstrual tracking mobile app. And the following are some of the strategies to follow.
   - Preparing events and ensuring to work with parents so that they can support adolescent girls.
   - Ensuring support groups where other adolescents who are using this app can connect with and help new users.

6. Reference

Abita, M. Z., Girma, M. D., & Wale, T. A. (2022). Determinants of adolescent childbearing in Ethiopia, analysis of 2016 Ethiopian demographic and health survey: A case-control study. *African Health Sciences*, *22*(2), 468–474. https://doi.org/10.4314/ahs.v22i2.54

Abraham, C., & Sheeran, P. (2014a). The health belief model. *Jones and Bartlett Publishers*, 31–44. https://doi.org/10.1017/CBO9780511543579.022

Abraham, C., & Sheeran, P. (2014b). The health belief model. *Cambridge Handbook of Psychology, Health and Medicine, Second Edition, June 2015*, 97–102. https://doi.org/10.1017/CBO9780511543579.022

Admassu, T. W., Wolde, Y. T., & Kaba, M. (2022). Ethiopia has a long way to go meeting adolescent and youth sexual reproductive health needs. *Reproductive Health*, *19*(1), 1–5. https://doi.org/10.1186/s12978-022-01445-3

Advocates for Youth. (2007). Adolescent Maternal Mortality: An Overlooked Crisis. *Advocates for Youth*, 2–3.

Africa, W. R. O. for. (2021). *Report of Adolescent Health Services Barriers Assessment in Ethiopia* (p. 51).

Ahadzadeh, A. S., Pahlevan Sharif, S., Ong, F. S., & Khong, K. W. (2015). Integrating Health Belief Model and Technology Acceptance Model: An Investigation of Health-Related Internet Use. *Journal of Medical Internet Research*, *17*(2), e45. https://doi.org/10.2196/jmir.3564

Ahlan, A. R., & Ahmad, B. I. (2014). User Acceptance of Health Information Technology (HIT) in Developing Countries: A Conceptual Model. *Procedia Technology*, *16*, 1287–1296. https://doi.org/10.1016/j.protcy.2014.10.145

Ajadi, S. (2020). Digital Health A health system strengthening tool for developing countries. *GSMAm4d*, 1–40.

Alloghani, M., Hussain, A., Al-Jumeily, D., & Abuelma'atti, O. (2015). Technology Acceptance Model for the Use of M-Health Services among Health Related Users in UAE. *2015 International Conference on Developments of E-Systems Engineering (DeSE)*, 213–217. https://doi.org/10.1109/DeSE.2015.58

AlQudah, A. A., Al-Emran, M., & Shaalan, K. (2021). Technology Acceptance in Healthcare: A Systematic Review. *Applied Sciences*, *11*(22), 10537. https://doi.org/10.3390/app112210537

Ammenwerth, E. (2019). Technology Acceptance Models in ealth nformatics: TAM and UTAUT. *Studies in Health Technology and Informatics*, *263*(July 2019), 64–71. https://doi.org/10.3233/SHTI190111

Apps, U. M., & Alan, A. K. (2018). *THE ROLE OF IGNORED MOTIVATORS : INTRINSIC MOTIVATIONS ' EFFECTS ON INTENTION OF*. 20.

Atnafu, A., Otto, K., & Herbst, C. H. (2017). The role of mHealth intervention on maternal and child health service delivery: Findings from a randomized controlled field trial in rural Ethiopia. *MHealth*, *3*, 39–39. https://doi.org/10.21037/mhealth.2017.08.04

Ayalew, H. G., Liyew, A. M., Tessema, Z. T., Worku, M. G., Tesema, G. A., Alamneh, T. S., Teshale, A. B., Yeshaw, Y., & Alem, A. Z. (2022). Prevalence and factors associated with unintended pregnancy among adolescent girls and young women in sub-Saharan Africa, a multilevel analysis. *BMC Women's Health*, *22*(1), 1–9. https://doi.org/10.1186/s12905-022-02048-7

BEIS UK. (2019). Regulation for the Fourth Industrial Revolution. In *Gov.Uk* (Issue June).

Benyera, Everisto. (2022). The Fourth Industrial Revolution and Africa: A Cure Which Kills the Patient. In E. Benyera (Ed.), *Africa and the fourth Industrial Revolution Curse or Cure?* (Issue January, pp. 145–164). Springer. https://doi.org/10.1007/978-3-030-87524-4

Bhatt, P., Akanfe, O., Guo, Y., & Gong, Y. (2022). Towards a Model for Inclusive Healthcare Access post COVID-19. *Proceedings of the 55th Hawaii International Conference on System Sciences*, *January*. https://doi.org/10.24251/hicss.2022.455

Birhanu, B. E., Kebede, D. L., Kahsay, A. B., & Belachew, A. B. (2019). Predictors of teenage pregnancy in Ethiopia: A multilevel analysis. *BMC Public Health*, *19*(1), 1–10. https://doi.org/10.1186/s12889-019-6845-7

Bloem, Jaap., Doorn, M. van., Duivestein, Sander., Excoffier, David., Maas, René., & Ommeren, E. van. (2014). The Fourth Industrial Revolution: Things to Tighten the Link Between IT and OT. *Sogeti VINT*, 40.

Buabeng-andoh, C. (2018). *Predicting students ' intention to adopt mobile learning technology acceptance model*. *11*(2), 178–191. https://doi.org/10.1108/JRIT-03-2017-0004

Chambers, R. (2006). The role of the health professional in supporting self care. *Quality in Primary Care*, *14*(3), 129–131.

