WOMEN'S
HEALTH

Maternal knowledge-seeking behavior among pregnant women in Tanzania

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Abstract

Background: Maternal mortality continues to be a global challenge with about 830 women dying of childbirth and pregnancy complications every day. Tanzania has a maternal mortality rate of 524 deaths per 100,000 live births.

Objective: Knowing symptoms associated with antenatal risks among pregnant women may result in seeking care earlier or self-advocating for more immediate treatment in health facilities. This article sought to identify knowledge-seeking behaviors of pregnant women in Northern Tanzania, to determine the challenges met and how these should be addressed to enhance knowledge on pregnancy risks and when to seek care.

Methods: Interview questions and questionnaires were the main data collection tools. Six gynecologists and four midwives were interviewed, while 168 pregnant women and 14 recent mothers participated in the questionnaires.

Results: With the rise in mobile technology and Internet penetration in Tanzania, more women are seeking information through online sources. However, for women to trust these sources, medical experts have to be involved in developing the systems.

Conclusion: Through expert systems diagnosis of pregnancy complications and recommendations from experts can be made available to pregnant women in Tanzania. In addition, self-care education during pregnancy will save women money and reduce hospital loads in Tanzania.

Introduction

Antenatal care is a well-proven method that uses relevant physical tests to detect issues linked to maternal morbidity and mortality.[1] Every day, nearly 830 women die as a result of complications during pregnancy or childbirth.[2] Developing countries account for almost all of these deaths, with maternal mortality rates of 239 per 100,000 live births compared to 12 per 100,000 in developed countries. One-third of maternal deaths are caused by hypertension (pre-eclampsia and eclampsia), whereas half are caused by antepartum hemorrhage, both of which are linked to poor prenatal care.[3] Late seeking of care has also been identified to be a crucial factor in maternal deaths.[4]

The maternal mortality rate in Tanzania is about 524 per 100,000 live births. According to a study conducted in Dodoma,[5] three-phase delays in seeking healthcare among pregnant women were identified as the main contributing factors to the deaths. The first-phase delay occurs when a family takes a long time to determine whether or not to seek help. This may be due to a lack of awareness of the warning signs, a lack of funds to bring the expecting mother to a medical center, or the expecting mother's

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inability to determine where she wants to give birth. The second-phase of the delay occurs on the way to the medical center, this can be attributed to the unavailability of transport to a health facility or bad roads. The third-phase delay occurs when a woman is unable to receive immediate and satisfactory treatment at a health facility, which may be due to staff shortages or inadequate expertise, as well as a lack of medications, medical supplies, or equipment. The third-phase delay also includes a delayed referral from one health facility to another. The Tanzania National Road Map Strategic Plan[6] reduces maternal, newborn, and infant morbidity and mortality by identifying two classes of critical challenges. These are as follows:

1. Health system factors: limited human resource, scarcity of quality health services, poor implementation of pro-poor policies, low implementation of modern family planning services, lack of equipment and supplies, substandard health infrastructure, defective referral systems, shortage of skilled healthcare providers, inadequate health management at all levels, and poor coordination between public and private facilities.
2. Non-health system factors: some social-cultural beliefs and practices, poor involvement and participation in planning, implementation, monitoring, and evaluation of health services in the communities, poor health-seeking behavior, weak educational sector, and gender inequality.

