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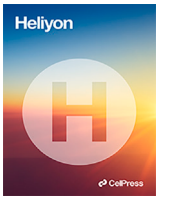

Research article

Exploring the barriers to feminine healthcare access among marginalized women in Bangladesh and facilitating access through a voice bot

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ABSTRACT

In today's digital age, ensuring high-quality healthcare services is paramount for both physical and mental well-being. This is particularly challenging in developing countries like Bangladesh, where marginalized individuals, especially women, face barriers to accessing essential healthcare. Financial constraints and limited awareness often hinder their ability to avail themselves of private or public healthcare services. Besides, women have distinct healthcare difficulties compared to men, and they are also more likely to catch certain illnesses and diseases. However, there is a noticeable gap in the existing literature, with insufficient research specifically dedicated to addressing the healthcare challenges faced by this underprivileged group of women in developing countries. In this study, we delve deeper into the healthcare challenges faced by underprivileged women in Bangladesh, including issues related to menstruation and gynecological disorders through a field study in a slum area. Drawing valuable insights from this field study, we propose leveraging voice bots in the telecommunications sector as an innovative solution to provide accessible and targeted healthcare support for marginalized women. We present the prototype of such a voice bot to be available 24/7 with detailed workflow and performance evaluation. We expect that our study will contribute to the ICTD scholarship by informing future interventions for economically disadvantaged communities as well as informing policymakers grappling with the healthcare challenges faced by underprivileged women.

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1. Introduction

The World Health Organization (WHO) emphasizes ensuring access to both mental and physical health care for all women [1]. Nonetheless, particularly marginalized women are more deprived of these privileges in many parts of the world. Furthermore, discussing menstruation and gynecological health issues is still frowned upon in many societies, which leads to women concealing their gynecological health difficulties and jeopardizing their overall health. A significant amount of study has also been conducted on women's unmet healthcare needs and how to make healthcare more accessible to them [2,3]. However, there has been minimal research focused on providing healthcare services that consider the socio-demographic, cultural, and other characteristics of marginalized or underprivileged women.

From the perspective of Bangladesh, a developing nation, marginalized women are the most exposed to discrimination, poverty, and abuse. Women who live in rural and impoverished areas are often the most marginalized in this situation, and their situation is further exacerbated by the nation's political and economic conditions [4,5]. They encounter many different types of prejudice, including violence and limited access to opportunities for education, healthcare, and work [6]. Conversely, because of their high socioeconomic standing, family income, and other factors, privileged women are individuals who enjoy social and economic advantages, such as better access to resources and opportunities, including jobs, healthcare, and education. In our study, we gathered data from both groups and created a comparison that highlights the differences in health between privileged and marginalized women.

An increasing amount of study is being done to identify the obstacles that people of diverse racial and ethnic backgrounds face when trying to get healthcare [7]. Knowing the obstacles is essential because it tells us where and how to launch an intervention program to remove them. It is imperative to attend to the distinct healthcare requirements of marginalized women in Bangladesh; nevertheless, there is a dearth of research on this population. Given the diverse barriers faced by different communities, it is essential to conduct separate studies to uncover their specific challenges. Our exclusive focus on marginalized women sheds light on their healthcare-seeking behavior and the effectiveness of available services in the context of a developing country.

There are numerous proposals in the literature for using technology to make it easier for individuals to receive healthcare [8]. Using the power of technology, several countries are taking steps to ensure healthcare services for individuals from all walks of life. Some examples include telemedicine, chatbots, voice bots, etc. [9]. Telemedicine and remote patient monitoring exemplify healthcare delivery, reducing the need for frequent hospital visits. Consequently, in addition to exploring the obstacles that underprivileged women in Bangladesh have in accessing healthcare, we also concentrated on developing technical solutions to make this easier for them.

To help women with gynecological and menstrual concerns, we suggest a mobile voice bot that can guide them toward proper activities while offering simple guidance and remedies. Accessible to the target demographic 24/7, women can engage with the bot by dialing a hotline and conversing about their concerns. The bot is designed to respond to health-related inquiries in their native language, specifically Bangla. Our study was shaped by three key research questions, outlined below.

RQ1 : What are the barriers to accessing healthcare facilities among marginalized women?
RQ2 : How can technology help facilitate their access to healthcare?
RQ3 : Can a 24/7 voice-bot service facilitate access to healthcare for these women?

To address these research questions, we undertook field studies focusing on marginalized women residing in the slum areas of Bangladesh to understand their context, challenges in daily life, and overall perspective on healthcare and healthcare-seeking behaviors. Furthermore, to gain a clearer understanding of the contrast, we also gathered data from privileged women and outlined the contrast with statistical analysis. This approach allowed us to pinpoint the variations between marginalized and privileged groups. Finally, we concentrated on designing technology to facilitate healthcare access keeping their reality in mind and proposed a 24/7 voice bot for them to respond to their queries related to menstruation and feminine health. Therefore, the key contributions of our study are as follows:

- We highlighted the obstacles that marginalized women in Bangladesh face while trying to get health care.
- We identified the impact of regional, cultural, and socioeconomic variables on marginalized women's access to feminine healthcare in Bangladesh.
- From the data analysis, our study confirms the acceptability of the m-healthcare service among marginalized women.
- We designed a 24/7 voice bot to improve marginalized women's access to primary healthcare services to remove obstacles to healthcare. In pursuit of this goal, we created a prototype, outlined the workflow, and conducted a formal evaluation of its performance.

2. Related works

Over the years, the literature has been enriched with a growing body of studies dedicated to addressing healthcare challenges faced by marginalized women. Researchers have increasingly explored the application of technology as a tool to overcome barriers to accessing essential healthcare services. In this section, we aim to shed light on the noteworthy contributions of these studies related to our work.

2.1. Healthcare disparities among marginalized communities

Healthcare access is affected by institutional, social, community, cultural, and individual variables globally [10]. Numerous studies examine broader disparities in healthcare access, focusing on marginalized populations and the unique challenges they encounter. The study [10] explores the socio-economic variables affecting healthcare disparities faced by marginalized populations and sheds light on integrative healthcare service delivery. Many other studies such as [11–15] underscore the significance of addressing social determinants of health to improve marginalized communities' access to healthcare services. Community-based interventions, involvement of marginalized communities in program development, and targeted interventions are recommended by these studies. Other studies have undertaken a similar investigation from the perspective of developing countries. For example, the study in [16] highlights the impact of the shortage of qualified healthcare providers and their unequal distributions across regions on poor people in Bangladesh. Some other studies focus on the inequality in maternal health in low-income countries [17] while others aim to underscore the disparities in the use of medical treatment for common childhood illnesses in Bangladesh [18].

2.2. Gender-based barriers in healthcare in developing countries

A significant number of studies focus on gender inequalities that persist in developing countries such as Bangladesh affecting women's mental and physical health. Studies [7,19,20] reveal that limited access to menstrual supplies and facilities, coupled with stigma, negatively impacts adolescent girls' menstrual health. Similarly, the study [21] shows the lack of assistance and facilities for managing menstruation hygiene among adolescent girls in low-income and middle-income countries, underlining the need for greater focus and education in this area. Other studies [22–24] demonstrate how maternal health outcomes and access to healthcare in South Asian countries are influenced by socioeconomic factors. Besides, many studies [25–27] point out challenges faced by women before and after marriage, such as limited access to education, healthcare, and other needs. It is also evident from the literature that limited access to financial resources contributes to delays in obtaining healthcare services [28]. Additionally, traditional family duties, including child care, meal preparation, etc., along with other familial obligations, hinder them from allocating time for their health [29].

2.3. Technology to bridge the gap

The intersection of technology to bridge the gap in healthcare access, especially for women has garnered attention of the researchers over the years. Many research [30–39] cover diverse topics in Human-Computer Interaction (HCI) and healthcare, including technology design for low-income rural women, patient safety, fieldwork research in healthcare, and design for gender inequality. Studies such as [40] showcase how technological interventions can bridge gaps, facilitating access to information, services, and resources that contribute to both improved health and empowerment for extremely impoverished people. Other studies [41–44] explore technology's role in addressing health and sanitation issues in low-resource settings. Besides, the study [45] suggests that media can play a vital role in creating awareness about menstrual hygiene practices in Bangladesh and breaking down taboos. The use of mobile health services in Bangladesh, facilitated by its extensive mobile phone coverage, can also enhance access to medical advice and information, as mentioned by numerous research studies [46–48,3]. Therefore, it is well-established in the literature that technology can facilitate access to healthcare and enhance the efficacy and accuracy of healthcare services.

2.4. Medical assistance using AI bots: an emerging trend

In recent years, with the integration of artificial intelligence (AI) in healthcare, AI bots such as chatbots or voice bots have demonstrated significant potential to overcome major gaps in healthcare accessibility and delivery [49–51]. Many research studies have explored the application and design of chatbots to facilitate accessing healthcare services, with some studies placing particular emphasis on the needs of women [52,8,53,54,51]. For example, the study in [52] proposes a chatbot that covers symptom-based disease diagnosis, home remedies, and food advice for women. Some studies focus on pregnant mothers offering easy-to-understand prenatal health support [8] while some provide quick advice on emergencies and health-related issues [53] using their proposed chatbot.