Champion, V. L., & Skinner, C. S. (2005). The health belief model. In: Glanz, K., Rimer B.K. and Viswanath, K., Eds. *Health Behaviour and Health Education: Theory, Research and Practice*, *4*, 45–65.

Chau, K., Lila, H., Hansen, M., Sommer, M., Lewis, M. L., Hekster, O., & Kamowa, V. (2021a). *Technical Brief on the integration of menstrual health into sexual and reproductive health and rights policies and programmes*. 1–72.

Chau, K., Lila, H., Hansen, M., Sommer, M., Lewis, M. L., Hekster, O., & Kamowa, V. (2021b). *Technical Brief on the integration of menstrual health into sexual and reproductive health and rights policies and programmes* (pp. 1–72).

Christiansen, A. M. H., Sørensen, B. L., Boas, I. M., Bedesa, T., Fekede, W., Nielsen, H. S., & Lund, S. (2023). The impact of the Safe Delivery Application on knowledge and skills managing postpartum haemorrhage in a low resource setting: A cluster randomized controlled trial in West Wollega region, Ethiopia. *Reproductive Health*, *20*(1), 1–11. https://doi.org/10.1186/s12978-023-01635-7

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed). L. Erlbaum Associates.

Creswell, J. W. (2014). *Research Design*. http://journal.um-surabaya.ac.id/index.php/JKM/article/view/2203

Critchley, H. O. D., Babayev, E., Bulun, S. E., Clark, S., Garcia-Grau, I., Gregersen, P. K., Kilcoyne, A., Kim, J. Y. J., Lavender, M., Marsh, E. E., Matteson, K. A., Maybin, J. A., Metz, C. N., Moreno, I., Silk, K., Sommer, M., Simon, C., Tariyal, R., Taylor, H. S., … Griffith, L. G. (2020). Menstruation: Science and society. *American Journal of Obstetrics and Gynecology*, *223*(5), 624–664. https://doi.org/10.1016/j.ajog.2020.06.004

Davis, F. D., & Davis, F. (1989). *Perceived Usefulness , Perceived Ease of Use , and User Acceptance of Information Technology*. *September*. https://doi.org/10.2307/249008

Deloitte. (2020). The Fourth Industrial Revolution: At the intersection of readiness and responsibility. *Deloitte Insights*, 25. https://doi.org/10.4337/9781786430328.00006

Dijkstal, F., Stankovic, M., & Ploeg, M. (2019). Potential of the fourth industrial revolution in Africa. *Research ICT Africa*, *October*, 137. https://doi.org/10.13140/RG.2.2.14260.12163

Drost, E. A. (2004). *Validity and Reliability in Social Science Research*. *38*(1), 105–125.

Dudouet, L. (2022). Digitised fertility: The use of fertility awareness apps as a form of contraception in the United Kingdom. *Social Sciences & Humanities Open*, *5*(1), 100261. https://doi.org/10.1016/j.ssaho.2022.100261

El-Wajeeh, M., H. Galal-Edeen, Prof. G., & Mokhtar, Dr. H. (2014). Technology Acceptance Model for Mobile Health Systems. *IOSR Journal of Mobile Computing & Application*, *1*(1), 21–33. https://doi.org/10.9790/0050-0112133

Endehabtu, B. F., Endehabtu, B. F., Tadesse, Y., Gelagay, A. A., Tilahun, B., Mekonnen, Z. A., & Gashu, K. D. (2019). Willingness to Use Mobile based e-Partograph and Associated Factors among Care Providers in North Gondar Zone, Northwest Ethiopia. *Online Journal of Public Health Informatics*, *11*(2). https://doi.org/10.5210/ojphi.v11i2.9468

Endehabtu, B., Weldeab, A., Were, M., Lester, R., Worku, A., & Tilahun, B. (2018). Mobile phone access and willingness among mothers to receive a text-based mhealth intervention to improve prenatal care in northwest ethiopia: Cross-sectional study. *JMIR Pediatrics and Parenting*, *1*(2), 1–13. https://doi.org/10.2196/pediatrics.9618

Farrag, M., & elsayed, manal. (2022). TECHNOLOGY ACCEPTANCE MODEL AS A MEDIATOR EXPLAINING FACTORS AFFECTING ONLINE EDUCATION. □□ □ □□ □ □□ □□□ □□ □□ □□ □, *0*(0), 0–0. https://doi.org/10.21608/aja.2022.104817.1177

Fatehi, F., Samadbeik, M., & Kazemi, A. (2020). What is digital health? Review of definitions. *Studies in Health Technology and Informatics*, *275*(December), 67–71. https://doi.org/10.3233/SHTI200696

Federal Democratic Republic Of Ethiopia, F. (2020). Digital Ethiopia 2025: A Digital Strategy For Ethiopia Inclusive Prosperity. In *FDRE*. https://doi.org/10.1007/978-3-030-42088-8_11

Fernandes, C., Claro, N., Monteiro, S., Pires, I. M., & Gouveia, A. J. (2022). The evolution of IS/IT in health care in last decades. *Procedia Computer Science*, *203*(2021), 707–713. https://doi.org/10.1016/j.procs.2022.07.105

Fitzpatrick, A. R. (1983). The Meaning of Content Validity. *Applied Psychological Measurement*, *7*(1), 3–13. https://doi.org/10.1177/014662168300700102

Flores, M., Glusman, G., Brogaard, K., Price, N. D., & Hood, L. (2013). P4 medicine: How systems medicine will transform the healthcare sector and society. *Personalized Medicine*, *10*(6), 565–576. https://doi.org/10.2217/pme.13.57

Fornell, C., & Larcker, D. F. (1981). Evaluating Structural Equation Models with Unobservable Variables and Measurement Error. *Journal of Marketing Research*, *18*(1), 39. https://doi.org/10.2307/3151312

Fowler, L. R., Gillard, C., & Morain, S. (2020). Teenage Use of Smartphone Applications for Menstrual Cycle Tracking. *Pediatrics*, *145*(5), e20192954. https://doi.org/10.1542/peds.2019-2954

Fox, L., & Signe, L. (2021). The Fourth Industrial Revolution (4IR) and the Future of Work: Could this Bring Good Jobs to Africa. *Evidence Synthesis Paper Series*, 1–48.