Tanzania, through the Ministry of Health, Community Development, Gender, Elderly, and Children (MoHCDGEC), has made numerous efforts to reduce maternal mortality rates. Programs such as the Primary Health Sector Development Program (PHSDP) aim to reduce maternal mortality through increased birth coverage aided by skilled birth attendants through increasing the accessibility of human and material resources. The National Road Map Strategic Plan in Tanzania is designed to enhance reproductive, maternal, infant, child, and adolescent health. The initiative includes One Plan II and Health Sector Strategic Plan (HSSP).[7] Strategies such as notifying maternal deaths in less than 48 h and responding to them within 7 days are being introduced in the Dodoma region, which is home to the country's capital. Action plans for perceived gaps are formulated during these meetings.[8]

Studies have shown increased maternity knowledge can help women to understand the role of clinicians better and proper pregnancy self-care. Research by Chesser et al.[9] found that providing expectant mothers with knowledge on prenatal education improved the number of attendees in group prenatal education classes and was connected to positive knowledge and health outcomes. In addition, Fondjo et al.[10] and McCaw-Binns et al.[11] presented that the distribution of cards with figures depicting the symptoms

of pre-eclampsia resulted in decreased adverse events among the patients, and awareness of pre-eclampsia and its related causes among pregnant women contributed to its prevention, control, and management.

As of 2020, an estimated 4.54 billion people were using the Internet, reflecting a 7% increase compared to 2019.[12] Engaging with pregnancy applications seems to have become a routine part of the maternity experience for many expectant mothers. Globally, the most common mobile application in medicine appears to be pregnancy apps, which attests to their ever-increasing popularity.[13] In addition, the majority of smartphone owners in the world are women, with implications that pregnancy itself is an incentive to buy a smartphone.[13] Pregnancy-specific websites include "What to expect when you're expecting" (WTE), BabyCentre, and the Bump. Sections on pregnancy and baby guides are found on medical websites such as WebMD, Mayo Clinic, and the UK's National Health Service (NHS). Mobile applications include those developed to accompany websites, for example, the BabyCentre app and the pregnancy tracker app from WTE while others such as *GiftedMom* deployed in Cameroon, *Jambo Mama*, and *Wazazi nipendeni* for Tanzania do not have corresponding websites. The content featured ranges from information on upcoming doctor's visits, interactive three-dimensional (3D) visualizations, and descriptions of fetal growth and risks at different stages of pregnancy. The information is usually presented on a week-to-week basis, with a tool to calculate gestational age (number of weeks of pregnancy). Pregnancy and baby editorial articles and real-time answers to questions asked by mothers during pregnancy are included.

However, information on pregnancy websites can give contradicting information to women.[14] This may be due to the information being for differing contexts. For example, schedules for medical visits, prevalent conditions will differ from country to country, and this may be reflected in the different websites. The language used also caters to the literacy level of the specific countries. For women in countries such as Tanzania, the language used and the lack of conditions such as malaria in pregnancy, a serious and often occurring condition, may make the information difficult to understand or may lead to confusion or distrust in the information given, respectively. Moreover, the information given can sometimes be too much, making it confusing and hard to retain for many women.[14]

To ensure online and mobile information sources provide the necessary knowledge to women that can allow them to improve care-seeking behavior, a more client-centered approach must be used for differing contexts.[14]

This study intended to investigate the knowledge levels and knowledge-seeking behavior of pregnant women in the Tanzanian context. We interviewed 182 women, which included those attending antenatal clinics and new mothers, as well as 6 gynecologists and 4 midwives. Interviews

with the pregnant women focused on where, when, and how they seek information on pregnancy, their trust in the information received, how relevant they find the information gained, and what information and features they wish were included in pregnancy apps. The interviews with the gynecologists and midwives focused on the most common pregnancy complications in Tanzania, their causes, symptoms, and recommendations for dealing with them. The scope was limited to women in urban areas, as they are more likely to seek information and statistics show a growth of maternal mortality rates in urban areas.[4]

This article is organized as follows. Section "Related work" addresses several related research works concerning maternal health information and practical applications. Section "Methods" introduces the overall approach to solve the issues of pregnant women in Tanzania. Section "Results" describes the study results based on key research findings, and section "Discussion" provides a discussion including recommendations. Section "Conclusion" concludes this research work.

