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Role of pH and Temperature Metrics in Fertility and Menstrual Health: A Global and Ethnic Perspective - Literature Review

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ABSTRACT

Objectives: *To examine the role of vaginal pH and basal body temperature (BBT) metrics in enhancing fertility and menstrual health across global and ethnic contexts.*

Setting: *Analysis of global and ethnic variations in fertility and menstrual health.*

Intervention: *A critical examination of non-invasive measures such as vaginal pH and BBT, along with factors like ethnicity, diet, lifestyle, and geographical location, in predicting ovulation and improving reproductive health outcomes.*

Main Outcome Measure: *The potential of vaginal pH and BBT monitoring, supported by technology, in offering personalized reproductive health insights.*

Results & Conclusion: *Variations in pH and BBT monitoring are observed across different ethnic groups, influenced by external factors. Findings suggest that integrating these metrics with educational and interventional programs can benefit women's psycho-social behaviors, quality of life, and emotional well-being. Further research is needed to validate these methods and explore their application in clinical settings, aiming to provide reliable, accessible tools for managing reproductive health with a personalized approach.*

Keywords

Vaginal pH, Basal Body Temperature, Fertility, Menstrual Health, Ethnicity, Non-Invasive Methods, Reproductive Health.

Introduction

Understanding the intricate dynamics of female reproductive health has always been a cornerstone of gynecological research [1]. Central to this exploration is the study of vaginal pH and basal body temperature (BBT) metrics which serve as pivotal, non-invasive indicators of fertility and overall menstrual health [2]. The significance of pH and BBT in the reproductive domain is rooted in their impact on vaginal microbiota, enzyme activity, and hormonal balance, all of which are crucial for maintaining fertility and a healthy menstrual cycle [3]. Variations in vaginal pH and BBT have been linked to different phases of the menstrual cycle and can serve as indicators of fertility windows, potential infections, and hormonal imbalances [4,5]. However, the interpretation and relevance of these metrics can vary across different ethnicities and geographies due to genetic, environmental, and lifestyle factors, making it imperative to adopt a comprehensive and inclusive research approach.

This literature review delves into the efficacy of these metrics within the context of diverse global and ethnic backgrounds, reflecting on how ethnicity, diet, lifestyle, and geographical variations influence their reliability and application in predicting ovulation and enhancing fertility outcomes. Recent advancements in digital health technology, such as those being developed by companies like Yon E, have further propelled the integration of pH and BBT monitoring into everyday health management, promising

personalized healthcare solutions [6]. However, the application and effectiveness of these metrics exhibit considerable variability across different ethnicities, necessitating a nuanced understanding of their role in reproductive health. This review aims to bridge this knowledge gap by synthesizing current research findings, thereby contributing to developing more inclusive and effective fertility and menstrual health strategies.

By scrutinizing the interrelation between vaginal pH, BBT, and a myriad of influencing factors, this paper underscores the potential of these metrics in fostering a deeper understanding of women's health. In doing so, it highlights the need for ongoing research and innovation in the field, advocating for approaches that are not only scientifically sound but also culturally sensitive and accessible to all women, regardless of their ethnic or geographical background.

Vaginal pH

Importance

For several reasons, measuring the pH of cervical mucus plays a significant role in women's health. For instance, an essential application is its ability to indicate bacterial vaginosis (BV), a common vaginal infection. In cases of BV, the cervical mucus pH increases in alkalinity, serving as a diagnostic marker. Additionally, cervical mucus pH has been linked to unexplained fertility. Sperm are susceptible to acidic environments, so accurate readings of cervical mucus pH are crucial for fertility tracking and understanding factors that may affect sperm survival [7].

Range, variations, and factors affecting vaginal pH

The normal vaginal pH for women of reproductive age typically ranges between 4.0 and 4.5. Notably, pre-menarchal or postmenopausal women might exhibit a slightly elevated pH exceeding 4.5 [8]. The maintenance of a balanced vaginal pH is crucial, influenced by factors such as the metabolic activity of Lactobacillus acidophilus, other indigenous microbial flora, estrogen levels, glycogen, and the presence of flora and pathogens. This pH balance is essential for vaginal health [9]. During menstruation, a considerable volume of menstrual blood is expelled through the vagina, where it may be absorbed by tampons or pads, remaining in contact with the vaginal environment. The pH of the vagina can increase during this time as menstrual blood typically has a slightly alkaline nature. Furthermore, hormonally-related menstrual cycle irregularities can lead to alterations in the vaginal mucosa. These changes may affect the microbial ecosystem within the vagina, heightening the risk of vaginitis**.** For women experiencing regular menstrual cycles, the vaginal pH generally falls within the range of 3.8 to 5.0 [10]. Research has shown that sperm acts as a significant alkalizing agent, swiftly neutralizing vaginal acidity (increasing the pH to over 6–7) for several hours post-coitus, which is crucial for spermatozoa's ability to traverse the female reproductive tract. Sperm effectively reduces vaginal acidity within seconds [11]. Moreover, contraceptives containing very low or no ethinylestradiol lead to relative hypoestrogenemia, hindering the body's capability to produce glycogen and, in turn, lactic acid. Consequently, women using these contraceptives are particularly susceptible to alterations in the vaginal ecosystem [12].

It has been observed that African American women exhibit a more diverse microbial profile compared to European women, who predominantly have a Lactobacillus-dominant microbiome, as shown in Figure 1. Furthermore, African American women are at a doubled risk of experiencing preterm births and bacterial vaginosis diagnoses, accompanied by a higher vaginal pH [13]. However, a study adjusting for confounding factors, especially vaginal flora, revealed no significant differences in vaginal pH levels between white and black women [14]. In contrast, a study by [15] involving 273 sexually active adolescents without lower genital tract infections noted marked differences in vaginal pH between Blacks and Whites (5.3 vs. 4.7), suggesting ethnic variations in vaginal pH. Additional research comparing the vaginal pH of Black (pH 4.7 ± 1.04) and Hispanic (pH 5.0 ± 0.59) women to that of White (pH 4.2 ± 0.3) and Asian (pH 4.4 ± 0.59) women found the former groups had a significantly less acidic environment. This is attributed to a higher prevalence of vaginal bacterial communities not dominated by Lactobacillus spp. in these ethnicities [16].