Gazibara, T. (2020). High School Girls and Smartphone Applications to Track Menstrual Cycle. *The Central European Journal of Paediatrics*, *16*(2), 132–139. https://doi.org/10.5457/p2005-114.269

Gazibara, T., Cakic, J., Cakic, M., Grgurevic, A., & Pekmezovic, T. (2020). High school girls and smartphone applications to track menstrual cycle. *Central European Journal of Paediatrics*, *16*(2), 132–139. https://doi.org/10.5457/p2005-114.269

Gesselleen, M. van. (2013). Attitudes and beliefs of the experience of menstruation in female students at the University of the Western Cape. *University of Western Cape*, *November*, 1–89.

Gibson, C. J., Dixon, B. E., & Abrams, K. (2015). Convergent evolution of health information management and health informatics: A perspective on the future of information professionals in health care. *Applied Clinical Informatics*, *6*(1), 163–184. https://doi.org/10.4338/ACI-2014-09-RA-0077

Gimpel, Henner., Niben, Marcia., & A. Gorlitz, Roland. (2013). QUANTIFYING THE QUANTIFIED SELF: A STUDY ON THE MOTIVATION OF PATIENTS TO TRACK THEIR OWN HEALTH. *Thirty Fourth International Conference on Information Systems*, *Milan*, 1–16.

GSMA. (2021). *The Mobile Economy Sub-Saharan Africa 2021*. 50.

Gurumurthy, A. (2022). *Beyond data bodies: New directions for a feminist theory*. *February*.

Hair, J. F., Hult, G. T. M., Ringle, C. M., Sarstedt, M., Danks, N. P., & Ray, S. (2021). *Partial Least Squares Structural Equation Modeling (PLS-SEM) Using R: A Workbook*. Springer International Publishing. https://doi.org/10.1007/978-3-030-80519-7

Hardon, A., Pell, C., Taqueban, E., & Narasimhan, M. (2019). Sexual and reproductive self care among women and girls: Insights from ethnographic studies. *BMJ (Online)*, *365*, 1–4. https://doi.org/10.1136/bmj.l1333

Haroun, H. S. W. (2016). *Reproductive cycles in females*. *2*(2), 62–64. https://doi.org/10.15406/mojwh.2016.02.00028

Henseler, J. (2021). *Composite-based structural equation modeling: Analyzing latent and emergent variables*. The Guilford Press.

Hohmann-Marriott, B., & Starling, L. (2022). "What if it's wrong?" Ovulation and fertility understanding of menstrual app users. *SSM - Qualitative Research in Health*, *2*(February), 9. https://doi.org/10.1016/j.ssmqr.2022.100057

Hossain, M. B., Alam, Z., Islam, S., & Sultan, S. (2021). *Health Belief Model , Theory of Planned Behavior , or Psychological Antecedents: What Predicts COVID-19 Vaccine Hesitancy Better Among the Bangladeshi Adults ?* *9*(August), 1–10. https://doi.org/10.3389/fpubh.2021.711066

House Sarah, Mahon Therese, C. S. (2012). *Price rivers pass through these mountains in narrow , winding bird migration into this region seems to come directly from encou / qter a mountain range standing across their pathway which The Northern Sage Sparrow (, 4mphispiza belli nevadensis) is after*. 1–347.

John Snow Inc. (2021). *Digital Health Activity (DHA) Annual Report, Activity Year II* (p. 68). https://pdf.usaid.gov/pdf_docs/PA00Z4ZK.pdf

Kassa, B. G., Belay, H. G., & Ayele, A. D. (2021). Teenage pregnancy and its associated factors among teenage females in Farta woreda, Northwest, Ethiopia, 2020: A community-based cross-sectional study. *Population Medicine*, *3*, 1–8. https://doi.org/10.18332/popmed/139190

Kassa, G. M., Arowojolu, A. O., Odukogbe, A. A., & Yalew, A. W. (2018a). Prevalence and determinants of adolescent pregnancy in Africa: A systematic review and Meta-analysis. *Reproductive Health*, *15*(1), 1–18. https://doi.org/10.1186/s12978-018-0640-2

Kassa, G. M., Arowojolu, A. O., Odukogbe, A. A., & Yalew, A. W. (2018b). Prevalence and determinants of adolescent pregnancy in Africa: A systematic review and Meta-analysis. *Reproductive Health*, *15*(1), 1–17. https://doi.org/10.1186/s12978-018-0640-2

Kassa, Z. Y., Tenaw, Z., Astatkie, A., Siyoum, M., Bekele, G., Taye, K., Mekonnen, S., & Kassaye, Z. (2019). Mobile phone based strategies for preconception education in rural africa. *Annals of Global Health*, *85*(1), 1–11. https://doi.org/10.5334/aogh.2544