Related work

Information-seeking practices of women in Africa

According to Ukonu and Ajaebili,[15] women in Nsukka, Southeast Nigeria, used multiple sources of information with family and friends being the most common source. They suggested that high reliance on friends and family as a source of information might have been influenced by low literacy level and income level among the respondents. They found that despite the rise of social media and Internet usage, mass media was declining as a primary source of health information which could have been influenced by low literacy and income among the women. Okafor and Goon[16] found that a majority of women in South Africa (70.2%) got information about physical exercise during pregnancy through social media, television, and radio, while 49.1% used books, newspapers, and magazines as a source of information. The study showed that lack of physical activity information from midwives in charge of their antenatal care clinic influenced high reliance on friends, family, magazines, and most importantly the Internet as a source of information.

Health information-seeking behavior in Tanzania

In Tanzania, studies on maternal health knowledge-seeking have primarily centered on rural women. A study by Mwangakala[17] found that the majority of women chose to get information about their maternal health from qualified healthcare providers. However, the limited accessibility of these providers led many expecting mothers to seek

information from traditional birth attendants and other women in society. Much of the information gained therefore was based on personal experiences and opinions rather than expert knowledge, which prevented the women from taking danger signs seriously. Similar findings were also reported by Kassim and Katunzi-Mollel.[18]

Studies on health information-seeking behavior have also shown large reliance on oral sources of information, with the preference being from skilled health providers.[19,20] However, Mwaisela and Mwantimwa[21] found that preferences for the source of health information varied from person to person, depending on the reasons for seeking information, although oral sources were also the most frequently used sources among women seeking breastfeeding information. Barriers to online health information seeking include the perceived difficulty in accessing information and perceptions of quality. In rural areas, illiteracy, lack of knowledge that the Internet can be a source for information, and costs may be reasons for the low usage of online sources.

Mobile applications for antenatal care

Numerous applications have been developed to support safe pregnancy and child delivery in the African context. One of the most successful applications is the MomConnect application in South Africa.[22] MomConnect, launched in 2014, sends Short Message Service (SMS) on behaviors that improve maternal and child health outcomes. The messages are tailored based on a woman's gestational age. In addition to SMS, women can also ask individual questions and provide feedback on antenatal care received. Users report very high satisfaction, with over 500 questions being asked daily. A similar application, GiftedMom, provides SMS-based and voice-based reminders on upcoming antenatal appointments as well as maternal health education to women in Cameroon.[23] In 15 rural areas, the application resulted in a 20% rise in antenatal clinic attendance. Meanwhile in Ethiopia, the Safe Delivery app[24] uses 5–7 min animated videos to provide instruction on the management of the third step of labor, with a focus on lifesaving techniques. Health workers can choose to view the entire video or view-specific techniques in the video. Weekly SMS quizzes with links to the video segments which showcase the results and lists of essential medicines and equipment are also provided. Health worker's experience with the app was overall positive, with many opting to use it to refresh knowledge on lifesaving techniques.

In Tanzania, maternal health applications include *Wazazi Nipendeni*—an SMS service by the Airtel telecommunications company, that aims to keep women aware and safe at all stages of their pregnancy by providing information on diet, family planning, danger signs, and a variety of other main topics.[25] In unadjusted models, exposure to the app predicted whether women delivered in a health facility

or screened for HIV with their partner. Several applications, from SMS-based ones to smartphone ones, have also been launched to help women in gaining knowledge of pregnancy progression and symptoms. Other applications include as follows:

1. Jambo Mama: an interactive mobile application that provides general health information regarding expecting women and connects them to their health workers. Medical records are sent to the hospital where the woman will give birth. Jambo mama also sends text updates about the mother's pregnancy and encourages her to answer questions about how she is feeling and how her pregnancy is progressing.

2. Wired Mothers: an SMS-based application with a voucher component that was used in a randomized controlled trial in Zanzibar to see whether a mobile app could improve antenatal care visits during pregnancy.

A major drawback to applications such as Jambo Mama and Wazazi Nipendeni is the need for doctors to manually reply to received messages, which is a tedious process for doctors that resulted in late responses to pregnant women.