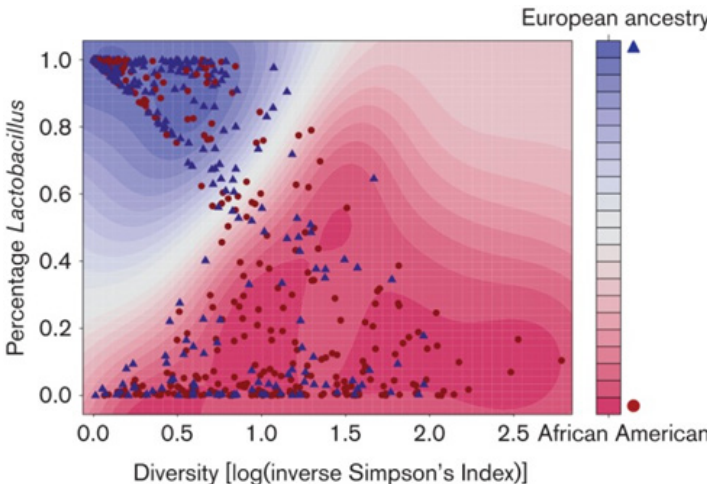


Figure 1: Proportion of lactobacilli, alpha diversity, and ethnicity.

However, microbiomes, as living entities, are dynamic and can shift due to a range of intrinsic factors such as menstrual cycles and pregnancy and external influences like diet, smoke exposure, environmental pollutants, antibiotics, exercise, and stress [17].

Use of Vaginal pH to Track Ovulation and Women Health

A healthy woman is considered to be in her luteal or follicular phase, indicating a non-fertile period, if her mucus exhibits acidity; otherwise, she is deemed to be in her ovulation or fertile phase [18]. Thus, vaginal pH can be used to track ovulation. This method involves measuring the pH level at the ectocervix of a female and comparing these measurements to a predetermined reference value. This reference may encompass a preset value established from previous ectocervix pH observations. By mapping historical pH levels of the ectocervix, it is feasible to discern a threshold value. Crossing this threshold signifies ovulation [19].

Subsequently, the same pH sensor, coupled with the designated apparatus, is employed to gauge the acidity of cervical mucus.

However, to enhance its sensitivity, further corroborated studies are essential. Emerging applications are still under development, including a compact, user-friendly Internet of Things (IoT) enabled device for vaginal pH strip reading, facilitating precise monitoring of vaginal pH fluctuations. Several factors may contribute to reduced pH levels in women, thereby complicating the process of tracking ovulation through pH levels. Despite the affordability and minimal technological demands of ovulation tracking and pH monitoring, many external factors influencing a woman's pH levels often outweigh the benefits [20]. To clearly illustrate more on how the importance of establishing vaginal pH metrics, it also serves as a benchmark to ascertain vaginal health. pH is crucial for detecting and controlling the development of bacterial pathogens. A pH level of 4.5 aligns with serum estradiol levels in premenopausal individuals, while a pH range of 5.0 to 6.5 indicates bacterial pathogens or a decline in estradiol, as shown in Table 1 [21]. Before entering menopause, estradiol hormone plays a vital role in averting health complications, including cardiovascular issues stemming from elevated cholesterol levels, and indirectly mitigating the risk of atherosclerotic heart disease while concurrently enhancing vaginal health and irregular period cycle [22,23]. This indicates how considering the importance of the pH matrix is simple and effective to achieve a better understanding of women about their vaginal health. Without considering the pH matrix to achieve vaginal health, it could increase the growth of bacterial pathogens and act as an indicator for decreased estradiol.

Table 1: Correlation of age group of premenopausal with vaginal pH and bacterial pathogen.

Age groups years	Number of Samples (n)	Vagina pH Range, Number of Sample, Total (%)		Bact. Patho. Growth (%)
		<4.5	>4.5	
15 – 20	21	7(33.3)	14(66.7)	71.43
21-30	31	11(35.48)	20(64.15)	77.42
31-40	39	4(10.26)	35(89.74)	82.05
41-45	10	3(30)	7(70)	90

Source: (Thura Jaafar et al., 2011)

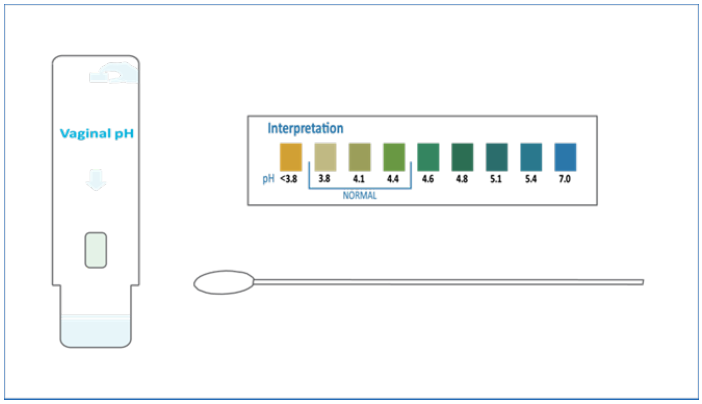


Figure 2: Vaginal pH Testing.

Source: https://primalabsa.ch/en/home/infectivology/vaginal-ph-test/

Temperature Metrics

Vaginal Temperature and its Importance

Throughout the menstrual cycle, a woman's core body temperature fluctuates. Notably, during the luteal phase following ovulation characterized by elevated progesterone levels this temperature increases by 0.3°C to 0.7°C compared to the follicular phase before ovulation. Women can detect this variation as a sign of ovulation, particularly noticeable during rest periods or immediately upon waking before undertaking any physical activity [5]. To comprehend this, reproductive hormones and BBT could change across the ovulatory menstrual cycle, as shown in Figure 3. The top graph, which is the dotted line showing serum luteinizing hormone (LH) peaks before ovulation; the middle graph shows fluctuations in serum levels of the ovarian hormones, estradiol, and progesterone across the menstrual cycle and the last bottom panel indicates the biphasic curve in morning basal body temperature (oral) across the menstrual cycle. Understanding this temperature shift is essential for enhancing fertility (fecundability) and managing reproductive health.