Kebede, A. S., Ajayi, I. O. O., & Arowojolu, A. O. (2019). Effect of enhanced reminders on postnatal clinic attendance in Addis Ababa, Ethiopia: A cluster randomized controlled trial. *Global Health Action*, *12*(1). https://doi.org/10.1080/16549716.2019.1609297

Kebede, E., Mesfin, E., & Singh, M. R. (2021). *Age at menarche; Factors that Influence It, and Menstrual Pattern of Secondary School Adolescents in Addis Ababa, Ethiopia*. https://www.emjema.org/index.php/EMJ/article/view/1735/733

Ketikidis, P., Dimitrovski, T., Lazuras, L., & Bath, P. A. (2012). Acceptance of health information technology in health professionals: An application of the revised technology acceptance model. *Health Informatics Journal*, *18*(2), 124–134. https://doi.org/10.1177/1460458211435425

Kim, J., & Park, H. (2012a). *Development of a Health Information Technology Acceptance Model Using Consumers ' Health Behavior Intention Corresponding Author : 14*, 1–14. https://doi.org/10.2196/jmir.2143

Kim, J., & Park, H.-A. (2012b). Development of a Health Information Technology Acceptance Model Using Consumers' Health Behavior Intention. *Journal of Medical Internet Research*, *14*(5), e133. https://doi.org/10.2196/jmir.2143

Kock, N., & Hadaya, P. (2018). Minimum sample size estimation in PLS-SEM: The inverse square root and gamma-exponential methods: Sample size in PLS-based SEM. *Information Systems Journal*, *28*(1), 227–261. https://doi.org/10.1111/isj.12131

Kothari, C. R. (2004). *Research Methdology, Methods and Techniques*. New Age International Publishers.

Levy, Johanna., & Romo-Aviles, Nuria. (2019). *" 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*. *8*, 1–11.

Little, A., Medhanyie, A., Yebyo, H., Spigt, M., Dinant, G. J., & Blanco, R. (2013). Meeting community health worker needs for maternal health care service delivery using appropriate mobile technologies in Ethiopia. *PloS One*, *8*(10), 1–14. https://doi.org/10.1371/journal.pone.0077563

Lund, S., Boas, I. M., Bedesa, T., Fekede, W., Nielsen, H. S., & Sørensen, B. L. (2016). Association between the safe delivery app and quality of care and perinatal survival in Ethiopia: A randomized clinical trial. *JAMA Pediatrics*, *170*(8), 765–771. https://doi.org/10.1001/jamapediatrics.2016.0687

Lupton, D. (2013). Quantifying the body: Monitoring and measuring health in the age of mHealth technologies. *Critical Public Health*, *23*(4), 393–403. https://doi.org/10.1080/09581596.2013.794931

Lupton, D. (2016a). Digitised health , medicine and risk. *Health, Risk & Society*, *17*(7–8), 473–476. https://doi.org/10.1080/13698575.2015.1143247

Lupton, D. (2016b). Digitised health, medicine and risk. *Health, Risk and Society*, *17*(7–8), 473–476. https://doi.org/10.1080/13698575.2015.1143247

Lupton, D. (2016c). Introduction. In *The Quantified Self A Sociology of Self* (pp. 1–7).

Lupton, D. (2016d). The diverse domains of quantified selves: Self-tracking modes and dataveillance. *Economy and Society*, *45*(1), 101–122. https://doi.org/10.1080/03085147.2016.1143726

Ma, Q., & Liu, L. (2011). The Technology Acceptance Model. *Advanced Topics in End User Computing, Volume 4, October 2017*. https://doi.org/10.4018/9781591404743.ch006.ch000

Maharaj, N. R. (2022). Adolescent pregnancy in sub-Saharan Africa – a cause for concern. *Frontiers in Reproductive Health*, *4*(December), 1–5. https://doi.org/10.3389/frph.2022.984303

Mamo, K., Siyoum, M., & Birhanu, A. (2021). Teenage pregnancy and associated factors in Ethiopia: A systematic review and meta-analysis. *International Journal of Adolescence and Youth*, *26*(1), 501–512. https://doi.org/10.1080/02673843.2021.2010577

Mamphiswana, R., & Bekele, M. (2020). The fourth industrial revolution: Prospects and challenges for Africa. *Towards the Digital World and Industry X.0 - Proceedings of the*

29th International Conference of the International Association for Management of Technology, IAMOT 2020, 264–275.

Manyazewal, T., Woldeamanuel, Y., Blumberg, H. M., & Fekadu, A. (2021). *The potential of digital health technologies in African context , Ethiopia*. 1–32.

Marent, Benjamin., & Henwood, Flis. (2021). Digital Health. *ResearchGate*, 17. https://doi.org/10.1016/j.soncn.2020.151085

Mathewos, S., & Mekuria, A. (2018). Teenage Pregnancy and Its Associated Factors among School Adolescents of Arba Minch Town, Southern Ethiopia. *Ethiopian Journal of Health Sciences*, *28*(3), 287–298. https://doi.org/10.4314/ejhs.v28i3.6

Medhanyie, A. A., Little, A., Yebyo, H., Spigt, M., Tadesse, K., Blanco, R., & Dinant, G. J. (2015). Health workers' experiences, barriers, preferences and motivating factors in using mHealth forms in Ethiopia. *Human Resources for Health*, *13*(1), 1–10. https://doi.org/10.1186/1478-4491-13-2

Mezmur, H., Assefa, N., & Alemayehu, T. (2021). Teenage pregnancy and its associated factors in eastern ethiopia: A community-based study. *International Journal of Women's Health*, *13*, 267–278. https://doi.org/10.2147/IJWH.S287715