On the other hand, in study [55], the authors propose the usage of voice bots to provide quick and accurate responses to patients, using the Naive Bayes Algorithm to determine disease likelihood. Another study [9] focuses on primary healthcare education and counseling for chronic patients in rural India, utilizing the multilingual bot. Besides, the study [56] explores voice bots to help ADHD child patients with daily tasks using self-instructional learning. Moreover, in [57], the authors propose a voice bot that provides interventions to females with metastatic breast cancer through a smart speaker system.

3. Methodology

This section outlines the methodology of our study. Fig. 1 outlines the workflow for the methodology we used. We gathered information from both privileged and marginalized communities throughout several phases and through a variety of media to investigate the general state of healthcare opportunities. We conducted a mixed-method analysis, i.e., both quantitative and qualitative analyses, after data collection. We offer our design concept in detail together with a functioning prototype based on the results of our exploration.

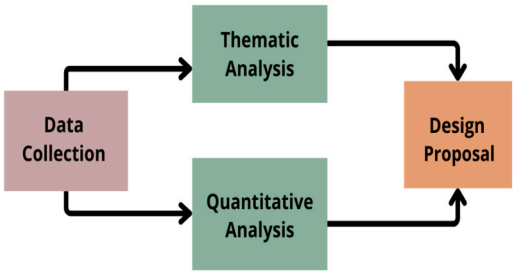


Fig. 1. Methodology.

3.1. Questionnaire design

First, we prepared a questionnaire to conduct a survey to understand the challenges of marginalized women's access to healthcare and outline the disparities between them and the privileged group. We discussed a range of health concerns that women encounter, such as persistent, gynecological, and psychological distress related to menstruation and pregnancy. The questionnaire also collected demographic data anonymously, such as age, family size, education level, employment status, marital status, and family income. Additionally, we asked about tendencies to hide gynecological issues and inquired about the use and willingness to use mobile-based health services. The survey contained both quantitative and qualitative questions, enabling us to gather numerical data and opinions for a comprehensive understanding of the subjects' health issues.

3.2. Data collection

To better understand the access to healthcare facilities of marginalized women and find out the disparities between healthcare access for privileged and underprivileged women, we collected data from both groups as done in the literature previously [58]. This happened in different phases and different modes, namely remote and in-person. Below, we outline the data collection process.

3.2.1. Data collection through online survey from privileged women

To collect data from the privileged group, we disseminated our survey online through social media. We relied on contacts with better living standards and internet accessibility, such as friends, colleagues, and acquaintances. This is Phase one of our data collection conducted remotely. In this phase, we received 44 responses from privileged individuals through the online survey. While iterating over their responses, the family income and educational status of these participants reassured us about their privileged status ensuring a comprehensive understanding of their socio-economic background.

3.2.2. Data collection through interviews from marginalized women

Acknowledging the limited internet exposure and educational constraints within marginalized communities, conducting an in-person survey became the only viable option for us. However, it is important to mention that this dual mode of the survey is also performed earlier in the literature [59]. Given the necessity to closely understand the lifestyle and healthcare accessibility challenges of marginalized women, we opted for fieldwork in their households. This helped us to confirm their marginalized status through a first-hand assessment of their living conditions, socio-economic status, and family income. We selected a specific slum area named Korail Slum in the city of Dhaka, the capital of Bangladesh, to reach a larger portion of the marginalized community as it is one of the single largest slum areas of Dhaka. There we engaged directly with our participants in their households. Below we outline our data collection process from marginalized women.

3.1.2.1. Housemaids and their neighborhood. For Phase Two data collection, on January 12, 2023, we conducted fieldwork in our residential buildings and interviewed seven housemaids in Bangla using the same survey questions. With their consent, we collected their data through the Google form. We also asked if we could visit their locality for more data collection. Two housemaids welcomed us, and from their neighbors, we gathered data from six housewives and two garment workers. Interview sessions lasted 10 to 15 minutes each. Therefore, in this round, we collected data from 15 participants.

3.1.2.2. Data collection from slum dwellers. On February 25, 2023, we visited Korail Slum to survey the women living there (Fig. 2). Most women volunteered to take part and described their experiences, including the difficulties they faced in obtaining healthcare facilities in Bangladesh. In-person interaction with them in their households allowed us to delve into profound discussions while also getting the survey filled out for each of them. We interviewed 15 marginalized women from this slum. Including housemaids and other residents of Korail Slum, the total number of marginalized women we interviewed was 30. Therefore, our survey included 74 women in total: 44 privileged and 30 marginalized.

3.3. Overview of quantitative and qualitative analysis

We analyzed the data we had gathered using both qualitative and quantitative methods. First, to give a thorough overview of the dataset, we mostly used descriptive statistics in our quantitative study. After that, we qualitatively examined the information from our

Fig. 2. Taking interviews in Korail slum.

interviews. We obtained a significant amount of perceptive, open-ended comments from the underprivileged women we interviewed. We conducted thematic analysis [60] on the text transcriptions of their responses. We read over the responses numerous times and were acquainted with the data before performing the theme analysis. Following that, we took the codes out of every answer. To create a uniform codebook, we compare the codes once they are generated and restate the answers. The themes were ultimately completed when we further taxonomized, categorized, and named our codes.

3.4. Sample size and sampling strategy

The sample size of 74 women in our study was determined based on our research objectives, feasibility, and available resources. Data saturation was reached with 74 participants, where comments and experiences started to repeat. The sampling strategy used was a combination of stratified and convenience sampling. Stratified sampling ensured representation from various demographic groups, while convenience sampling allowed for feasible participant recruitment, considering the marginalized population's limitations.

3.5. Ethical approval

The purpose of this study was to investigate concerns about feminine health that affect both rich and underprivileged groups. The institutional review board (IRB) approved the study, and all participants gave their informed consent before any personal data was gathered, as a precaution against unethical conduct. Protective measures were put in place to ensure data integrity [61], confidentiality, and privacy, such as the use of secure data storage and an anonymous online survey. Detailed information about the study, participant rights, and potential risks and benefits was provided. Special care was taken to protect the rights of marginalized groups, including providing them with detailed explanations wherever needed to enhance their understanding. Overall, these efforts ensured that the study was conducted ethically, ensuring the rights of all participants.

4. Findings

In this section, we provide an in-depth exploration of our findings, beginning with participants' demographic details and extending to both quantitative and qualitative analyses.

4.1. Participants' demography

Table 1 gives an overview of the demographic details of our participants. The table makes it evident that there is a wide range of age, marital status, and other characteristics among our participants. As anticipated, though, we find that whereas the marginalized women have hardly finished high school, the privileged women are all quite educated. According to our assumptions, the privileged women also have monthly family incomes that are significantly higher than those of the other groups.

4.2. Findings from the households of marginalized women

In our field visit to the Korail slum, we got the opportunity to have a first-hand experience of the households of the marginalized people (Fig. 10). Korail Slum serves as a sobering reminder of Bangladesh's harsh reality of poverty. The homes are constructed from rusty corrugated metal and scraps of wood, and their thin walls offer very little weather protection. Families gather together on makeshift beds within, attempting to find solace in the little space. Laundry is dangling from every available spot in the congested, little streets outside. The lanes are lined with clotheslines, and locals hang their freshly laundered clothing outside to dry naturally. Breathing becomes challenging due to the overwhelming scent of burning rubbish and smoke in the air.

Korail Slum is another place where poor hygiene and sanitation are clearly lacking. There is a serious health concern for the locals due to the piled-up trash on street corners and the untreated sewage that runs down exposed gutters. People find it difficult to maintain their health because of the unsanitary living circumstances, and illnesses including respiratory infections and diarrhea are common. The residents of Korail Slum attempt to make the most of their limited resources while continuing with their everyday lives despite their difficult living conditions.

Table 1
Demographic table of privileged and marginalized participants.

	Categories	Privileged		Marginalized	
		Count(*n*)	%	Count(*n*)	%
Age	<18 years old	1	2.3%	2	6.7%
	18-30 years old	38	86.4%	16	53.3%
	31-44 years old	5	11.4%	11	36.7%
	45-54 years old	0	0.0%	1	3.3%
	55 & over	0	0.0%	0	0.0%
Marital status	Prefer not to answer	0	0.0%	0	0.0%
	Widowed	0	0.0%	3	10.0%
	Single	27	61.4%	2	6.7%
	Divorced	1	2.3%	2	6.7%
	Married	16	36.4%	23	76.6%
Occupation	Unemployed	1	2.3%	7	23.3%
	Housewife	1	2.3%	7	23.3%
	Student	22	50.0%	1	3.3%
	Employed	18	40.9%	15	50.0%
	Business Woman	2	4.5%	0	0.0%
Education_level	Did not attend school	0	0.0%	12	40.0%
	Primary School	0	0.0%	13	43.3%
	Secondary School	0	0.0%	4	13.3%
	College	19	43.2%	1	3.3%
	Graduate	11	25.0%	0	0.0%
	Post Graduate	14	31.8%	0	0.0%
Family income	Between 0-10,000 BDT	0	0.0%	3	10.0%
	Between 10,000-20000 BDT	0	0.0%	17	56.7%
	Between 20,000-30,000 BDT	1	2.3%	10	33.3%
	Between 30,000-40,000 BDT	10	22.7%	0	0.0%
	Above 40,000 BDT	33	75.0%	0	0.0%

(a) Privileged (b) Marginalized

Fig. 3. Educational level of the participants is represented in two categories: 3a for privileged and 3b for marginalized.