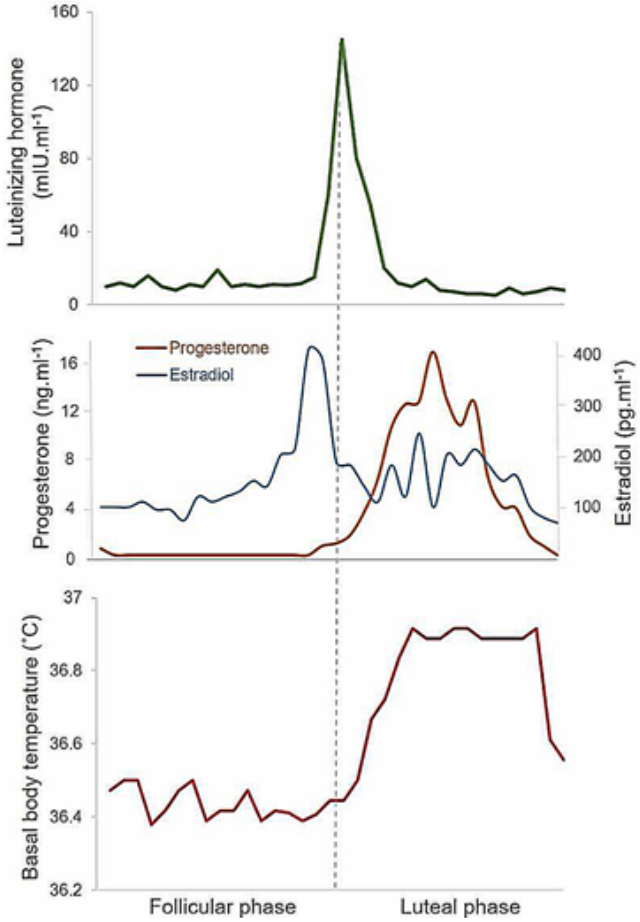


Figure 3: Increases of core body temperature in the post-ovulatory luteal phase compared to the follicular phase.

Source: Fiona C. Baker et al., 2020.

The future of health management looks promising, with wearable technologies and sophisticated algorithms expected to empower women by pinpointing the optimal days for conception, thereby

playing a pivotal role in clinical settings [24]. Continuous monitoring of body temperature through a vaginal biosensor proves especially beneficial in diagnosing ovulatory dysfunctions such as luteal phase deficits and polycystic ovarian syndrome [25].

Factors Influencing

The intricate interplay between reproductive hormones and thermoregulation involves complex biological mechanisms, with progesterone and estrogen significantly influencing body temperature regulation [5]. Various elements can disrupt BBT, including fever, alcohol consumption, emotional or physical stress, sleep irregularities, environmental temperature shifts, sleep patterns, changes in weather conditions, and the commencement or cessation of birth control pills or fever-reducing medications. In 2005, the "GAP" method was introduced as a superior contraceptive alternative to traditional methods, calculating the temperature difference by subtracting a male partner's BBT from the female's. This approach assumes that hormonal fluctuations in women are the sole variable affecting this difference. However, the study's limited scope encompassing only 33 cycles and its inapplicability to women not cohabitating with male partners draw attention to its limitations [26].

Accurately measuring the menstrual cycle's impact on body temperature is challenging due to internal factors, like fever and sleep disturbances, and external conditions, such as room temperature. Nevertheless, adhering to the "three-over-six" rule, which requires three consecutive daily temperature readings to exceed the previous six, can help mitigate these confounding factors by indicating a trend of rising core body temperature [27]. Initially, mercury thermometers were used orally, rectally, or vaginally for temperature measurement. However, with the advent of digital thermometers and growing concerns over mercury exposure, women are now advised to use oral digital thermometers for temperature readings immediately upon waking [28].

Use in Period Tracking and Ovulation

Basal Body Temperature monitoring stands out as a crucial, non-invasive method. BBT is the lowest temperature recorded after a period of rest. It involves the daily measurement of body temperature immediately upon awakening, following at least five hours of sleep over several days and menstrual cycles [5]. To measure BBT, women use a highly accurate basal thermometer and can either measure it orally, rectally, or vaginally. The obtained readings should be consistently recorded on a designated chart, using uniform procedures (including the same thermometer, position, and timing). A notable dip in temperature, identified on the chart as the lowest point during the follicular phase, precedes a thermal shift indicating ovulation.

Following ovulation, there is an increase of BBT of 0.5°F to 1.0°F, which can be used as a confirmatory signal for ovulation. This is known as a biphasic pattern [5], as shown in Figure 4. However, some women ovulate without experiencing an increase in temperature [5]. This is known as a monophasic pattern, as shown in Figure 5. While this method has been commonly used over the years, several problems are associated with it. First the morning temperatures may not problems reflect a biphasic pattern due to morning activities that one may indulge in. Additionally, recording the temperatures every morning may be tiring. And they are prone to human error [29]. Accumulating data across multiple months enhances the accuracy of predicting ovulation times within these cycles. However, it is essential to note when external factors might have influenced the temperature readings [28,30]. The analysis and interpretation of BBT offer valuable insights into female fertility and ovulation, benefiting from recent advancements in the field.

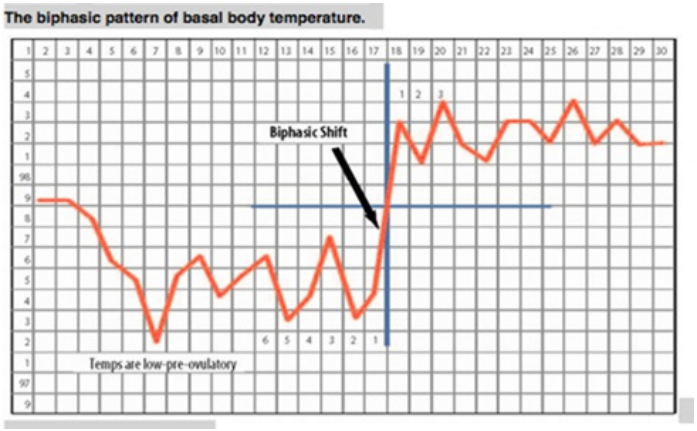


Figure 4: Biphasic pattern of basal body temperature.

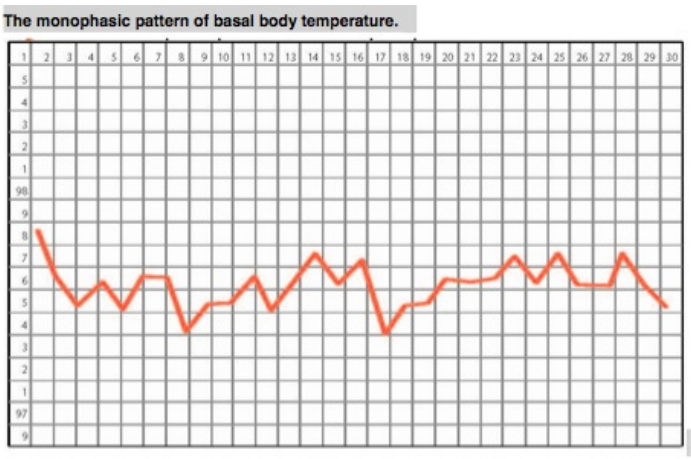


Figure 5: Monophasic pattern of basal body temperature.