Mittiku, Y. M., Mekonen, H., Wogie, G., Tizazu, M. A., & Wake, G. E. (2022). Menstrual irregularity and its associated factors among college students in Ethiopia, 2021. *Frontiers in Global Women's Health*, *3*. https://doi.org/10.3389/fgwh.2022.917643

MoH. (2021). Digital health BluePrint. In *MoH* (Issue August). https://doi.org/10.4324/9781003185215-24

Mohamed, N. C., Moey, S., & Lim, B. (2019). *Validity and Reliability of Health Belief Model Questionnaire for Promoting Breast Self-Examination and Screening Mammogram for Early Cancer Detection*. *20*, 2865–2873. https://doi.org/10.31557/APJCP.2019.20.9.2865

Narasimhan, M., Logie, C. H., Gauntley, A., Gomez, R., Leon, P. D., Gholbzouri, K., Siegfried, N., Abela, H., Narasimhan, M., Logie, C. H., Gauntley, A., Gomez, R., Leon, P. D., Gholbzouri, K., Siegfried, N., Abela, H., & Ouedraogo, L. (2020). *Self-care interventions for sexual and reproductive health and rights for advancing universal health coverage*. https://doi.org/10.1080/26410397.2020.1778610

Niculaescu, C., & Landa-avila, I. C. (2021a). *Using the Health Belief Model to design a questionnaire aimed at measurin g people ' s perceptions regarding COVID-19 immunity certificates*. 1–14.

Niculaescu, C., & Landa-avila, I. C. (2021b). *Using the Health Belief Model to design a questionnaire aimed at measurin g people ' s perceptions regarding COVID-19 immunity certificates*. 1–14.

Njuguna, N., & Landry, S. (2020). The Fourth Industrial Revolution and digitization will transform Africa into a global powerhouse. In *Foresight Africa 2020 report* (pp. 1–14).

Olusola Oladeji, M. T., & Oladeji, B. (2022). Strengthening quality of maternal and newborn careusing catchment based clinical mentorship and safedelivery app: A case study from Somali region ofEthiopia. *International Journal of Midwifery and Nursing Practice*, *5*(1), 13–18.

Orji, R., Vassileva, J., & Mandryk, R. (2012). Towards an Effective Health Interventions Design: An Extension of the Health Belief Model. *Online Journal of Public Health Informatics, 4*(3). https://doi.org/10.5210/ojphi.v4i3.4321

Pan American Health Organization. (2021). *From the Evolution of Information Systems for Health to the Digital Transformation of the Health Sector. IS4H Conference Report*. General Publications. https://iris.paho.org/handle/10665.2/53364

Parellada, C. B., Boas, I. M., Nielsen, H. S., Sørensen, B. L., & Lund, S. (2020). *Journal of Health Informatics in Developing Countries Submitted: February 13 th , 2020 Accepted: March 21 st 2020 User patterns of the Safe Delivery App ; explorations from a cluster randomized controlled trial in Ethiopia*. *14*(1), 1–13.

Privacy International. (2019). *No Body's Business But Mine: How Menstruation Apps Are Sharing Your Data*. 9th September 2019. https://privacyinternational.org/long-read/3196/no-bodys-business-mine-how-menstruations-apps-are-sharing-your-data

Rasanathan, K., & Evans, T. G. (2020). Changes in health since Alma-Ata. *Policy and Practice, July*, 801–808.

Remme, M., Narasimhan, M., Wilson, D., Ali, M., Vijayasingham, L., Ghani, F., & Allotey, P. (2019). Self care interventions for sexual and reproductive health and rights: Costs, benefits, and financing. *BMJ (Online)*, *365*, 1–6. https://doi.org/10.1136/bmj.l1228

Rowlands, David. (2019). What is Digital Health? And Why Does it Matter? *Digital Workforce Academy*, 38.

Schwab, K. (2016). *The Fourth Industrial Revolution*. World Economic Forum.

Self Care Forum. (2020). What do we mean by self care and why is it good for people? *Self Care Forum*. https://www.selfcareforum.org/about-us/what-do-we-mean-by-self-care-and-why-is-good-for-people/

Serbessa, H., Makonnen, T., & Abi, M. (2023). THE CONTRIBUTION OF URBAN AGRICULTURE TO HOUSEHOLD FOOD SECURITY AMONG URBAN VEGETABLE PRODUCERS IN ADDIS ABABA, ETHIOPIA. *Journal of Sustainable Development in Africa*, *Volume 25, No.1*(ISSN: 1520-5509).

Sharon, T. (2017). Self-Tracking for Health and the Quantified Self: Re-Articulating Autonomy, Solidarity, and Authenticity in an Age of Personalized Healthcare. *Philosophy and Technology*, *30*(1), 93–121. https://doi.org/10.1007/s13347-016-0215-5

Shiferaw, S., Spigt, M., Tekie, M., Abdullah, M., Fantahun, M., & Dinant, G. J. (2016). The effects of a locally developed mHealth intervention on delivery and postnatal care utilization; A prospective controlled evaluation among health centres in Ethiopia. *PLoS ONE*, *11*(7), 1–14. https://doi.org/10.1371/journal.pone.0158600

Snowdon, A. (2020). *A FrameWork For Health Care Transformation*. *36*.

Snowdon, A. (2021). Digital Health: A Framework for Healthcare Trandformation. *HIMSS*, 70.