4.3. Findings from statistical analysis

In our statistical analysis, we conducted descriptive statistics, a fundamental phase of data exploration that provided us with valuable insights and patterns inherent in our dataset.

First, the demographic data of the privileged and the marginalized women pictures the grim contrast of the living conditions of these two groups. We observe significant differences in their education levels and income, drawing a clear boundary between them. Figs. 3a and 3b show the educational levels of both parties. As expected, privileged women demonstrate favorable conditions, with more than 58.2% graduates whereas 43.3% of the marginalized group did not attend school at all. Similarly, in the case of family income, 72.5% of the privileged women have a family income of more than 40000 BDT, while in the marginalized group, 46.7% have a family income between 10000 and 20000 BDT, indicating a financial struggle for many. Figs. 4a and 4b display the distribution of family income among privileged and marginalized women.

We later delved into their overall health condition and healthcare practices such as the frequency of health checkups, their comfort level in discussing health concerns, particularly with male doctors as well as their perspectives on topics like menstruation and reproductive health. First of all, we asked both groups about any sensory, physical, or mental disabilities they may have and found that 93% of privileged women do not have any. On the contrary, 20% of the marginalized group reported having such disabilities. This indicates a higher presence of disabilities in this group. A comparable pattern emerged in the responses concerning miscarriages. Our findings revealed that 36.7% of marginalized women reported experiencing at least one miscarriage, whereas the corresponding

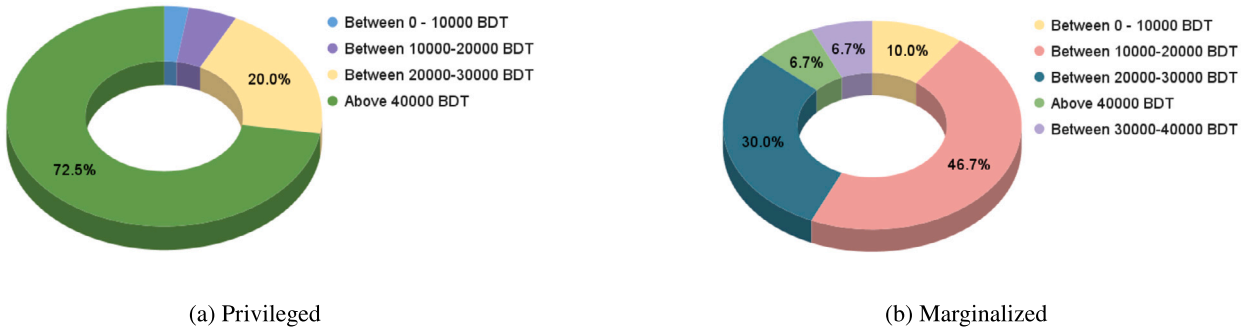


Fig. 4. The family income of the participants is represented in two categories: 4a for privileged and 4b for marginalized.

percentage in the privileged group was significantly lower at 4.3%. This stark contrast is evidence of the hardship the marginalized women face particularly in the case of reproductive healthcare.

Next, regarding the frequency of health checkups among privileged and marginalized women, we observed a varied pattern. Interestingly, the majority of women in both groups responded that they only get a health checkup when they feel the need for it. However, among the marginalized group, we found that more than 75% women had never undergone any such checkups, in contrast to 27.5% in the privileged group. The overall pattern indicates a significant gap in proactive healthcare practices.

Our findings also revealed poor menstrual hygiene practices among marginalized women. Fig. 5 picture the contrast in the case of menstrual hygiene practices of privileged and marginalized women. We can see that in Fig. 5a most of the privileged women (95.3%) use sanitary napkins whereas the usage of cotton napkins is prevalent among the marginalized group which is 60%, (Fig. 5b). This difference may result from the high costs of sanitary napkins, reflecting the financial constraints that hinder marginalized women from opting for such products. Similarly, the responses regarding awareness and management of premenstrual syndrome (PMS) exhibited distinct differences between privileged and marginalized women. Among the privileged group, we found nearly 77.5% being aware of PMS whereas 86.7% of the marginalized participants reported being completely unaware of this syndrome.

Furthermore, Fig. 6 depicts the shyness both groups experience while discussing menstrual health. Our findings reveal that 80% of the marginalized participants express extreme discomfort discussing their menstrual health (Fig. 6b). In contrast, only around 9% of the privileged group agreed to have such feelings of discomfort (Fig. 6a). Additionally, Fig. 7 shows the responses of the participants regarding hiding menstrual problems. We see that 41.86% of privileged women strongly disagreed with concealing menstrual issues (Fig. 7a), indicating openness and comfort in discussing them. In contrast, marginalized women had a significant proportion who acknowledged attempting to hide menstrual problems (Fig. 7b), possibly due to shyness and societal taboos.

On top of that, Figs. 8a and 8b show the comfort levels of privileged and marginalized women in communicating health concerns with male doctors. In line with our expectations, the privileged women mostly felt comfortable expressing their concerns with a male doctor, with some neutral responses and a small percentage (13.95%) feeling uncomfortable. On the contrary, the majority of the marginalized women expressed extreme discomfort in doing so while a few had different views. These results highlight the complex dynamics surrounding menstruation in marginalized communities.

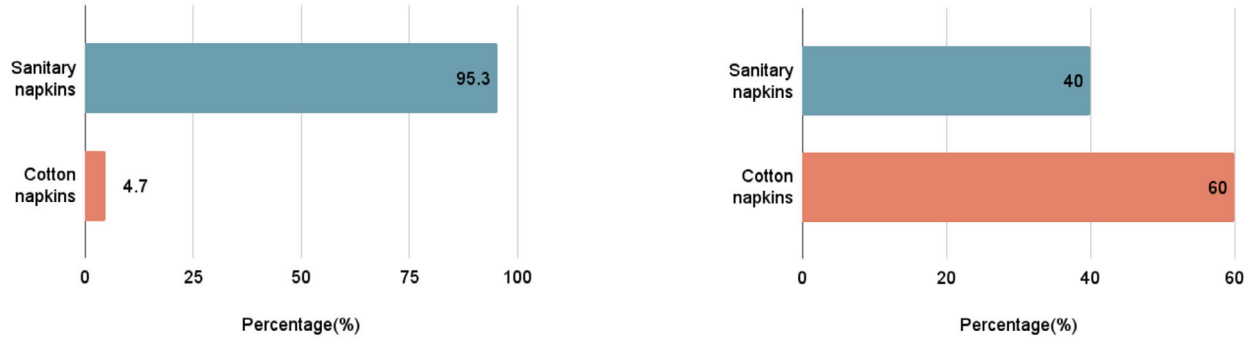
Besides, we found all of the privileged women have smartphones whereas only one of the marginalized women has so. However, we found the rest of the marginalized women had a button phone. We asked both groups whether they would be willing to use any voice bot service available 24/7 which they can avail through their button phone that would respond to their gynecological health-related queries. Fig. 9 depicts our findings in this regard. It is noteworthy that while the majority of both groups express their willingness to use such a system, the percentage is notably higher among marginalized women as 90% of are likely to use (Fig. 9b) in contrast to 67.43% of the privileged group (Fig. 9a). This discrepancy might be the result of higher perceived applicability of such a system for this group, possibly due to limited access to comparable facilities.

4.4. Findings from thematic analysis

The interview with marginalized women illuminated the various challenges they encounter in accessing healthcare and treating health issues. Our in-depth study revealed several themes, which we expand on below.