Source: https://doi.org/10.1002/btm2.10058

Mobile Applications on Ovulation and Period Tracking

Period tracking apps were first launched in 2013, where approximately 50 million women globally use these apps to track their period cycles and receive predictions about them [31]. Most of these applications predict the user's ovulation day and their fertile window [32]. In September 2023, the app with the most downloads, 2,965,198, was Flo Period and Pregnancy Tracker, followed by Period Calendar and Period Tracker [33]. Figure 6 shows the downloads for each app. These applications use a range of markers, such as BBT, cervical mucosal changes, and luteinizing

hormone, to make these predictions. Several studies, however, have some findings that compromise the credibility of these applications**.** Worsfold [33] assessed the accuracy of period tracker apps across five distinct menstrual cycle profiles, reflecting a range of real-world scenarios. They found significant discrepancies in the apps' predictions for menstrual onset, ovulation, and fertile windows, ultimately deeming calendar-based fertility predictions unreliable. This highlights the potential inaccuracies and risks associated with period tracking applications [32].

Despite introducing the Evidence Standards Framework by the National Institute for Health Care and Excellence (NICE), a study revealed that most health apps fall short of meeting its minimum evidence requirements. Notably, NHS Health Apps Library apps did not provide more substantiating evidence than those found in the Apple app store [34]. Another study examining 90 apps marketed as Fertility apps found that 26.8% used a range of markers; however, they did not include these measures in the prediction algorithms. Also, 54% of the apps only use calendars to predict ovulation and period, which means they offer users inaccurate information about their fertile window [35].

Calendar

For decades, women have used physiological signs as fertility markers, employing the Symptothermal Method a paper-and-pencil approach to track menstrual cycle indicators like temperature shifts and cervical mucus changes, identifying the start and end of their fertile period [36].

Wearables

Wearable devices that help track periods and ovulation have also gained popularity. These devices which contain sensors, can collect different physiological measures and use them to predict menstrual cycles. Some examples of such devices include the Oura Ring, which tracks temperature and heart rate. Another example is the Ava bracelet, which checks HRV and simultaneously measures multiple indicators, including heart rate and skin perfusion, showcasing superior performance in fertile window prediction with 90% accuracy, 93% specificity, and 81% sensitivity compared to other wearables that primarily measure body temperature [24,37]. One study, however, indicates these devices' limitations, with the Oura ring detecting the fertile window 3 days before ovulation and 2 days after it. Similarly, the Ovula ring detects the fertile window 3 days before ovulation [38]. Research shows that wearables are a better alternative to calendars and digital apps, which is mainly because they automatically measure temperature, eliminating the need to measure temperature every morning [38].

Sensors

The OvuSense is a vaginal temperature sensor that predicts the Fertility window by analyzing the intravaginal window. It boasts a 99% accuracy rate for ovulation detection and 89% for prediction [39]. In a study assessing the user acceptability of the sensor, 76.9% of women found it extremely comfortable to use [40]. Other devices combine intravaginal and external body temperature measurements for enhanced precision. For example, NaturalCycles pairs a thermometer with a mobile app to log daily temperatures,

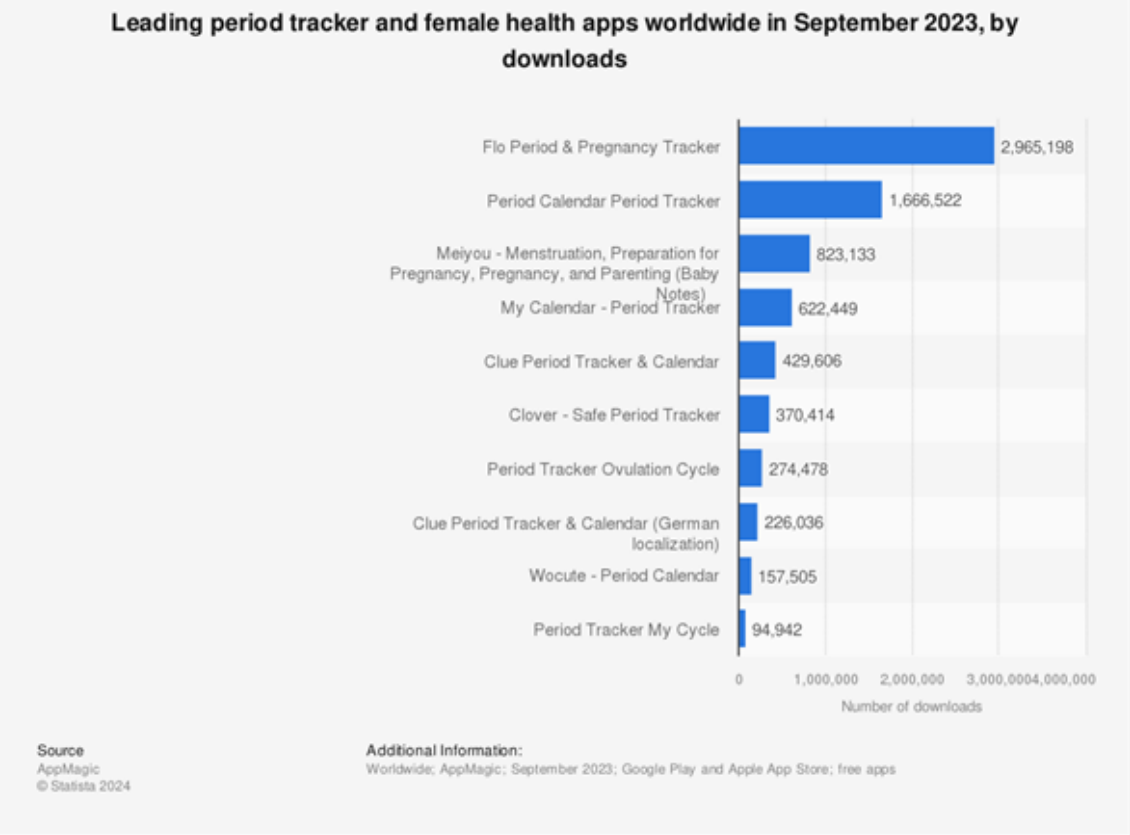


Figure 6: Leading period trackers and female health apps.

accurately identifying ovulation and fertile days with only a 0.05% error rate in classifying infertile days as fertile [41].