Snowdon, Anne., Schnarr, Karin., & Alessi, Charles. (2014). " It ' s All About Me ": The Personalization of Health Systems. *International Center for Health Innovation: Western HealthSciences*, *February*, 60.

SÜRÜCÜ, L., & MASLAKÇI, A. (2020). Validity and Reliability in Quantitative Research. *Business & Management Studies: An International Journal*, *8*(3), 2694–2726. https://doi.org/10.15295/bmij.v8i3.1540

Swan, M. (2012). Health 2050: The realization of personalized medicine through crowdsourcing, the quantified self, and the participatory biocitizen. *Journal of Personalized Medicine*, *2*(3), 93–118. https://doi.org/10.3390/jpm2030093

Swan, M. (2013). The quantified self: Fundamental disruption in big data science and biological discovery. *Big Data*, *1*(2), 85–99. https://doi.org/10.1089/big.2012.0002

T, N., R, C., M, M., S, L., A, B., A, T., O, B., J, B., Clinton, M. T., K, W., R, K., B, H.-R., M, D., J, W., J, L., D, M., P, D., S, B., S, D. G., … B, K. P. (2020). *Self-Care for Health: A National Policy Blueprint* (Issue October).

Tadesse, E. (2016). *The Role of Micro and Small Enterprises on Local Economic Development: The case of Nifas Silk Lafto Sub- city*. *January*, 92.

Taherdoost, H. (2017). *Validity and Reliability of the Research Instrument ; How to Test the Validation of a Questionnaire / Survey in a Research*. *January 2016*. https://doi.org/10.2139/ssrn.3205040

Tesfachew, T. (2022). Ethiopia ' s d rive to advance digital transformation. *United Nations Conference on Trade and Development*, *02*(April), 14.

Thomsen, C. F., Barrie, A. M. F., Boas, I. M., Lund, S., Sørensen, B. L., Oljira, F. G., & Tersbøl, B. P. (2019). Health workers' experiences with the Safe Delivery App in West Wollega Zone, Ethiopia: A qualitative study. *Reproductive Health*, *16*(1), 1–11. https://doi.org/10.1186/s12978-019-0725-6

UNICEF WASH. (2022). Menstrual health and hygiene. *The World Bank*, *5*(3), 92.

UNIDO. (2019). Bracing for the New Industrial Revolution Elements of a Strategic Response Discussion paper. *UNIDO*, 20.

United Nations Conference on Trade and Development. (2021). *Technology And innovation Report 2021* (p. 196).

Wall, J. M. (2009). *By The University of Utah in partial fulfillment of the requirements for the degree of fulfillment of Department of Health Promotion and Education Copyright ©*. *August*.

Wash, U. (2017). *Menstrual Hygiene Management In Ethiopia National Baseline Report from Six Regions of*. *1*.

WHO. (2017). *Building a Digital Information Infrastructure (Infostructure) for Health*.

WHO. (2018). Declaration of Astana. *Who*, 2893–2894.

WHO. (2021). Global Strategy on Digital Health 2020-2025. In *WHO*. https://doi.org/10.1007/s13312-020-1789-7

Wold, H. (1980). Model Construction and Evaluation When Theoretical Knowledge Is Scarce. In *Evaluation of Econometric Models* (pp. 47–74). Academic Press.

https://www.nber.org/books-and-chapters/evaluation-econometric-models/model-construction-and-evaluation-when-theoretical-knowledge-scarce

Worku, M. G., Tessema, Z. T., Teshale, A. B., Tesema, G. A., & Yeshaw, Y. (2021). Prevalence and associated factors of adolescent pregnancy (15–19 years) in East Africa: A multilevel analysis. *BMC Pregnancy and Childbirth*, *21*(1), 1–8. https://doi.org/10.1186/s12884-021-03713-9

World Health Organization. (2009). Self-care in the Context of Primary Health Care; Report of the Regional Consultation Bangkok, Thailand, 7-9 Januari 2009. *World Health Organization*, *January*, 80.

World Health Organization [WHO]. (2021a). *WHO Guideline on self-care interventions for health and well-being*.

World Health Organization [WHO]. (2021b). *WHO Guideline on self-care interventions for health and well-being*.

WSSCC. (2018). As We Grow Up: A Tactile Book on Menstrual Hygiene Management. *United Nations Office for Project Services (UNOPS)*, *1*.

Wu, X., Zhao, M., & Liao, H. T. (2020). Integrating Health Belief Model, Technological Self-efficacy, and the PEN-3 cultural model: Conceptualizing the impact of culture and technology on aalth for advancing Sustainable Smart Health. *E3S Web of Conferences*, *218*. https://doi.org/10.1051/e3sconf/202021802019

Yakubu, I., & Salisu, W. J. (2018). Determinants of adolescent pregnancy in sub-Saharan Africa: A systematic review. *Reproductive Health*, *15*(1). https://doi.org/10.1186/s12978-018-0460-4

Zaineldeen, S., Hongbo, L., Koffi, A. L., & Hassan, B. M. A. (2020). Technology acceptance model' concepts, contribution, limitation, and adoption in education. *Universal Journal of Educational Research*, *8*(11), 5061–5071. https://doi.org/10.13189/ujer.2020.081106

Zeleke, L. B., Alemu, A. A., Kassahun, E. A., Aynalem, B. Y., Hassen, H. Y., & Kassa, G. M. (2021). Individual and community level factors associated with unintended pregnancy among pregnant women in Ethiopia. *Scientific Reports*, *11*(1), 1–9. https://doi.org/10.1038/s41598-021-92157-4