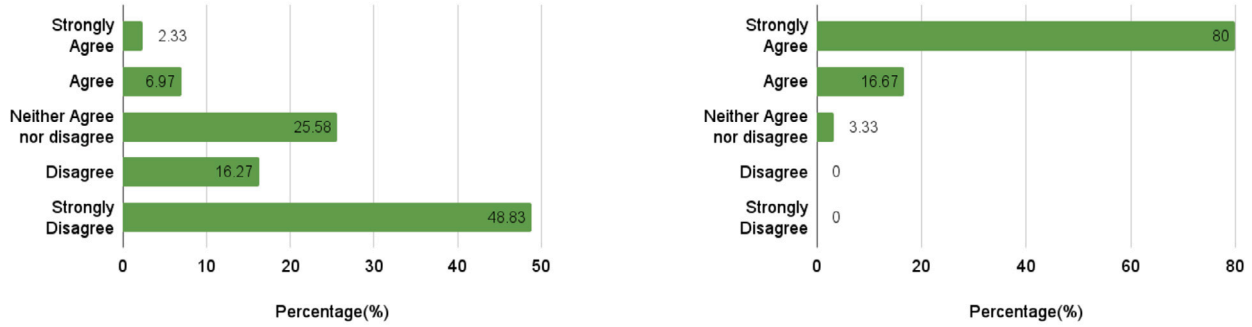
4.4.1. Lack of knowledge

Through our on-site visit and rigorous statistical analysis, we have gathered insights into the educational circumstances of marginalized women. Our survey revealed that a substantial portion, approximately 43.3% of the participants, did not have the opportunity to attend school, while around 40% had only received primary education. The low level of education among marginalized women is a significant barrier since it restricts their access to critical healthcare information and makes it difficult for them to appreciate the importance of seeking medical attention. Because of their extraordinarily low literacy rates, many members of this disadvantaged demographic are unaware of even the most fundamental knowledge on menstrual, reproductive, and gynecological health. As a result, individuals find it difficult to make educated decisions when confronted with symptoms or issues linked with these disorders. One participant shared her pregnancy story as follows –



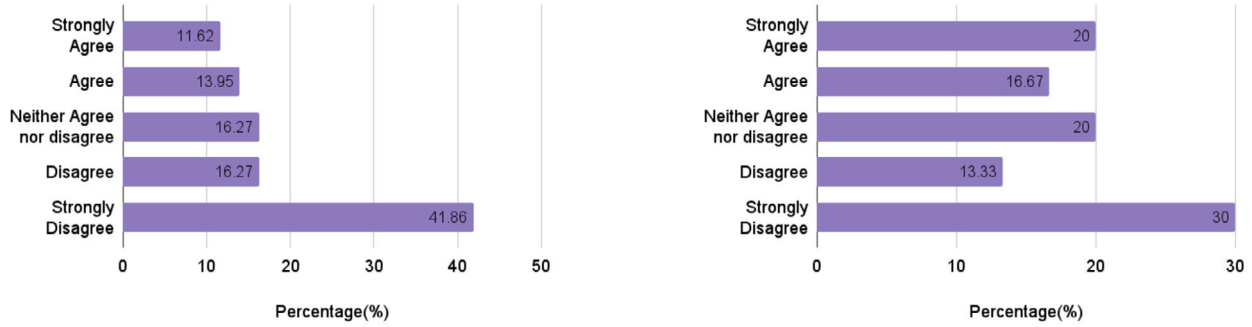
(a) Privileged (b) Marginalized

Fig. 5. Responses regarding napkin type used by the participants are represented in two categories: 5a for privileged and 5b for marginalized.



(a) Privileged (b) Marginalized

Fig. 6. Responses regarding feeling of discomfort in discussing menstrual health issues are represented in two categories: 6a for privileged and 6b for marginalized.



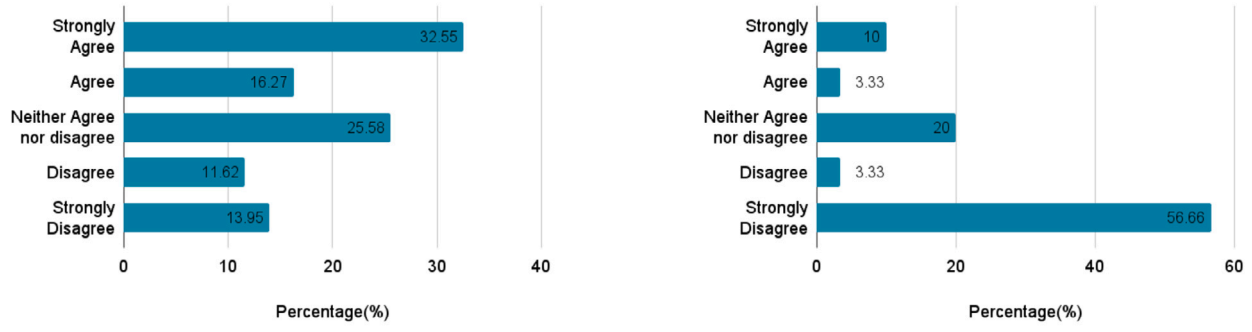
(a) Privileged (b) Marginalized

Fig. 7. Response regarding the tendency to hide menstrual problems is represented in two categories: 7a for privileged and 7b for marginalized.

"*I got married when I was 13, suddenly my period stopped and after several months, my neighbors told me that I was expecting.*" (Participant-2)

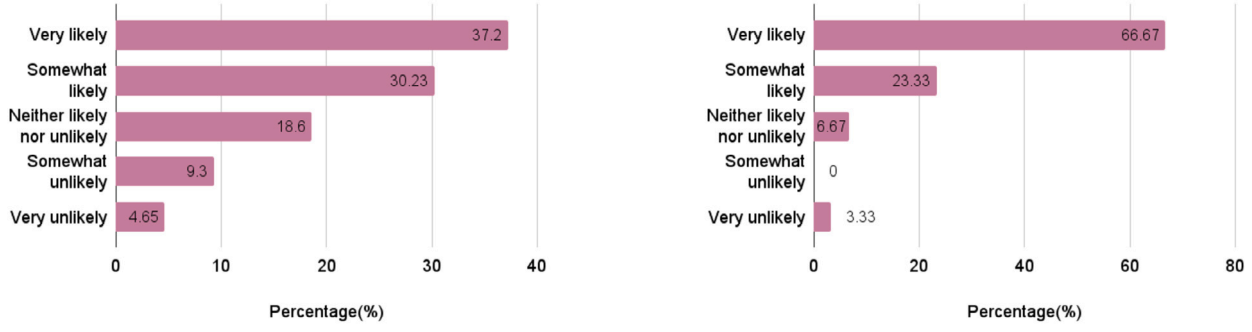
Furthermore, our research uncovered a distressing finding that some marginalized women even lack basic knowledge about their own identity such as age. This can result in delays in diagnosis and treatment, heightened health risks, and overall poorer health outcomes. One participant shared their perspective on this matter, stating,

"*I think my age is 42. I lost my parents in childhood. My neighbors said I got married at the age of 20 and it's been 22 years of my marriage, so I am assuming that my age is 42.*" (Participant-3)



(a) Privileged (b) Marginalized

Fig. 8. Responses regarding feeling comfortable in communicating health concerns with male doctors are represented in two categories: 8a for privileged and 8b for marginalized.



(a) Privileged (b) Marginalized

Fig. 9. Responses regarding the willingness to use 24/7 voice bot service are represented in two categories: 9a for privileged and 9b for marginalized.

On top of this, the scarcity of healthcare resources further compounds their difficulties in acquiring accurate knowledge regarding appropriate medications and healthcare providers to consult. For instance, one participant shared her experience as follows.

"*My period is not regular but I feel shy to talk about it and don't know which doctor to consult.*" (Participant-4)

4.4.2. Misconceptions regarding symptoms

Within marginalized communities, there is a notable prevalence of misconceptions regarding health symptoms. These misconceptions significantly cause delays in health checkups and visits to healthcare facilities. These misconceptions stem from cultural or traditional convictions, limited access to healthcare information, or insufficient education. To illustrate, some women perceive particular symptoms as natural consequences of aging or lifestyle choices, leading them to disregard the need for medical attention. Others place their trust in home remedies or alternative therapies rooted in traditional beliefs, even if these remedies prove inadequate in addressing the underlying health condition. One participant shared her perspective on this matter, stating,

"*While I was pregnant, after a few months I started to bleed, but when I consulted elders, they told me it was normal and didn't allow me to seek any medical care. After some days, I faced excessive abdominal pain, and thus I lost my child.*" (Participant-1)

Such misunderstandings often contribute to delayed or inappropriate treatment, leading to the exacerbation of health conditions and potential complications. For example, a woman may mistakenly dismiss persistent abdominal pain as a normal occurrence during her menstrual cycle, unaware that it could indicate a more serious underlying condition like ovarian cysts or endometriosis.

4.4.3. Trust issues rooted from negative experiences

Through our interviews, we discovered that marginalized communities harbor a lack of trust and hesitancy to seek future treatment due to negative past experiences with healthcare providers. This absence of trust emerges as a significant barrier hindering access to healthcare services, as women may experience anxiety and reluctance when engaging with healthcare professionals, fearing a repetition of previous negative encounters.

Trust concerns also emerge when patients feel judged or stigmatized by healthcare providers due to their marginalized status, including socioeconomic background, gender, or ethnicity. Marginalized women already endure discrimination or bias in their ev-

eryday lives, and unfortunately, these biases can extend to their interactions with healthcare providers. One participant shared her personal encounter, shedding light on the impact of such trust issues.