Similarly, DuoFertility® employs a small underarm sensor to continuously record temperature, using patented algorithms for automatic ovulation detection with 100% sensitivity [40]. Incorporating basal body temperature readings from fertility awareness methods with devices that provide continuous temperature monitoring could improve the diagnosis of ovulatory disorders [37]. Many technologies developed for period and ovulation tracking use different physiological measurements, including body temperature, skin temperature, and heart rate, among others, whereas others use BBT. But right now, none of them, as per our knowledge, use vaginal pH in period tracking. In our research, we came across one study that was testing out a Fertility detection period using BBT and Vaginal PH. The sensor is, however, yet to be patented [42].

Positive and Negative Impacts

Research demonstrates the potential of automated vaginal pH testing and machine learning-based microscopy for suggesting various vaginal conditions [43]. However, implementing diagnostic tools based on vaginal pH is challenging due to the scarcity of studies on their effectiveness across different ethnicities and the inherent variability in vaginal pH [37]. Nonetheless, advanced devices equipped with algorithms and temperature sensors offer a non-invasive, convenient means to track physiological signals, including body temperature, with heightened accuracy during nighttime, when data collection is most robust [5].

Understanding of Women's Vaginal Health and its Effects

Measuring vaginal temperature and pH can significantly enhance our understanding of vaginal health. Utilizing such devices to monitor ovulation and menstruation could provide valuable insights. Clinical guidelines advocate for the daily cleansing of the vulvar area with a pH-balanced, hypoallergenic wash to maintain health. It's essential for intimate feminine hygiene products to undergo rigorous clinical testing to confirm their safety, efficacy in offering targeted antimicrobial properties, and ability to preserve the delicate balance of the vulvovaginal microbiota [44]. Experts recommend the use of a gentle, hypoallergenic liquid wash for daily vulva hygiene to prevent the accumulation of fecal matter, sweat, urine, and vaginal discharge, which could lead to unpleasant odors [45]. While these products do not aim to treat infections, their role in complementing medical care by promoting cleanliness and odor control is increasingly recognized. However, misusing some hygiene products may disrupt the vulvovaginal area's pH balance, altering the microbiota and compromising infection prevention [46]. Education on the proper use and potential risks of intimate hygiene products is crucial for healthcare providers and women, fostering improved intimate health and hygiene practices [47]. This awareness supports both emotional and physical well-being.

A review linking stress with bacterial vaginosis identified eight studies, half of which found a statistically significant correlation. Additional qualitative research on emotional health highlighted the variable impact of symptoms on women's lives. Sexual health studies universally reported that relationship dynamics and sexual intimacy were often negatively affected. Social behaviors varied among participants, with many exhibiting avoidance tactics [48]. Factors such as age, ethnicity, diet, stress, smoking, obesity, exercise, and the menstrual cycle all influence vaginal health [49]. Given the multifaceted nature of vaginal health and vaginitis, emphasis was placed on modifiable factors. Literature identifies diet, physical activity, and mental health as crucial areas for lifestyle intervention, pointing to consuming vegetables and fruits, maintaining a healthy weight and BMI, and effective stress management as pivotal to good viginal health [50].

Understanding and promoting a healthy lifestyle are the most effective ways to decrease the occurrence and impact of health problems, reduce healthcare expenses, and improve the quality of life [51,52]. Many cases of vaginal health issues, like vaginitis, are often connected to poor dietary habits, such as consuming too much sugar, vegetables, dairy, and fruits; factors like maintaining a healthy weight, having a normal BMI, staying physically active, and effectively managing stress levels are also linked to vaginitis; for mental well-being is another essential aspect to consider concerning vaginal health problems [53]. To comprehend this, ANCOVA analysis showed that after adjusting for pretest scores, the mean score on the scale of lifestyle related to vaginal health was significantly higher in the intervention group (28.48 ± 0.38) compared to the control group (23.65 ± 1.23) ($P < 0.001$) as shown as Table 2. This is showing educational and overall understanding vaginal health intervention is beneficial in promoting three aspects of women's lifestyle related to vaginal health.

Table 2: Results Obtained for Women's Lifestyle (Nutrition Behaviours, Physical Activities, and Mental Health) Score Before and After Intervention in the Control Group.

Variables	Intervention group	Control group	P Value b
Nutrition behaviors			
Sweet intake	1.93 ± 0.77	1.35 ± 0.52	0.005
Fruit intake	2.69 ± 0.51	2.45 ± 0.77	0.001
Vegetable intake	2.67 ± 0.53	2.18 ± 0.84	< 0.001
Dairy intake	2.70 ± 0.53	1.93 ± 0.83	< 0.001
Diet planning for 6 months	2.66 ± 0.64	1.95 ± 0.77	< 0.001
Physical activities			
Habitual routine activities	2.68 ± 0.61	2.29 ± 0.90	< 0.001
Going to the gym 3 - 5 times per week	1.52 ± 0.82	1.20 ± 0.46	< 0.001
Walking 3 - 5 times per week at least 30 minutes	2.32 ± 0.81	1.97 ± 0.84	< 0.001
Physical activities, even due occupied situation	2.81 ± 0.47	2.45 ± 0.74	< 0.001
Physical activity in bad weather at home	2.59 ± 0.71	2.19 ± 0.87	< 0.001
Continuing physical activity	2.66 ± 0.04	1.95 ± 0.05	< 0.001
Mental health			
Sleep (7 - 8 hours)	2.85 ± 0.43	2.56 ± 0.69	< 0.001
Relaxation (deep breathing, walking)	2.20 ± 0.76	1.26 ± 0.56	< 0.001
Solving problems in mental counseling center	1.29 ± 0.53	1.17 ± 0.43	0.002

Relationships			
Discussion with husband about problems	2.94 ± 0.27	2.46 ± 0.76	< 0.001
Good relationship with husband	2.95 ± 0.25	2.52 ± 0.71	< 0.001
Gratitude	2.76 ± 0.54	2.03 ± 0.94	< 0.001
Truth to others	2.82 ± 0.47	2.08 ± 0.93	< 0.001
Self-efficacy	2.96 ± 0.22	2.61 ± 0.64	< 0.001
Responsibility	2.95 ± 0.33	2.59 ± 0.71	< 0.001
Acceptance of mental health education	2.86 ± 0.36	2.43 ± 0.79	< 0.001

Source: Roxana Parsapure et al., 2016.