Mobile phone–based pregnancy support systems

A mobile phone–based approach is a personalized approach that helps to educate women on issues related to pregnancy, monitoring of the child and mother's progress, critical updates, post-delivery support, and follow-up with medical check-ups through mobile phone. In the presence of good mobile phone technologies and mobile network infrastructure, a suitable platform that is available at all times to help in reducing pregnancy-related stress and anxiety and its complications is vital. This platform will not only help the mother but also her spouse to be aware of changes that occur during pregnancy and the necessary precautions that need to be taken.[26] Expert systems, decision support systems, pregnancy-related websites, and mobile applications designed to run on mobile phones all fall in this category.

Expert and decision support systems for detection of early pregnancy complications

An expert system for Predicting Early Pregnancy with Disorders using Artificial Neural Networks (ANNs) was developed by Maylawati et al.[27] Several early pregnancy disorders such as ectopic pregnancy, pre-eclampsia and eclampsia, hyperemesis gravidarum, and hydatidiform mole were successfully detected from input symptoms. The study used ANNs and backpropagation algorithm.[27]

Kitporntheranunt and Wiriyasuttiwong[28] also developed a medical expert system for ectopic pregnancy diagnosis, with testing showing a 100% correspondence to the clinical diagnosis in the testing group. Another maternal health expert system was developed in Eldoret, Kenya, for hypertension diagnosis.[29]

A fuzzy approach has also been used by Umoh and Nyoho[30] for pregnancy risk factor monitoring. Their research aimed at diagnosing and monitoring pregnancy risk factors in women with accuracy in the presence of a huge amount of data. The model was aimed to provide a decision support platform to physicians, health practitioners in obstetrical, and also pregnancy risk factor researchers. The study also assisted health practitioners in obstetrical and gynecology clinics in providing education to women about the advantages of early clinic attendance and the risk factors related to pregnancy.

Paydar et al.[31] developed a clinical decision support system (CDSS) to predict the pregnancy outcomes of pregnant women affected with Systemic Lupus Erythematosus (SLE). The system performed well in predicting pregnancy outcomes of the infected women.

Methods

The principal investigator conducted a survey and observation study in Arusha, Tanzania, from February to August 2020. The study design used was a mixed-method explanatory sequential design where 182 (94.8%) of the participants were pregnant women and mothers, while 10 (5.2%) were gynecologists and midwives. Arusha city in Tanzania was selected because it is an urbanized city, and recent studies have suggested that the maternal mortality rate in Tanzania has risen over recent years and is now increasingly urban. These results have raised concerns from the Government of Tanzania and stakeholders about the reasons for such inconsistencies.[4]

Participants

A total of 192 participants (6 gynecologists, 4 midwives, 168 pregnant women, and 14 recent mothers) took part in the study. Participants were selected randomly from three major hospitals in the city—Mt. Meru Referral Hospital, Arusha Lutheran Medical Centre, and AICC hospital. One hundred eighty-two women participated in the study, where 32 women were sent online questionnaires for validation purposes and 50 women were selected from each of the three hospitals. Time and resource constraints influenced the selected sample size. The inclusion criteria was women who were pregnant at the time of the study, recent mothers who had given birth within 6 months of the study's commencement, and medical personnel who were either gynecologists or midwives. The research was strictly limited to the researcher and the participants.

Table 1. Demographic characteristics of the women who participated in the data collection process.

Demographic	Category	Number of participants
Age	18–23	27
	24–29	94
	30–35	61
Education	Primary education	47
	Secondary education	94
	Higher education	41
Number of prior pregnancies	0–3	163
	4–7	19

Ethical approval for the study was granted by Kibong'oto Infectious Diseases Hospital—The Nelson Mandela African Institution of Science and Technology—Centre for Educational Development in Health, Arusha (KIDH-NM-AIST-CEDHA)—KNCHREC under research proposal number KNCHREC 0038/RW/2/21. The study took place between February and August 2020. Table 1 shows the demographics of the women who took part in the data collection.