7. Appendices

7.1 Adolescent Girls Self Administered Survey Questionnaire

Respondent Consent Form

My name is Bernabas Petros, and I am a Masters graduate student at Addis Ababa University, College of Development. I am inviting you to participate in a research study. Involvement in the study is voluntary, so you may choose to participate or not. I am now going to explain the study to you. Please feel free to ask any questions that you may have about the research; I will be happy to explain anything in greater detail. I am interested in learning more about menstrual cycle mobile application acceptance among adolescent girls. You will be asked to scale (1 to 7) your agreement or disagreement to the statements stated in the questionnaires. This will take approximately 15-20 min of your time. All information will be kept anonymous and confidential. Be noted that the results of the study will be disseminated to Addis Ababa Public Health Research and Emergency Management Directorate. The benefit of this research is that you will be helping us to understand determinants of menstrual cycle mobile application acceptance among adolescent girls. This information would help us to identify the key determinants in order to develop menstrual tracking mobile application and other related adolescent friendly technologies in our contexts. If you do not wish to continue, you have the right to withdraw from the study, without penalty, at any time. Hence, if you have any question, you can contact the researcher Mr. Bernabas Petros (0911998036 or barnifull@gmail.com) or the supervisor Dr. Yeshtila Wondemeneh (yeshwonde@gmail.com).

I voluntarily agree to participate in this research project

1. Yes
2. No

Appendix 1: Section I: Respondents Socio-Demographic Characteristics

Respondent's Characteristics			
No	**Questions**	**Answer**	**Skip**
	What is your name?		
	How old are you?	1. 13 years old 2. 14 years old 3. 15 years old 4. 16 years old 5. 17 years old 6. 18 years old 7. 19 years old	
	Where did you learn?		
	Which grade are you?	1. 7 2. 8 3. 9 4. 10 5. 11 N/S	

		6. 11 S/S 7. 12 N/S 8. 12 S/S	
	What is your average grade point in the first semester?		
	What is your religion?	1. Orthodox Christian 2. Catholic 3. Protestant 4. Muslim 5. Others (specify)	
	What is the average monthly income of your parents?		
	What is the highest education your parents completed?	1. Primary 2. Secondary 3. Technical/Vocational 4. Undergraduate degree 5. Graduate degree	
	Are you menstruating?	1. Yes 2. No	
	At what age was your first period?	1. 10 years old 2. 11 years old 3. 12 years old 4. 13 years old 5. 14 years old 6. 15 years old 7. 16 years old	
	Is your period cycle regular?	1. Yes 2. No	
	Including the current year, for how many years have you been using a smartphone?	1. 0-2 2. 3-5 3. Over 5	
	Do you have the experience of self-tracking app usage?	1. Yes (What is it? _____) 2. No	
	Do you know the menstrual tracking mobile app?	1. Yes 2. No	If No (2), go to section II.
	Do you have the experience of menstrual tracking app usage?	1. Yes (For how many years? _____) 2. No	

Appendix 2: Section II: Your Views on Menstrual Tracking Mobile Application

1. **Strongly Disagree**
2. **Moderately Disagree**
3. **Slightly Disagree**
4. **Neutral**
5. **Slightly Agree**

6. **Moderately Agree**
7. **Strongly Agree**

No	Construct	1	2	3	4	5	6	7	
Perceived Usefulness (Benefits) of the Menstrual Tracking Mobile Application									
1.	Menstrual tracking mobile application will enable me to accomplish tasks quickly (e.g. in tracking my period cycle dates as well as identifying my fertile, infertile and upcoming periods).								
2.	Using menstrual tracking mobile applications in preventing pregnancy naturally will increase my productivity.								
3.	Using a menstrual tracking mobile application will improve my performance to track my period.								
4.	Menstrual tracking mobile application will make it easier to verify my menstrual sensations and experiences.								
5.	Using menstrual tracking mobile applications will enhance my effectiveness on informing healthcare professionals concerning my health status.								
6.	Menstrual tracking mobile application will give me access to information on contraceptives, and menstruation related ideas.								
7.	Using a menstrual tracking mobile application will give me greater control over my body.								
8.	I would find a menstrual tracking mobile application								

	will be useful in tracking my period and identifying changes in it.								
9.	The advantages of menstrual tracking mobile applications surpass the disadvantage.								*Removed after the pilot test*
Perceived Ease of Use of the Menstrual Tracking Mobile Application									
10.	Learning to operate a menstrual tracking mobile application would be easy for me.								
11.	I would find it easy to get menstrual tracking mobile applications to do what I want it to do.								
12.	My interaction with the menstrual tracking mobile application would be clear and understandable.								
13.	I would find menstrual tracking mobile applications to be flexible to interact with.								*Removed after the pilot test*
Perceived Barriers of the Menstrual Tracking Mobile Application									
14.	I'm afraid that my data will be passed on to third parties without my consent or commercialized.								(Champion, V. L., & Skinner, 2005; Mohamed et al., 2019; Niculaescu & Landa-avila, 2021a; Wall, 2009)*Removed after the pilot test*
15.	This service will be difficult for me to access if offered exclusively in English.								*Removed after the pilot test*
16.	Using a menstrual tracking mobile app will be difficult and uncomfortable.								
17.	Menstrual tracking mobile application will consume my time.								
18.	Using menstrual tracking mobile application is prohibited in my cultural and								