While traditional approaches rely on body temperature and rectal measurements for general health assessment, the unique microenvironment of the vagina necessitates further exploration. Integrating well-being and lifestyle data holds promise in aiding the prevention of vaginal imbalances and infections. Dietary patterns significantly influence the vaginal microbiome, the link between high sugar intake and an increased risk of bacterial vaginosis [54]. A diet that is rich in fruits, vegetables, and probiotics (that can be found in yogurt) can promote the growth of beneficial Lactobacillus species, which is crucial for maintaining a healthy vaginal pH (around 3.8-4.5) [55]. Physical activity levels could impact vaginal health. There is a connection between regular exercise and a strengthened immune system that potentially reduces the risk of recurrent infections [15]. Conversely, a sedentary lifestyle might weaken the immune response, making individuals more susceptible to vaginal imbalances.

Vaginal Health and Women's Health Being

A woman's vaginal health is a crucial role in her overall well-being. Understanding one's vaginal health can improve emotional and physical control, resulting in fewer issues. Taking proactive steps like good hygiene, hydration, and medical advice when needed allows women to experience benefits. These may include reduced infection risk, better intimacy fulfillment, more self-assurance, and an enhanced quality of life. Being proactive about vaginal health enables women to prevent and address any imbalances [56].

Neglecting vaginal health may result in adverse consequences for emotional and physical well-being, notably the development of vulvovaginitis. The etiology of this condition is frequently attributed to inadequate vaginal hygiene practices and the presence of threadworms [57]. Thais Chimati Felix categorizes vulvovaginitis as an inflammatory or infectious condition affecting the vulva and vaginal mucosa, constituting a significant 70% of women's complaints in gynecological consultations, and this prevalence is associated with a lack of awareness concerning overall vaginal health and the importance of proper hygiene care [58].

A pertinent observation from the provided table underscores the significance of maintaining proper vaginal hygiene, indicating that women without vulvovaginitis tend to clean their genitalia more frequently (three or more times per day) (45.7%) compared to those with vulvovaginitis who typically clean twice per day (50%) as shown in Table 2. Patients exhibiting cytological results indicating altered microbiota ($p<0.05$) demonstrated associations with various factors. Notably, there were observed alterations in odor, with an odds ratio (OR) of 4.69 and a significance level of $p = 0.0155$. Additionally, these individuals were found to engage in genital hygiene practices involving toilet paper, employing a wiping technique from back to front, with an OR of 4.9 and $p = 0.0212$. Furthermore, a connection was established between altered microbiota and infection or cutaneous/dermatitis reactions due to depilation in the genital area, showcasing an OR of 3.3 and $p = 0.0438$. Wearing tight jeans was also identified as a contributing factor, with an OR of 4.0526 and a significance level of $p = 0.0107$, as shown in Table 3 and Figure 7. Vulvovaginitis has demonstrated associations with unfavorable pregnancy outcomes, encompassing factors such as infertility, ectopic pregnancy, premature rupture of membranes, and neonatal infection. Additionally, individuals affected by vulvovaginitis may experience an elevated susceptibility to an increased transmission risk of HIV infection, and the impact extends to menstrual cycle disturbances, potentially influencing the regularity and patterns of menstruation [59]. As per the findings presented by [60], the heightened severity of vulvovaginal symptoms is notably linked to poorer emotional well-being, compromised sexual functioning, and diminished self-concept and body image. This observation underscores the intricate interplay between vulvovaginal health and various aspects of an individual's psychological and emotional state.

The importance of understanding and having an awareness of overall vaginal health is paramount. Neglecting this understanding could affect women's emotions and well-being. Based on the structured study has shown that about 63% of the respondents failed to recognize how their well-being of the vagina, 45% experiencing vaginal symptoms, and only 4% of women believed that they had a bad condition in their vaginal health, such as vulvodynia and vulvovaginitis [61]. Having these conditions or not knowing the importance of vaginal health will directly impact their emotional, physical, and well-being.

The strong presence of mental health and emotional problems in women experiencing a lousy condition of vaginal such as vulvodynia and vulvovaginitis, has an association with depression and post-traumatic disorder (PTSD), with a total of 13.8% of the women screened positive for depression, and 13.0% screened positive for PTSD, women with vulvodynia were more likely to screen positive for depression (20.8%) than women with short-term or past vulvar symptoms (12.5%) and women without vulvodynia (13.1%), women with current vulvodynia were most likely to screen positive for PTSD (20.0%) than women with short-term or past vulvar symptoms (15.3%). Women without vulvodynia (9.5%), and lastly, among women with vulvodynia, 12.0% of women screened positive for both depression and PTSD, as shown in Table 4 and Figure 8.

Table 3: Genital Hygiene and Genitalia Habits Among Women with or Without Vulvovaginitis.

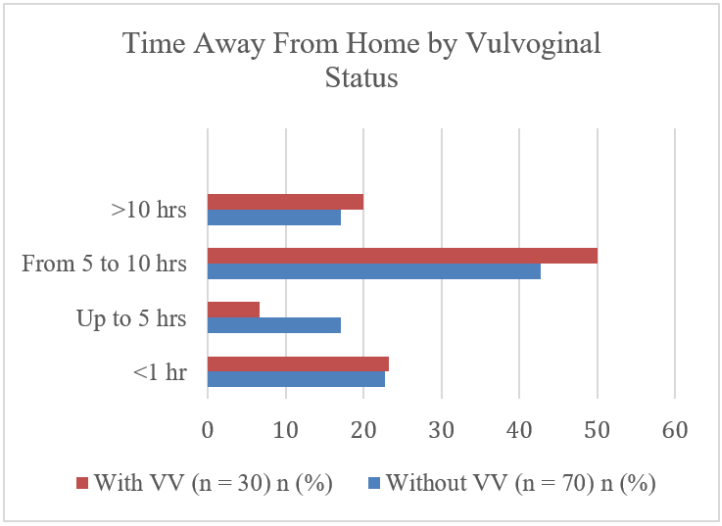
Variables	Classification	Total (n = 100) n (%)	Without VV (n = 70) n (%)	With VV (n = 30) n (%)	p-value
Time away from home	<1 hr	23 (23)	16 (22.8)	7(23.3)	0.466
	Up to 5 hrs	14 (14)	12 (17.1)	2 (6.6)	
	From 5 to 10 hrs	45 (45)	30 (42.8)	15 (50)	
	>10 hrs	18 (18)	12 (17.1)	6 (20)	
Frequency of washing genitalia/day (including baths)	One	13 (13)	9 (12.8)	4 (13.3)	0.718
	Two	44 (44)	29 (41.2)	15 (50)	
	Three or more	43 (43)	32 (45.7)	11(36.6)	
Hygiene after urinating	Wash with water	20 (20)	15 (21.4)	5 (16.6)	0.865
	Dry towel	4 (4)	3 (4.2)	1 (3.6)	
	Dry with toilet paper	93 (93)	65 (92.8)	28 (93.3)	
	Wet handkerchief step	3 (3)	1 (1.4)	2 (6.6)	
	Do not wash and do not dry	1 (1)	-	1 (3.3)	
Hygiene after evacuation	Toilet paper back to front	9 (9)	3 (4.2)	6 (20)	0.021*
	Toilet paper front to back	71 (71)	52 (74.2)	19 (63.3)	
	Water	52 (52)	35 (50)	17 (56.6)	
	Soap	33 (33)	24 (34.2)	9 (30)	
	Wet wipe	3 (3)	2 (2.8)	1 (3.3)	
	Does not sanitize	-	-	-	
Absorbent use on the day of greatest flow	Up to 3	36 (36)	24 (34.2)	12 (40)	0.17
	More than three	53 (53)	37 (52.8)	16 (53.3)	
Internal absorbent use	Yes	24 (24)	14 (20)	10 (33.3)	0.181
	No	76 (76)	56 (80)	20 (66.6)	
Absorbent use external intermenstrual (daily protector)	Yes	19 (19)	13 (18.5)	6 (20)	0.404
	No	66 (66)	46 (65.7)	20 (66.6)	