"*I still remember the day when a guy came to our slum with a bag full of medicines, claiming they would help us with our pain. Since we are poor people, we accepted the offer of free medicine without a second thought. Little did we know that we were in for a big shock. My son is educated; he later found out that the medicine had expired a long time ago, and he immediately forbade all of us from taking it. It was a terrible feeling to know that we had been taken advantage of just because we were poor and vulnerable. It's as if people think they can do whatever they want with us, feed us whatever they want, just because we are not rich.*" (Participant-5)

4.4.4. Patriarchy, domestic violence and lack of power

Based on our comprehensive statistical analyses and insightful interview sessions, it has come to light that women residing in marginalized communities predominantly experience unemployment. This lack of employment renders them financially disadvantaged, depriving them of decision-making power and the ability to contribute financially to their families. The patriarchal nature of society exacerbates their challenges even further. Consequently, women in marginalized communities endure domestic violence endangering various health issues among marginalized women as well as creating significant barriers for them to seek medical attention. Disturbingly, we heard numerous instances where women expressed frequent experiences of physical abuse, resulting in serious injuries. One participant shared her distressing experience, emphasizing the challenges faced by marginalized women in this regard.

"*I was pregnant for 5 months but lost my child due to domestic violence. My husband beats me almost every night.*" (Participant-6)

Another participant expressed her remorse in this regard as follows:

"*I got bald because of the continuous torture of my husband; he pulls my hair so often. Also, I got a severe leg injury because he recently beat me up; he didn't even let me go to the doctor after beating me so badly.*" (Participant-7)

4.4.5. Shyness and discomfort

Through our research, we discovered that a significant number of women in marginalized communities experience unease when discussing their health concerns, particularly with male healthcare providers. Many women expressed discomfort with sharing gynecological issues with a male doctor. This sentiment can be attributed to cultural norms prevalent in several communities, particularly in our subcontinent, where women are socialized from a young age to keep their health matters private and refrain from openly discussing them, particularly with male healthcare professionals. During our interviews, we inquired about the reasons behind their discomfort with sharing their issues with male healthcare providers. Below we state the story of two participants on navigating their first menstrual periods shedding light on this significant aspect.

"*When I first got my period, I told my father about it since I didn't know anything about it. My mother and grandmother slapped me and told me not to share anything about this topic with any male member of my house. Since then, I have felt hesitant to talk about it with male healthcare providers, as I have never shared these issues with any male person.*" (Participant-8)

"*I was twelve years old when I first got my period. I remember being in school when I felt a strange sensation in my lower abdomen. I didn't know what was happening to me, but soon enough, I started bleeding. I was scared and confused, and I didn't know who to turn to for help. My mother never talked to me about it. I felt embarrassed and ashamed of what was happening to me. I tried to hide it by using old clothes and rags as makeshift pads, and sometimes I used to wear multiple pajamas so that my clothes didn't get blood-stained. However, it was uncomfortable and messy. I didn't want to go to school or leave my house. I was afraid that someone would find out and make fun of me. I felt isolated and alone.*" (Participant-10)

This cultural conditioning sometimes causes embarrassment and discomfort while seeking medical assistance, exacerbating marginalized women's difficulties in accessing healthcare facilities.

4.4.6. Lack of affordability

In our thorough research we found that, because marginalized areas typically have low incomes, healthcare services are expensive, making it difficult for women to purchase them, particularly when their disease worsens. Most individuals live hand to mouth due to low income, and many struggles to pay for adequate housing or to manage their daily food. Thus, it appears somewhat extravagant to them to spend money on medical care when the illness is not too serious or in a critical state. Healthcare professionals might occasionally be found in the community, but they may lack the necessary training to identify and handle particular conditions. Furthermore, our survey revealed that marginalized women frequently are unaware of the government-funded healthcare services at affordable rates. One of the participants described this situation as follows:

"*As a poor woman from Bangladesh, I am the sole provider for my family and have recently been experiencing severe abdominal pain. I've been trying to find affordable healthcare options but have found none that I can afford. Government hospitals and private clinics are too expensive, and the local quack doctors may not be properly trained. I have no choice but to wait it out and hope my symptoms improve.*" (Participant-9)

Fig. 10. Households of Korail slum.

5. Design proposal

We were able to determine the obstacles marginalized women face in getting healthcare through our field research and mixed-method analyses, which addresses our RQ1. The next step is to answer RQ2, which asks whether technology can help marginalized women with their current problems. To do this, we must examine several factors, including the shortcomings of the government's and non-government's current initiatives for these people, the viability of technologies to close the gap, and the ability and willingness of marginalized women to use technology. After considering these issues and determining the response to RQ2, we will address the viability and design of a 24/7 voice bot service as a main healthcare provider to address RQ3.

5.1. Technology for bridging healthcare gaps

The barriers hindering healthcare access for marginalized women, such as poverty, low literacy, and misconceptions, cannot be eliminated overnight and require significant government efforts and initiatives. In a developing country like Bangladesh, eradicating these barriers may take considerable time. However, technology offers a promising alternative to providing healthcare to marginalized populations. Existing literature [62,7,63] provide ample evidence supporting the use of technology to ease healthcare access for underprivileged individuals. Therefore, technology can play an important role in bridging these disparities and improving healthcare outcomes for women in Bangladesh.

Using technology for feminine e-health has various advantages, including increased access to critical information for women who have limited access to formal healthcare. Digital platforms like websites and online forums offer education on critical topics such as menstruation and mental health, empowering women to better manage their well-being. Moreover, technology bridges the healthcare gap between rural and urban areas in Bangladesh through telehealth services, addressing scarcity in rural regions and aiding marginalized women facing financial constraints or mobility issues. Additionally, technology enables culturally sensitive healthcare apps, providing vital information and education, and facilitates data collection and analysis to understand marginalized women's healthcare needs. By ensuring connectivity among healthcare stakeholders and utilizing digital tools, technology has the potential to significantly improve access to healthcare and empower marginalized women, ultimately narrowing healthcare disparities and improving outcomes in Bangladesh. Thus, we might endeavor to reduce healthcare disparities and enhance healthcare outcomes for Bangladesh's impoverished women by skillfully utilizing technology. All of these discoveries address our RQ2.

5.2. Our proposal: a 24/7 voice bot service

The existing body of literature presents ample evidence showcasing various types of technology, such as apps, chatbots [51,63], voice bots, etc., being effectively employed to facilitate healthcare access to a great extent. However, in our study, our focus is on the marginalized women who predominantly have access to basic button phones and encounter numerous barriers to traditional health facilities including illiteracy, financial constraints, societal taboos, unawareness of existing healthcare initiatives, etc. Therefore, it appears that the most impactful assistance for them would be a voice bot, operating 24/7, delivering essential healthcare problem-related primary solutions, and acting as a virtual health assistant. A system like this can help patients and medical professionals communicate more effectively. Through the program, patients, particularly those who are female and reside in rural areas will be able to remotely seek out feminine healthcare services.

According to our data, most marginalized groups in Bangladesh are not aware of the free or low-cost healthcare choices that are accessible to them or of the nearby hospitals or clinics where they can get treatment for specific health conditions. We plan to expand the functionality of our voice bot to include information about physicians connected to nearby hospitals and the reasonably priced services provided by public hospitals. Furthermore, in the event of an emergency, the bot can promptly connect users to nearby medical facilities or provide a list of public clinics in the area along with their hours of operation if they specify their current location. Here, Fig. 11 shows the design of our proposed 24/7 voice bot service.

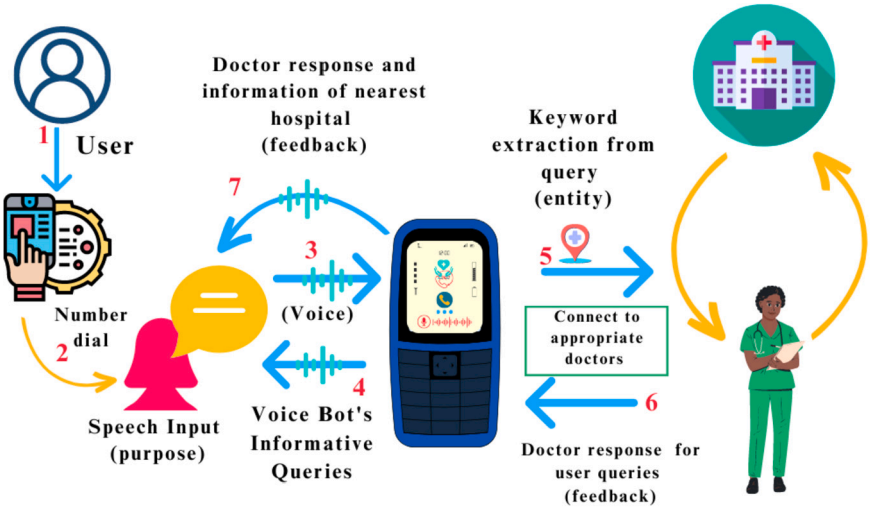


Fig. 11. Proposed 24/7 voice bot service.