	religion beliefs.								
19.	My family didn't allow and support me to use menstrual tracking mobile application.								
Perceived Self Efficacy									
20.	I can download a menstrual tracking mobile application when I want to.								
21.	A reminder notification on my smartphone to log in each day would be important to my use of menstrual tracking mobile app.								
22.	I am confident that I will remember to use a menstrual tracking mobile application when I want to prevent pregnancy.								*Removed in PLS-SEM analysis in order to improve the reliability and convergent validity.*
23.	I can find ways to pay for menstrual tracking mobile applications.								*Removed after the pilot test*
Perceived Threat to Menstrual Irregularities and Teenage Pregnancy									
24.	There is a good possibility that I will get menstrual irregularities.								*Removed after the pilot test*
25.	I am susceptible to menstrual irregularities.								*Removed in PLS-SEM analysis in order to improve the reliability and convergent validity.*
26.	I worry a lot about menstrual irregularities.								*Removed in PLS-SEM analysis in order to improve the reliability and convergent validity.*
27.	My feelings about myself would change if my period is irregular.								
28.	When I think about menstrual irregularities I feel nauseous.								
29.	Menstrual irregularities would threaten my daily activities.								

30.	I am afraid even to think about teenage pregnancy.								*Removed after the pilot test*
31.	I feel that my chance of teenage pregnancy is high.								*Removed in PLS-SEM analysis in order to improve the reliability and convergent validity.*
32.	I feel that my friends are at risk of teenage pregnancy.								*Removed in PLS-SEM analysis in order to improve the reliability and convergent validity.*
33.	The thought of teenage pregnancy scares me.								
34.	If I were pregnant, my education would be endangered.								
35.	Teenage pregnancy would threaten my relationship to my family and relatives.								
Attitude to use the App									
36.	I have positive feelings towards the use of menstrual tracking mobile application technologies.								(Buabeng-andoh, 2018; Davis & Davis, 1989)
37.	Using a menstrual tracking mobile application is a wise idea.								
38.	I have no objection of using menstrual tracking mobile app if available.								
Cues to action									
39.	If I see my friends using menstrual tracking mobile app, it reminds me to use of it.								
40.	Routine educational talks regarding teenage pregnancy and menstrual irregularity awareness would help me to get menstrual tracking mobile app.								
41.	I am confident that I will remember to use a menstrual								*Removed after the pilot test*

		tracking mobile application when I want to track my period.								
42.		My social media (Facebook, telegram etc) reminds me to use menstrual tracking mobile app.								*Removed after the pilot test*
Self Tracking Motivation to use the Menstrual Tracking Mobile App **I like menstrual tracking mobile app because…**										
43.	**Self entertainment**	…I enjoy getting lost totally in self-tracking activities.								*Removed after the pilot test*
44.		…It is fun and entertaining.								*Removed in PLS-SEM analysis in order to improve the reliability and convergent validity.*
45.		…I like playing around with my smartphone.								*Removed in PLS-SEM analysis in order to improve the reliability and convergent validity.*
46.	**Self association**	…I want to help/inspire others.								*Removed in PLS-SEM analysis in order to improve the reliability and convergent validity.*
47.		…I want to compare my results to others.								*Removed after the pilot test*
48.		…I want to present myself to others.								*Removed after the pilot test*
49.	**Self design**	…I want to manipulate factors that affect my period regularity.								
50.		…I enjoy being my own master/self sovereignty.								*Removed in PLS-SEM analysis in order to improve the reliability and convergent validity.*
51.		…I'm interested to know how my period cycle works.								
52.		…it helps me to optimize my menstrual health.								

53.	**Self discipline**	…it motivates me to keep on working for a goal (e.g. to prevent adolescent pregnancy naturally).								
54.		...it motivates me to avoid period irregularity.								
55.		…it facilitates my self-discipline.								
56.	**Self healing**	…I don't trust in the healthcare system.								*Removed after the pilot test*
57.		…I want to be independent from traditional medical treatments								*Removed after the pilot test*
Behavioral Intention to use Menstrual Tracking Mobile Application										
58.		I intended to continue to use menstrual tracking mobile app in future.								
59.		I expect that I would use menstrual tracking mobile app in future.								*Removed after the pilot test*
60.		I plan to use menstrual tracking mobile app in future.								
61.		I look forward to those aspects of my menstrual health that require me to use menstrual tracking mobile applications technologies.								*Removed in PLS-SEM analysis in order to improve the reliability and convergent validity.*

7.2 Key Informant Interview Questions

1. What is menstrual irregularity? How did you describe menstrual irregularity? What is your experience concerning period irregularity? What did you feel when your period is irregular?
2. What are the causes for menstrual irregularity? Why is your period irregular?
3. What are the solutions for menstrual irregularity? What did you do if your period is irregular?
4. How did you see teenage pregnancy?
5. What are the challenges if a teenage girl is pregnant?
6. What solutions did you recommend for a teenage girl to prevent teenage pregnancy? How did you prevent teenage pregnancy?

7.3 Background Profile

I am Bernabas Petros (sex: male). I studied Bachelor of Science (BSc) in Midwifery at Addis Ababa University, faculty of medicine from 2016-2020. I also studied Bachelor of Arts (BA) in Management at St. Mary's University from 2017 to 2021 as well as Bachelor of Theology (BTh) in Community Development at Evangelical Theological College from 2017 to 2022. In addition, I took an online education on sexual reproductive health rights (SRHR) given by the collaboration of Health [e] Foundation, Amsterdam Medical College, Addis Ababa University, and Ethiopian Midwife Associations in 2021. I also involved in volunteer activities as adolescent health counselor at civil society organizations. I am very interested in health related research and sustainable development of my country.