Before the study, ethical clearance/permission for this stage was obtained from the hospitals. All participants were informed on the purpose of the research, the scope of data to be collected, how their data would be used, and their right to decline participation or to withdraw at any point. Participants gave written consent before the start of the study.

Survey design

The survey consisted of both questionnaires and interviews. The questionnaires were distributed to the pregnant women and recent mothers; they consisted of 15 questions divided into 2 sections. The first section focused on collecting demographic details such as area of residence, age, education level, and the number of prior pregnancies. The second section assessed knowledge-seeking behaviors. The questions included were on: whether they used their smartphones to search for information regarding symptoms that they experienced during pregnancy, the applications or websites they used, whether there was a correlation between the results from websites and what the doctors tell them, challenges they face when using the applications, and what additional knowledge and system features, they felt were needed to address the challenges faced. Participants provided both free responses and the most relevant options from multi-choice questions. During the interviews, field notes were recorded and reviewed at the end of the survey.

The interviews were conducted with gynecologists and midwives. They were structured and consisted of 13 questions. The questions were aimed at identifying common complications women experience during pregnancy, complications that were prevalent in Tanzania but less so elsewhere, the risk factors associated with the complications, how the complications can be prevented and managed, symptoms that should result in help-seeking behavior, and any first aid treatments that can be administered at home. The interviewer recorded the responses during the interview and reviewed them during the analysis stage.

The questionnaire was validated before the study by 32 women who were sent online questionnaires (Google Forms). Originally, the questionnaire contained 30 questions, but these were reduced to 15 after the validation study, as the omitted questions mainly provided repetitions of previous answers. Some questions were also rephrased to make them easier to understand and to prompt more verbose responses on the women's experiences. In the online questionnaire, a description of the study was provided followed by a consent form that was filled before participating in the questionnaire. Personal details such as the city of residence, age, and level of education were included. The validation results showed that the questionnaires provided to the women produced better results when they were provided with multiple choices and checkboxes. Questions such as "Do/Did you search for Nutrition, safe exercises during pregnancy, and self-care during pregnancy? Is there any additional information you search for?" Provided limiting responses with little insight, and the likelihood of the women forgetting some information was great, but when women were given a variety of information to select from, we found that they selected more information they sought during pregnancy. In addition, questions that required long answers were skipped more with the women this was an indicator to structure questions with answers they could select from to maintain the women's engagement during the study. Moreover, the women were hesitant to respond to questionnaires that had too many questions, we eliminated the repetitious questions to encourage more women into participating in the questionnaire while maintaining the intent of the questionnaire.

Observation

Observations were conducted after the interviews. We asked the pregnant women and recent mothers to show us how they interacted with the applications or websites to search for information using their phones. We asked them to type in the questions they had on the applications and questioned them on the results obtained to gauge their understanding.

Data analysis

The collected data were pre-processed by the principal investigator by analyzing consistencies in responses and filtering responses that did not match the questions.

Table 2. The types of information pregnant women searched for based on the most popular information sought to the least popular information sought.

Type of information	Number of women (%)
Nutrition	99.5
Self-care during pregnancy	64.3
Physical changes	61.5
Exercise during pregnancy	53.3
How to prepare for labor	52.7
Substances to be avoided during pregnancy	48.9
Breastfeeding and baby food	40.7
The dos and don'ts during specific periods	35.2
Fetal development	34.6
How to sleep when you are pregnant	29.7
Pregnancy count down	24.2
Psychology in pregnancy	14.8

Responses from the questionnaires were fed into the Visual Paradigm data visualization tool, which is a UML CASE Tool supporting UML 2, SysML, and Business Process Modeling Notation (BPMN) from the Object Management Group (OMG). The responses to multiple-choice questions were presented using histograms to determine the distribution of responses. Pie charts were used to present the qualitative responses where the proportion of responses were distributed based on the demographics of the participants.