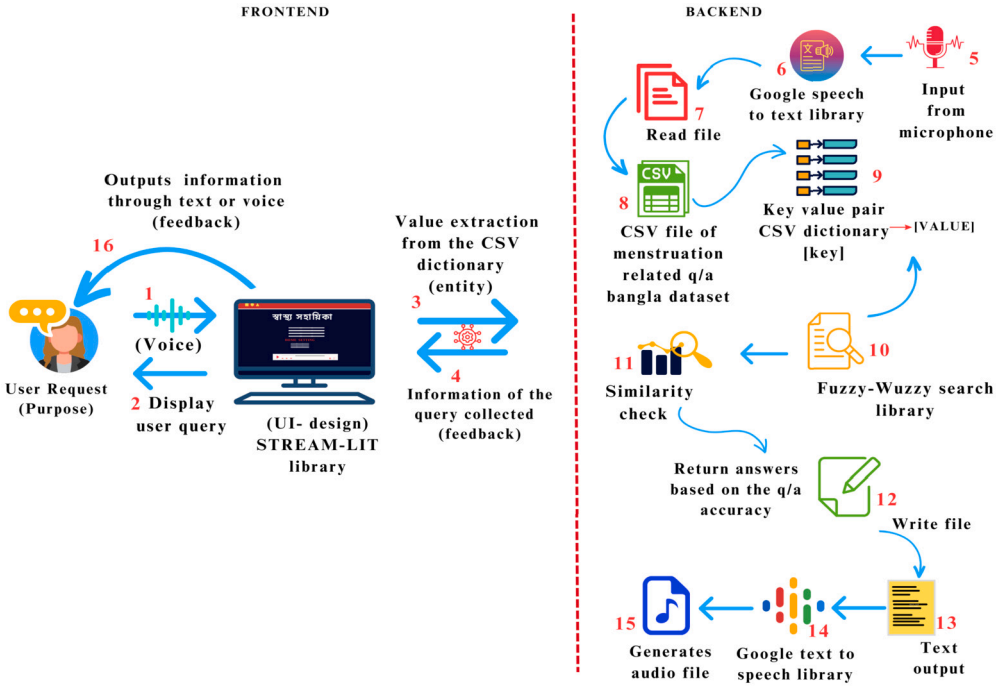


Fig. 12. Architecture of our developed voice bot prototype.

5.3. Architecture of our developed voice bot prototype

Given that our research's target market is marginalized women, we chose to construct a speech bot rather than a chatbot after considering all of the elements mentioned in our findings. To demonstrate the functionality of such a system, we developed a voice bot prototype and tested it accordingly. We prepared a questionnaire with menstruation-related queries in Bengali to serve as the knowledge base of the voice bot and employed speech-to-text API with string-matching algorithms to create the prototype for the initial phase of development. Our voice bot prototype takes user input in Bangla and responds with a voice in Bangla. The architecture of our voice-bot prototype is presented in Fig. 12.

5.4. Preparing questionnaire dataset for the prototype

Since our voice bot is intended to react to health-related concerns, we needed to create a questionnaire database as its knowledge basis. However, because these questions and answers are about healthcare, we sought assistance from various doctors linked with

Fig. 13. Field research at a government hospital.

government hospitals in Bangladesh to develop and finalize them. In the subsections that follow, we will go into greater detail about the questionnaire preparation stages.

5.4.1. Field research to understand the common gynecological issues

On 9th February 2023, our research team conducted a field study to understand the most common gynecological issues faced by underprivileged women (Fig. 13). During our visit, we observed that most patients were between 35 and 47 years old, while some were as young as 17, 23, or 30 years old.

Our research showed that lower abdominal pain and discomfort were the most often reported problems by the patients. Many of them described experiencing excruciating pain that often felt like their uterus was about to fall out. Furthermore, a few patients stated that they wanted an operation to remove tumors from their uteri that were causing them excessive bleeding. Moreover, we discovered that a large number of individuals were heavily bleeding throughout their periods. The physicians advised getting a pregnancy test and doing an ultrasound in addition to prescribing some required medications.

We also discovered that some patients experienced itching in their vaginal area. Other concerns included pain during intercourse, urine, dizziness, and headaches. For these types of cases, doctors recommended urine testing, and individuals who experienced headaches, dizziness, and leg muscle discomfort were advised to see medicine specialists because they were not gynecological issues.

5.4.2. Dataset overview

Following our fieldwork, the key insight that emerged is that menstruation-related issues constitute a primary cause of various gynecological problems. During our interview with the duty doctor, she also highlighted the fact that women mostly seek medical attention for menstruation-related concerns. Therefore, realizing the importance of regular periods and menstrual hygiene in preventing gynecological problems, we tailored our questionnaire dataset i.e., the knowledge base of the voice bot focusing on menstruation with the help of our fifth author who is a physician himself. With 408 questions in Bengali and their corresponding answers, we made our best attempt to structure the dataset to mirror patient-doctor interactions, in simple and easily understandable language. We further sought approval from a gynecologist at Mugda Medical College for validation of the questionnaire i.e., to ensure the adequacy and accuracy of our questions and suggestions. Lastly, we integrated our dataset into the prototype-making process.

5.5. Query and response

We tried to keep our system simple, informative, and precise. When a user submits a query, the system follows a series of steps: it converts the spoken question using speech-to-text, performs pre-processing steps including tasks like string matching, language localization, and Text-to-Speech conversion, and then analyzes the user's input. The bot's objective is to identify the specific menstrual or gynecological issue the user is referring to and understand the type of problem they are facing. For each identified condition, the bot addresses four distinct types of requests:

Problem Definition: Explaining the potential reasons behind the menstrual or gynecological problem.
Symptoms: Describing the signs or symptoms associated with the gynecological or menstrual issue.
Reason: Identifying the cause of the problem.
Recommendation: Offering advice on how to prevent the problem from occurring.

Our design is primarily focused on three main aspects: (1) Purpose, (2) Entity, and (3) Feedback. The user input message specifies the aim or intent, such as resolving a conflict or seeking a service. The entity collects the main keywords from the user's input message. For instance, if a user is saying, "I am suffering from abdominal pain", here "abdominal pain" would be the main keyword. After extracting the keywords, the voice bot will provide feedback to offer the user the most applicable response from the knowledge base. Fig. 14 depicts the design architecture of our prototype.

5.6. Implementation of the prototype

Our prototype consists of a backend and a simple frontend. The voice bot's backend has several important components and functionalities that are essential for its operation. Fig. 15 shows the backend design flowchart. This system at first loads our prepared

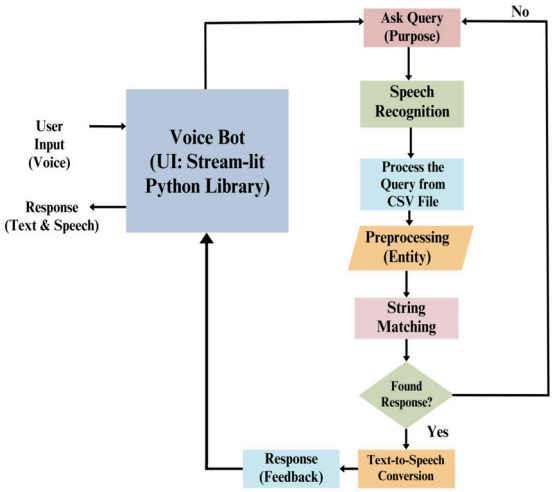


Fig. 14. Architecture of the voice bot.

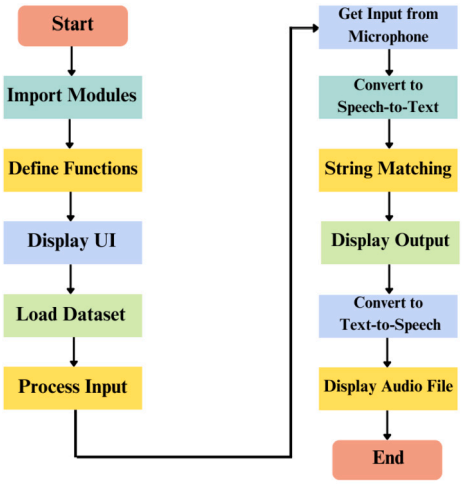


Fig. 15. Backend design flowchart.

dataset that contains Bangla questions and answers on menstruation. These are compiled into a dictionary for easy querying. The speech recognition library and Google's speech recognition API are used to process user input. Voice recognition is also included for microphone-based input. The backend processes queries using a Fuzzy matching algorithm, which computes similarity scores and selects the best match depending on a threshold. Variations, typos, and incomplete matches are all accommodated by the algorithm. Fig. 16 shows the String Matching Algorithm flowchart. We have used Google Text-to-Speech (gTTS) module in the backend for text-to-speech conversion. When the 'Read out answers' checkbox in the user interface is chosen, the gTTS library creates Bangla audio responses, which are then played back. We also kept a UI slider so that we could alter the similarity score requirements for matching queries.

An important aspect to mention here is that for large-scale applications, the pricing structure of the gTTS module could become a significant consideration. In exploring alternative approaches, we identified several options that could be more cost-effective for this specific application such as tools like Mozilla DeepSpeech or Kaldi. However, though they offer open-source alternatives for speech recognition the quality is far below that of Google's with increased overhead. During the development phase of our voice bot prototype, we opted for the Google Library Speech API to leverage its increased efficiency and facilitate the creation of a functional model.