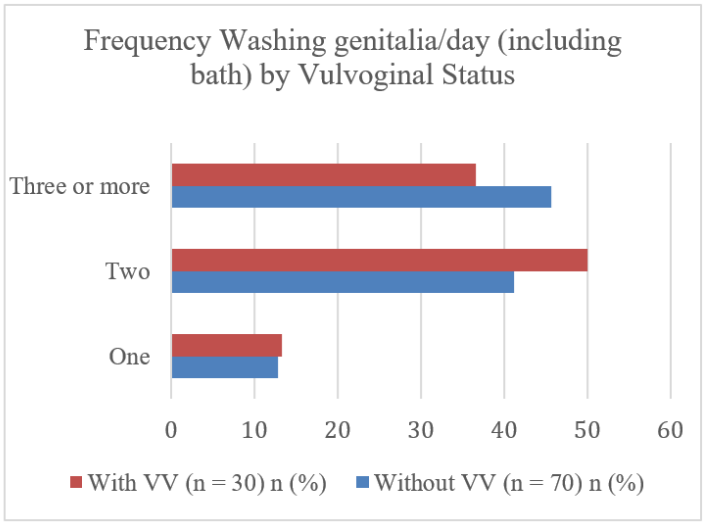
*Significant p-value; **Wear for at least 8 hrs a day/5 day or more per week.
Source: Chimati.et al, 2020.

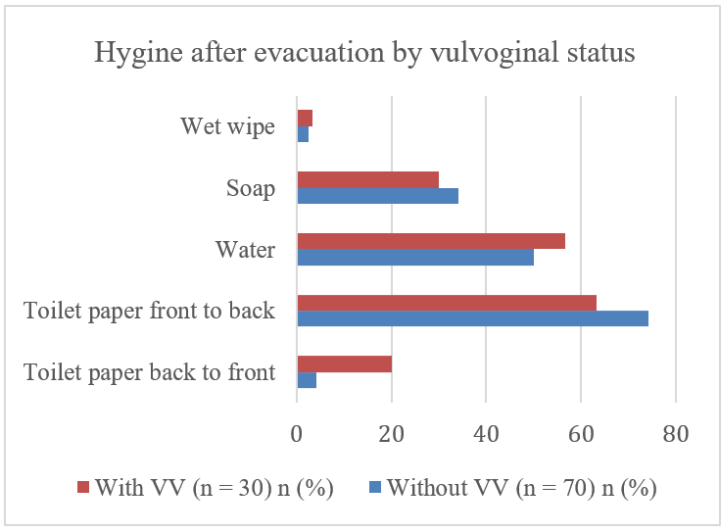
Table 4: Sociodemographic Characteristics of 1,795 Women Aged 18–65 Years by Vulvodynia Status: The Woman-to-Woman Health Study.

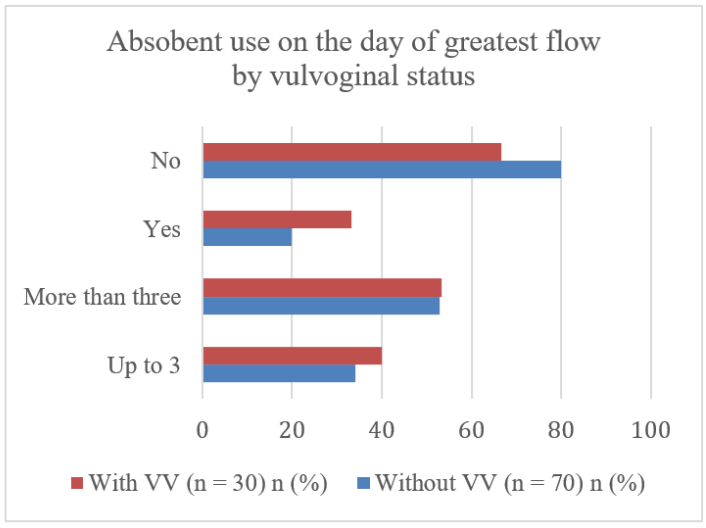
Characteristics	Total n (%)	Women with vulvodynia n (%)	Women with short-term or past vulvar symptoms n (%)	Women without vulvodynia n (%)	p-value
Total	1795	221 (12.5%)	609 (33.9%)	965 (53.8%)	
Race and Ethnicity					
White	1321(73.6%)	179 (81.0%)	464 (76.2%)	678 (70.3%)	0.0001
African-American	325 (18.1%)	21 (9.5%)	94 (15.4%)	210 (21.8%)	
Hispanic	50 (2.8%)	8 (3.6%)	22 (3.6%)	20 (2.1%)	
Other	99 (5.5%)	13 (5.9%)	29 (4.8%)	57 (6.0%)	
Had sexual intercourse in the past 6 months					
Yes	1287 (73.3%)	173 (79.4%)	494 (82.2%)	620 (66.1%)	<0.0001
No	470 (26.8%)	45 (20.6%)	107 (17.8%)	318 (33.9%)	
Screened positive for depression					
Yes	248 (13.8%)	46 (20.8%)	76 (12.5%)	126 (13.1%)	0.005
No	1547 (86.2%)	175 (79.2%)	533 (87.5%)	839 (86.9%)	
Screened positive for PTSD					
Yes	229 (12.8)	44 (11.9)	93 (15.3)	92 (9.5)	<0.0001
Suggestive	156 (8.7)	25 (11.3)	64 (10.5)	67 (6.9)	
No	1410 (78.6)	152 (68.8)	452 (74.2)	806 (83.5)	