Results

Smartphone ownership and usage for information searching

The majority of women owned smartphones. Of the 182 women who were interviewed, 114 (62.6%) owned a smartphone while 68 (37.4%) did not own a smartphone. However, only 99 (86.8%) smartphone owners used their devices to access information regarding pregnancy. The rest were either uninterested or unaware of pregnancy apps and websites and relied mostly on doctors, midwives, and friends.

The information that was most commonly searched for regarding pregnancy was on nutrition, specifically on the types of foods to eat for a healthy pregnancy, and on self-care during pregnancy. Table 2 presents the types of information searched for based on their popularity.

The main source of pregnancy information on smartphones was mobile applications, where all 99 women used mobile applications with the BabyCentre app being the most popular used by 95 women (95.96%) and YouTube being the second most popular used by 61 women (61.6%). The Bump, Pregnancy+, WebMD, What to expect, Mediscape, NetMums, YouTube, Instagram, Pinterest, The Blueberry, Flo, Pregnancy Tracker, and Pregnancy calendar

were also used. The reason given for the preference for mobile applications was mobile phones are readily available and the information is presented in a more user-friendly way than when viewed on the website:

> It is easy to access information through my phone compared to a computer, I walk with my phone everywhere and the mobile applications are more user-friendly there. For me to use the websites I need to get a computer from the internet café or ask a friend because the website is more user-friendly on a computer

The apps also provided additional features such as weekly notifications on changes to expect, the countdown to delivery, and pregnancy week by week. Notifications in particular were deemed very useful:

> Mobile applications alert you at the beginning of every week on the countdown to your due date, it reminds you of what you need to do and normal physical changes during pregnancy. This keeps me at peace because I know what's going on.

Regarding user experiences with BabyCentre, participants remarked on the easy-to-understand language and wide range of information on safe and unsafe practices as helpful and engaging:

> Baby center gives me information such as how far I am in my pregnancy in weeks and also tells me how many days I have left until I give birth, it also tells the growth progression of my baby, this helps in understanding my pregnancy. (P1)

> The application provides information on what exercises are safe to do, foods that are good to eat and the ones to avoid, the amount of sleep I need to get. This helped me in coping with pregnancy. (P2)

However, one participant who was a first-time mother complained about the community clubs:

> I don't like talking to other women online, they make me anxious. I would rather read the information provided in the applications and listen to the experts.

The reason for YouTube's popularity was the perceived ease of understanding information due to the use of videos and animations:

> It doesn't take me a long time to understand information from YouTube, it is easier for me to understand because they explain things in simple words, pictures, and videos compared to other sources.

Overall, we observed that most of the women 72 (72.7%) used a combination of sources (websites and applications) to search for information, with only 27 (27.3%) using a single source. Websites and applications

with more visual presentations were preferred to wordy ones, as the women felt wordy applications could be confusing and less engaging (easy to lose interest in).

Other sources of information on pregnancy, childbirth, and childcare

Other sources of pregnancy information that were reported were medical doctors (obstetricians and gynecologists), midwives, friends, and sometimes books to search for information. Preference on where to get the information varied among women who did not own smartphones. Sixty-eight (100%) women preferred doctors, 52 (76.5%) preferred midwives, 27 (39.7%) preferred friends, and 7 (10.3%) preferred books:

> I prefer asking doctors about pregnancy because they can explain well, and I trust them more. (P1)

> I like talking to the midwives, they are mostly mothers so they understand my situation better. (P2)

> I am more open talking to my friends, they explain their experiences to me at home. I don't have to go to the hospital a lot. (P3)

> When I read books, I gain a lot of knowledge. In case I don't understand something, I ask the doctor or midwife in the next meeting. (P4)

Correlation of information between doctors and the applications

When asked whether the applications matched what the doctors told them, 91 (91.9%) of women said that they found correspondence between what the doctor said and what was written in the applications, while 8 (8.08%) women said that the information provided was sometimes different.