We developed a simple and user-friendly front end for our system using Python's Streamlit package. Users have the convenience of providing voice input to pose questions and receive responses in both text and audio formats.

5.7. Prototype testing

We manually tested our prototype by asking questions and analyzing its answers to assess its accuracy. We tested the bot by asking 100 questions in total. Our testing process involves presenting the bot with identical questions in various formats. Through

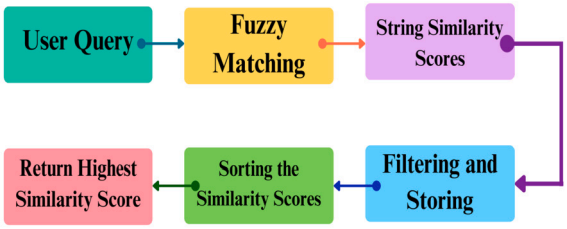


Fig. 16. String Matching Algorithm flowchart.

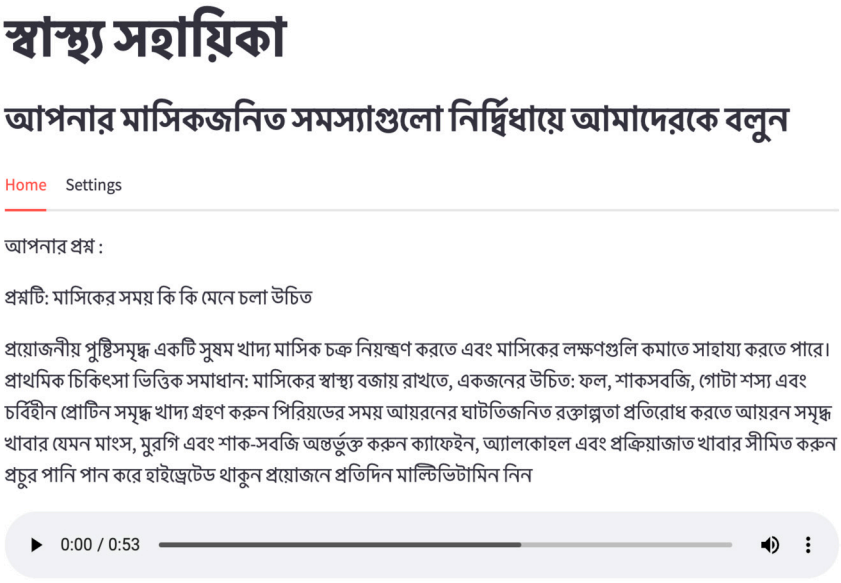


Fig. 17. Our voice bot prototype giving correct answer.

our testing, we found that it correctly answered 76 of the 100 questions and responded inaccurately 24% of the time. Upon further investigation, we discovered that the bot struggles to match strings properly, particularly if the query lacks at least three matching words from the dataset. We experimented with adjusting the matching threshold to improve accuracy, aiming to ensure relevant responses by controlling the similarity level between user queries and dataset entries.

Among the 76 correct answers, in 37 cases, we asked the questions to the bot in the same manner as stored in our dataset, and our model predicted them correctly. However, in the rest of the 39 cases, we asked the questions a bit differently than stored in the dataset, while keeping some keywords that matched the questions from our dataset. However, our bot could answer them correctly.

Similarly, in 11 cases, we asked new queries but only a few keywords matched the dataset, and the bot answered them inaccurately. There are 13 instances in which we asked the bot queries that did not match any keywords from our dataset, and as expected, our bot responded inaccurately. Therefore, the accuracy of our produced prototype reaches 76%. Figs. 17 and 18 show two cases where the bot provides right and incorrect replies, respectively.

6. Discussions

We have attempted to clearly outline the context of privileged and marginalized women in the sections above, including information about their financial situation, households, families, health problems, and level of awareness among one another. Given that the study focused on feminine healthcare, we went into great detail about how marginalized women have a difficult time getting healthcare because of the high cost and their low awareness and education levels. This section will address our findings in light of previous research on related genres. We begin by discussing the difficulties involved in carrying out these kinds of investigations and then we go on to consider the responses to our research questions that the study provided.

6.1. Challenges during data collection

Many of the women refused to participate in the data-collecting process because the majority of the questions on our questionnaire were personal. Their hesitancy could be due to a variety of factors, such as past unpleasant experiences, societal or cultural pressure, lack of information or resources, shame or humiliation, lack of trust, or fear of judgment. Furthermore, some women could not be aware of their health or not have access to healthcare services. Furthermore, a notable obstacle faced during the data collection stage

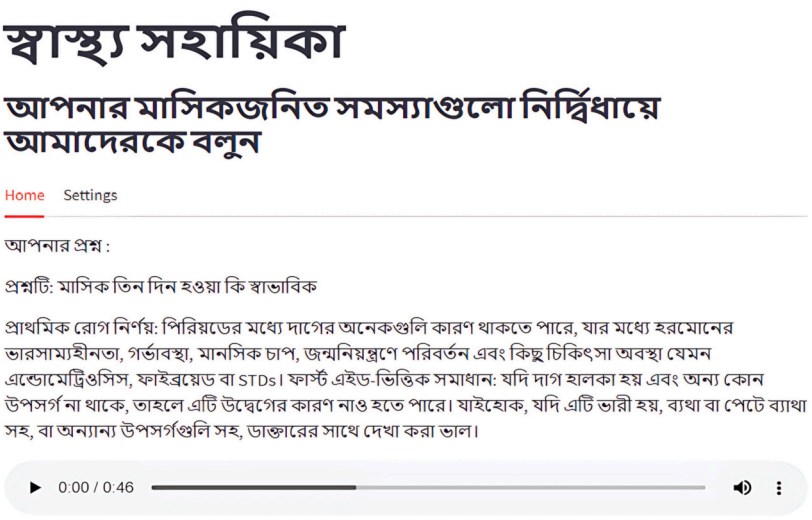


Fig. 18. Our voice bot prototype giving the wrong answer.

was time constraints. This restriction made it more difficult to obtain an extensive dataset. To enable a more thorough analysis, it would be beneficial to set aside additional time for data collecting in subsequent projects. We expect that our experiences will serve as valuable insights for future researchers, offering crucial considerations and lessons learned in the realm of data collection.

6.2. RQ1: barriers to accessing healthcare

Our research focuses on underprivileged women in urban Bangladesh and other South Asian countries, addressing a gap in the HCI community's attention to homeless and related populations [64]. We explore the context of a densely populated developing nation and its implications for healthcare, social support, and economic analysis, which can inform future ICTD interventions for economically disadvantaged individuals. Our data highlights disparities between privileged and marginalized women, revealing that literacy levels and financial conditions significantly impact access to healthcare and awareness as already reflected in the literature [23]. We observed high levels of food insecurity and malnutrition among marginalized communities, particularly impacting women working in blue-collar jobs like the garment sector [65].

This malnutrition contributes to serious health problems, maternal fatalities, and infant deaths [22]. Additionally, low literacy rates and limited access to education perpetuate cycles of illiteracy and hinder school attendance for children in impoverished areas [66]. Unhygienic household environments, lack of sanitation, and poverty further deteriorate health risks and financial distress, with women often facing limited financial autonomy and employment opportunities [67,68]. Leveraging technology for healthcare delivery could address some of these challenges, offering cost savings, convenience, and accessibility to marginalized communities [69].

6.3. RQ2: technology, current health initiatives, and marginalized women

The rapid expansion of ICT and telecommunications in Bangladesh offers promise for alleviating nationwide healthcare service shortages, leveraging widespread mobile phone access. Despite several m-health initiatives, substantial improvements are needed in the country's healthcare sector, with government-led efforts aiming to enhance information systems through ICTs, [70]. Challenges persist, including the exclusion of marginalized women due to literacy and digital access barriers. Despite collaborative efforts among NGOs, government entities, and private sectors, m-health adoption faces hurdles in normalization, technical limitations, and low literacy rates [71].

Governance challenges, inadequate infrastructure, and resistance to change further impede progress [72]. Usability issues, legal frameworks, and lack of standardized systems underscore the need for comprehensive governance and trust-building efforts [73]. Interoperability issues, lack of standardized frameworks, and corruption highlight the necessity for policy coherence and effective oversight mechanisms [74]. Initiatives such as 'Aponjon' demonstrate the potential of mobile technology in maternal and child healthcare, yet challenges persist in reaching marginalized women and addressing their healthcare needs effectively [75]. In this regard, technology-enabled solutions hold promise in bridging these gaps and fostering a sustainable healthcare ecosystem in Bangladesh.

6.4. RQ3: designing technologies fitting to context and 24/7 voice bot service

In Bangladesh, a noticeable healthcare disparity exists, particularly concerning feminine health issues, where privileged individuals enjoy better access to healthcare, education, and resources compared to their marginalized counterparts. Marginalized women encounter challenges such as inadequate access to safe menstrual hygiene products and limited knowledge about gynecological,

physiological, and psychological health, resulting in higher disease rates. Addressing this gap requires enhanced healthcare access, increased resources, and education to empower marginalized individuals about their health. Effective technology design must align with the local context to address societal challenges.