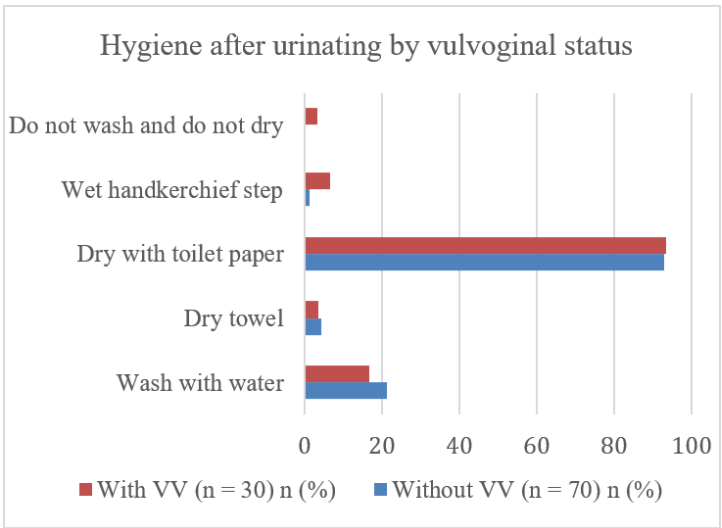
Source: Lisbeth Iglesias et al., 2015.











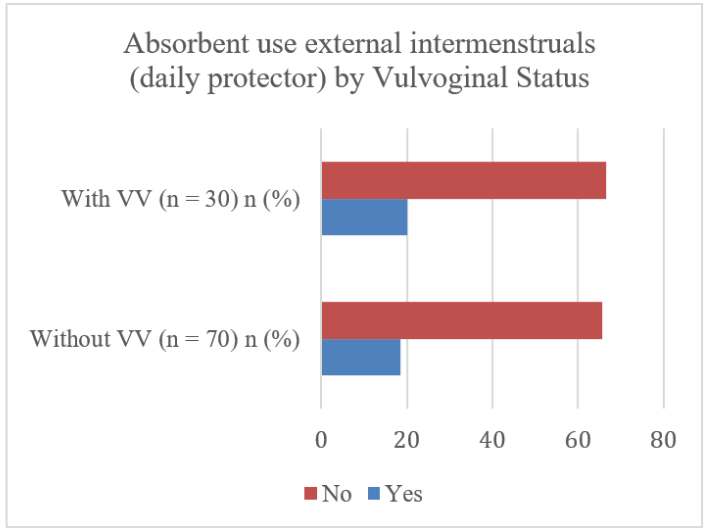


Figure 7: Genital Hygiene and Genitalia Habits Among Women with or Without Vulvovaginitis (VV).

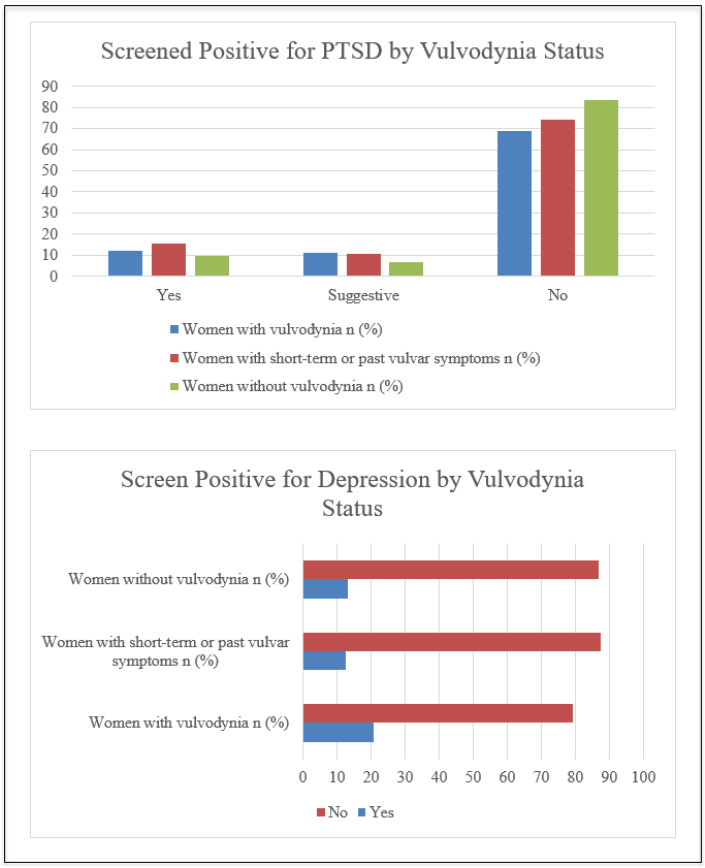


Figure 8: Mental Health by Vulvodynia Status.
Source: Lisbeth Iglesias et al., 2015.

Conclusion

Our investigation into the use of vaginal pH and basal body temperature as tools to track fertility reveals promising yet varied results. These simple, non-invasive methods, especially with technology, can provide valuable information about ovulation and menstrual health. Our research shows that these metrics can significantly impact women's health, potentially improving their understanding of their reproductive system and contributing to better emotional and physical well-being. However, more research is needed. Our study points out that while these methods are helpful, their effectiveness can vary greatly depending on a woman's ethnicity and other factors. This variability highlights the need for more detailed studies that include women from diverse backgrounds to ensure these tools are effective for everyone. Ultimately, our study opens the door to exciting possibilities in women's health, emphasizing the importance of personalized health tools. By continuing to investigate and improve these methods, we can move closer to offering women everywhere the knowledge and resources they need to manage their reproductive health confidently.

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Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Disclosure

The author is affiliated with Yon E, a company involved in the development of femtech products relevant to the research discussed in this manuscript.

Data Statement

All data used in this review is sourced from publicly available literature and has been properly cited to acknowledge the original sources.

Author Contributions

Adil Maqbool led the research, analysis, and writing of the manuscript, contributing extensively to the conception, design, and execution of the study. His work included the critical evaluation of the scientific data and the development of key insights into the role of pH and temperature metrics in fertility and menstrual health. Roswitha Priscilla Verwer was responsible for conducting comprehensive literature research and refining the gathered references, which involved the removal of duplicates and the validation of sources to ensure the inclusion of relevant and high-quality data.

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