Education level may have influenced whether the women felt there were differences in the provided information, with the more educated women being more likely to report observing a difference. This could be due to their higher information and technology literacy, which resulted in their searching for information from more online sources, using more search terms, and overall reading more articles, even those with more complicated language. The main perception was that applications provided more information than doctors:

> The applications provide more information than the doctors, sometimes the doctors don't tell you enough about your pregnancy so through the applications I get to learn more. (P1)

P1 was concerned with toxoplasmosis, which is a parasitic infection caused by the *Toxoplasma gondii* parasite,

one of the most common parasites on the planet. Eating undercooked tainted meat, coming into contact with infected cat feces, or mother-to-child transmission during pregnancy are the most common ways to become infected. Toxoplasmosis infection can cause flu-like symptoms, However, the majority of those who are affected never show any signs or symptoms. According to the interviews with doctors, the condition is more common among women in Western countries than it is in Tanzania. Women rarely get toxoplasmosis in Tanzania because few people live with pets in the house, which reduces the likelihood of getting infected. As a result, this condition is rarely talked about with patients.

Recommendations on improving apps and websites for maternal information

The main recommendation given by 144 (79.1%) women was to include health professionals in the development of the system to improve trust in the systems:

> I will have more confidence in the systems if health professionals will work with system developers in developing the systems, it will build more trust in the results we receive. (P1)

> I do not want to be confused with the information I receive from the systems, if health professionals will be involved then there will be less confusion. (P2)

> When I am sure that health professionals are involved in these applications, I will be motivated to buy a smartphone and use the applications. (P3)

Another popular recommendation was to have the system information matching the Tanzanian context 122 (67%):

> Sometimes the advice I receive from the system do not match what is in the environment, it is frustrating. (P1)

> The size of the fetus is compared to things that I have never seen before, I think those things are found in western countries, not here. (P2)

> These systems are developed for western people. Their methods are not like ours they are more advanced; I would prefer something that is designed for us which I can understand. Then I will use the applications. (P3)

> I don't understand English very well, If there are applications in Swahili then I will start using them. (P4)

Challenges faced during information search

Only a minority of the women 20 (20.2%) reported facing challenges in retrieving the information they sought online.

The main challenge reported was finding an explanation for the symptoms they faced using search engines. However, observation showed that far more women were not able to find the right keywords to use on search engines. One participant, for example, was asked to search for symptoms that she was experiencing. The participant was able to describe in Swahili that she felt dizzy, bloated, and had a headache. However, she was only able to describe one symptom, "headache." She also failed to include pregnancy in her search terms. Consequently, the results she obtained were too vague.

More than half of the women 66 (66.7%) complained that the search results were too wordy for them to understand:

> It is sometimes not easy to understand results from google because they provide too much information which ends up confusing me, so I lose interest in the middle. (P1)

> It is easier to receive information from YouTube because they keep the flow of information interesting, they include a lot of pictures that help me understand better. (P2)

The influence of prior pregnancies on the knowledge-seeking behavior

The number of prior pregnancies was seen to have influenced the knowledge-seeking behavior of the women, with first-time pregnancies prompting more curiosity than women who have had more than one pregnancy:

> I understand pregnancy because this is my second child. Every pregnancy is different, my first pregnancy was smooth but this time my first trimester was hard. I still seeking information from the experts and the internet but not as much as I did in my first pregnancy. (P1)

> This is my first child; I search for information anytime I experience a new symptom or whenever I want to learn about my progress and the baby. It is better to be prepared, it eliminates fear. (P2)

> I still seek for health information when I am pregnant regardless of being a mother of two. It was more frequent in my first pregnancy but I have learned through experience how pregnancy works so it is not very frequent now. (P3)