Our survey on healthcare among marginalized women in Bangladesh reveals a preference for mobile phone-based solutions over apps, indicating potential digital literacy gaps. Participants' limited app usage experience suggests the need for user-friendly alternatives like basic dialing and SMS messaging. These insights underscore the importance of user-centered research to tailor technology solutions to local contexts and user needs. By creating accessible, affordable, and user-friendly solutions, we can narrow the healthcare gap between privileged and underprivileged women, contributing to overall well-being improvement. In this regard, a voice bot service providing primary health care 24/7 would do a great deal to help marginalized people, especially women, with their health issues. The details are discussed below.

Accessibility: A voice bot system can be accessed using a cell phone, which is a widely used and easily accessible technology in Bangladesh. Furthermore, according to the report [76], just 5.4% of the population of Bangladesh uses smartphones. Because the voice bot service is also easily available on button phones, women who are unable to travel to clinics or hospitals can have more access to healthcare resources.

Cost-effective: Voice bot implementation may prove to be an affordable means of enhancing healthcare accessibility and mitigating inequalities, especially in impoverished regions. Primary recommendations can be obtained through this for those who are reluctant to see doctors because of financial difficulties.

Personalization: A voice bot system can be designed to offer personalized healthcare advice and support, especially for women who have specific healthcare needs and concerns. This technology provides tailored guidance to address their individual requirements effectively.

Privacy: A voice bot system can enhance women's comfort in discussing sensitive healthcare matters, leading to improved privacy and confidentiality. Our surveys revealed that many women feel hesitant to share gynecological concerns with others, particularly male doctors. Implementing a voice bot system can help alleviate this hesitation and provide a more secure and confidential platform for addressing such issues.

6.5. Potential regulatory barriers in implementing our proposed voice bot

The implementation of our proposed 24/7 voice bot could encounter various regulatory barriers and risks. The first and foremost concern is data privacy and security, given the sensitive nature of health-related queries. In this regard, strict data protection laws and health information privacy regulations have no alternative to ensure the confidentiality and secure handling of user information. Besides, obtaining informed consent from users for processing health-related data poses a significant regulatory challenge that requires careful consideration of ethical guidelines. The voice bot's interaction with health queries may also trigger compliance issues with healthcare regulations, necessitating alignment with industry standards. Additionally, the system may face accessibility challenges, which emphasize the need for inclusive design and compliance with diverse regional laws. These regulatory barriers are worth taking into account while considering the implementation of such a system.

7. Limitations and future work

Despite the important contribution of our study in uncovering the barriers to healthcare access for marginalized women in Bangladesh and the potential of our proposed voice bot solution, several limitations entail this study. In this section, we will address these limitations and outline our plans for future work.

Limitations of our study include the potential lack of representativeness of marginalized women in Bangladesh due to the selected slum, i.e., Korail slum, which, being situated in the capital of Bangladesh, may not fully capture the experiences of marginalized women in more remote areas. The study acknowledges that urban populations, including those residing in slums, generally benefit from comparatively better healthcare facilities, improved communication infrastructure, etc. This urban advantage may influence the experiences and access to resources reported by the participants in the study. We were unable to approach a huge community of poor women since we could not reach them. As a result, we lack their perspectives on the healthcare disparities they face, as well as their thoughts on our proposed technology. Additionally, focusing on a single slum might limit the comprehensiveness of our findings, as the challenges faced by marginalized women can vary across different settings. These factors should be considered when interpreting the results of our study.

On top of that, the survey might not have captured the full extent of the healthcare challenges faced by marginalized women due to the sample size. Finally, it is essential to acknowledge the presence of social desirability bias and potential self-reporting limitations in the survey, factors that cannot be entirely dismissed and may have impacted the nature of responses obtained. Bearing in mind all these limitations, our first and foremost avenue of future work is to broaden the scope of our study by including additional slums with diverse contexts, including those situated in rural or remote areas. Furthermore, we aim to expand our sample size to enhance the robustness and representativeness of our findings.

Regarding the design of our voice bot system, there are certain areas for further improvement. First of all, our system's efficiency relies on the knowledge within the dataset, and any question, beyond this dataset, be it related to menstruation, may not yield a suitable response. To address this concern, first of all, we aim to expand our dataset to encompass a broader spectrum of questions. Besides, acknowledging the financial expense of gTTS module for large-scale implementations, we plan to investigate and evaluate cost-effective alternatives to the Google Library Speech API. More importantly, in our roadmap for future work, we plan to implement

a dynamic learning mechanism incorporating machine learning algorithms instead of the existing gTTS module. This will enable the system to learn and adapt over time by continuously updating its knowledge base and amplifying overall accuracy. Moreover, exploring the integration of Language Model (LLM) APIs emerges as another promising direction in this regard. Leveraging the capabilities of such APIs can significantly enhance our voice bot's responsiveness to user queries, overcoming the current dataset limitations.

Moreover, it is noteworthy that, Bengali, the language spoken by the people of Bangladesh, has more than 33 regional dialects [77]. Since the target audience for our suggested design is the marginalized women of Bangladesh, our voice bot model must be able to recognize the regional dialects. This is important as our target group members hardly speak standard Bengali, and rather use these dialects for day-to-day communication. This would be an interesting yet much-needed future extension of our work. Furthermore, our questionnaire dataset of the voice bot prototype is currently tailored specifically to address issues related to menstruation. However, in the future, we expect to have an expanded dataset including all concerns regarding gynecological healthcare to cater to the diverse and evolving needs of women's health and ensure a more thorough coverage of the spectrum of gynecological health concerns.

Additionally, to ensure our bot is available at all times, it must be integrated with a telecom system. Our next steps involve presenting our concept to existing telecom companies to successfully engage them in making our bot accessible through all national telecom carriers. We also plan to collaborate with NGOs and governments to reduce the operational costs of the 24/7 voice bot system, considering the financial situations of marginalized women.

Furthermore, we recognize the significance of enhancing the bot's effectiveness through personalized responses and recommendations based on the user's specific information, such as age, symptoms, and medical history. In this regard, it might also be useful to make the voice bot interactive, i.e., asking further questions to users regarding their personal information if needed. However, all these require the collection of personal information, with which the question of data protection and privacy comes into the picture. Our plan in this regard is to adhere strictly to privacy and data protection regulations, including compliance with GDPR and other relevant standards. Overall, the privacy and security of user data will be a paramount focus, and we plan to implement stringent protocols to obtain user consent, anonymize data where possible, and establish transparent practices in line with the highest standards of ethical data handling.

Added to that, our intention is to enhance our voice bot so that users can obtain information about physicians at nearby hospitals. In the event of an emergency, the user can easily connect to nearby medical facilities by providing the bot with their current location information. Additionally, the bot can provide a list of nearby government clinics, their operating hours, and information about the low-cost services offered by those government hospitals. Finally, it is worth highlighting that our proposed design of the voice bot holds the potential for broader applications. While, in this research, we primarily focused on women and feminine health, in the future, we envision extending its capabilities to cater to males and also addressing a spectrum of other health concerns.

8. Conclusion

Our research sheds light on the barriers that impede healthcare access for marginalized women in the context of developing countries, emphasizing the need for targeted interventions. Our exploratory study revealed the day-to-day challenges faced by marginalized women stemming from limited awareness, misconceptions, and hesitancy in seeking medical assistance. Moreover, financial constraints and societal taboos add further difficulties in securing timely medical appointments. Recognizing the disparities between healthcare access for privileged and underprivileged women is crucial for achieving equity. Technology emerges as a viable solution to bridge gaps caused by the mentioned issues such as poverty, scarcity of resources, etc.

Therefore, to overcome these barriers to healthcare for marginalized women, in this study, we propose a 24/7 voice bot service and present a working prototype of such a system along with performance analysis. While there might still be some challenges entailing such a solution, our research reveals that such a system has significant potential to facilitate healthcare access for the targeted community. Our future endeavor aims to develop an efficient m-healthcare system offering prompt guidance, primary recommendations, and doctor referrals, addressing both health concerns and financial constraints. We hope that our research will aid in the creation of healthcare solutions that are more suited to the requirements of marginalized women.

CRediT authorship contribution statement

Sreya Sanyal Puja: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Nahian Noor Neha:** Writing – review & editing, Writing – original draft, Visualization, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Ofia Rahman Alif:** Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Tarannaum Jahan Sultan:** Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Md. Golam Zel Asmaul Husna:** Supervision, Resources, Investigation, Data curation. **Ishrat Jahan:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Project administration, Formal analysis. **Jannatun Noor:** Writing – review & editing, Writing – original draft, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data and code will be made available on request.

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During the preparation of this work, the authors used ChatGPT [78] for language editing. After using this tool, the authors reviewed and edited the content as needed and they take full responsibility for the content of the publication. Moreover, we would like to thank Dr. Arowa Binte Matin for reviewing our questionnaire.

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