> I read about pregnancy a lot; it is difficult for me to be pregnant for the first time. Everything is new so I have a lot to learn. (P4)

Discussion

According to this study, Women in urban Tanzania were seen to lack knowledge about pregnancy complications which is contrary to popular belief. The majority identified vaginal bleeding and abdominal pain as symptoms of pregnancy complications. However, symptoms such as swollen face, hands, and feet, blurred vision, severe headache, and difficulty urinating at 20 weeks of pregnancy which are often overlooked indicate a serious complication called pre-eclampsia which is one of the leading causes of maternal mortality in Tanzania. Due to poor knowledge on obstetric dangers, many women seek care when their condition has worsened, leaving experts with little to do, but if they had known about these conditions and their symptoms, countless lives would have been saved.[32]

With the increase in smartphone usage, women have been seen to use their mobile phones to access information on pregnancy.[13] However, in this study, the majority of the women struggled to get the information they searched for on the Internet, this was primarily due to poor input of symptoms which often led to vague results. In addition, when the results provided lengthy responses, the women would often lose interest in reading the information. They preferred short answers to questions and the use of audio, videos, and pictures as a method of information delivery.

The research conducted shows that to enhance knowledge that women have on the risks during pregnancy and the services that they are to receive, the information provided to them must be represented in a short simple format. The user interface should be simplified using common icons, easy words, and provide more descriptions to make it a suitable platform for them to learn. Also, with the help of videos, pregnant women will be able to understand the information provided easily.

Moreover, the majority of the women requested health specialist's recommendations on pregnancy complications, safe practices during pregnancy such as nutrition, exercise during pregnancy, substances, and behavior to avoid during pregnancy, preparation for labor, and breastfeeding and baby food to be included in the system to enhance trust in the applications and diverse knowledge in regard to pregnancy. In addition, the women shared that information on fetal development and physical changes related to pregnancy will help them in understanding their pregnancy progression.

The challenge faced by some women in the study is their inability to search for the information they need. When developing a suitable platform for pregnant women in Tanzania, there is a dire need to present symptoms in a way that can easily be understood by the woman so as to provide the most relevant results.

Women in urban Tanzania were the focus of the study. However, pregnant women in rural Tanzania should have their knowledge-seeking behavior studied so that researchers may develop solutions that are customized to their needs. Another limitation of the study was a restriction of time and resources; more research should be done in different parts of Tanzania and with a large sample size to compare the requirements of pregnant women in order to develop an acceptable solution for each pregnant woman.

Conclusion

With maternal mortality still being high in developing countries, women need to know pregnancy complications. In this study, women have shown great interest in learning about complications that are accompanied by pregnancy, and self-care recommendations during pregnancy provided that there are reliable platforms endorsed by health specialists. The participation of experts when developing these platforms is vital because it ensures the women are being provided with reliable information. In this study, we were able to collect requirements for pregnancy applications from women in the Tanzanian context. Based on the data collected, we found that expert systems are ideal for providing women with the necessary knowledge.

With proper training of the machine learning models, expert systems can enhance knowledge in pregnant women which will aid in the reduction of the maternal mortality rate in Tanzania. Moreover, providing women with self-care tips will not only improve the quality of pregnancy but also will save women time and money.

In the future, we aim to develop an expert system that will diagnose pregnancy complications, provide knowledge on the causes of the complications, and recommendations from experts. In addition, the expert system will provide self-care information for natural pregnancy conditions.

Author contributions

The study consists of three contributors E.S.K. the student (female), E.L. the internal supervisor (female), and J.K. the external supervisor (male). The study was conceived by E.S.K. and E.L. E.S.K. designed the study, carried out data collection and analysis, and was responsible for the preparation of the manuscript. E.L. and J.K. were in charge of a thorough revision of the paper. The final manuscript was read and approved by all of the authors.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Supplemental material

Supplemental material for this article is available online.

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