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Design and Implementation of Persuasive Technology for Maternal health care: Nigeria as a Case study

[1]Charity E. Mbanusi, [2]Virginia E. Ejiofor, [3]Irabor Chuks Clarence and [4]Godspower I. Akawuku

[1,2,3,4]Department of Computer of Science, Nnamdi Azikiwe University, Awka, Nigeria
Email: Chary4sam@gmail.com

ABSTRACT

Persuasive technologies are Human-Computer Interaction (HCI) systems integrated with strategies designed to encourage users to perform specific target behaviors. Maternal healthcare services in Nigeria are structured to promote information-seeking behaviors and enhance the health and wellness of pregnant and nursing mothers through social and motivational approaches. However, these strategies have been largely ineffective, resulting in a persistently high rate of maternal deaths due to poor health practices and the lack of engagement with smart e-health solutions. This research investigates the immediate and remote factors contributing to inappropriate maternal healthcare behaviors, aiming to design and implement a responsive persuasive technology that encourages responsible maternal health-seeking behaviors. To achieve this goal, a mixed-method approach was adopted, incorporating user studies (survey), research design, and the Persuasive System Design (PSD) framework. The findings from the user-based research were carefully mapped to five critical factors affecting the adoption of appropriate maternal health-seeking behaviors in rural communities. These factors were then aligned with corresponding persuasive strategies, which informed the development of innovative and cost-effective design guidelines. These guidelines are intended to motivate attitudinal and behavioral changes in the health and information-seeking practices of expectant and nursing mothers in rural African communities. Following the research phase, a persuasive technology for maternal healthcare was designed and implemented using an object-oriented methodology. This technology was developed in PHP and it addresses negative maternal healthcare attitudes by encouraging positive behavioral changes among users. The system incorporates relevant persuasive strategies and is built from the ground up to ensure privacy, while providing personalized and tailored views for users.

Keywords: Persuasive technology, Maternal health, Nigeria

INTRODUCTION

Over the last decade, new innovations and developments in digital technologies (mobile and web) coupled with access to internet services across developing African nations, have motivated the application of sociotechnical interventions into various areas of our lives. Persuasion simply means to motivate or encourage action towards achieving definite goal(s). Knowingly or unknowingly, people, organizations, institutions and governments often employ persuasion, and tend to influence the public every time we speak or perform certain activities, with the aim to make someone perform or carry out a particular target behavior. Many studies in the social and management sciences focus on human-to-human persuasion, where a human or institutional authority (persuader) tries to persuade a target audience (persuadee) manually. For instance, [1] observe that human-human social facilitation and cooperation are used to persuade residents in a community to adopt a healthier lifestyle. Persuasion may lead to a voluntary transformation in people's attitudes and behaviours. Over the years, results from studies have shown that computer technologies can be designed to motivate attitudinal and behavioral changes (human-computer persuasion). This has led to increase in research interests as it concerns using suitable technologies to support potential users to carry out intended behaviors in different domains of human life.

Materials and Methodology

This system is implemented and communicates using PHP, Wamp Server, JavaScript with a MySQL database in real-time, to ensure that actions from the users of the system are logged to the system. This study focuses on designing and implementing a persuasive technology system designed to promote regular and timely ante-natal, intrapartum, and postpartum care for expectant and nursing mothers in developing regions. To achieve this, the study adopted a mixed-method approach that combines Design Science Methodology, Persuasive Strategies, and Object-Oriented Analysis and Design Methodology. This mixed methodology was chosen to optimize the benefits of each component method in the development process. The subsequent sections offer a comprehensive explanation of the rationale behind the selection of each method and how they were systematically applied to accomplish the objectives of this study. The first phase, problem identification and motivation, focuses on clearly defining the research problem and highlighting the importance of addressing it. It involves conducting a thorough review of existing literature, current practices, and the state of the art in the problem domain to justify the need for a solution. This phase can be compared to data collection or information gathering. It may utilize qualitative, quantitative, or mixed methods to assess the feasibility of developing a solution. Research strategies such as case studies and action research, as well as methods like surveys and observations, are often employed to guide this phase and validate its outcomes. The second phase involves defining the objectives of the solution, which can be either qualitative or quantitative. These objectives are shaped by a thorough understanding of the problem's context and the efficacy of existing solutions. This phase ensures that the proposed solution is both innovative and practically relevant. The third phase, design and development, is centered on creating the artefact while also contributing to the body of knowledge in the field. The artefact can be developed using appropriate system design methods, including object-oriented design tools and techniques. The fourth and fifth phases, demonstration and evaluation, are combined into a single phase in the context of this study due to their interrelated nature. Demonstration focuses on validating the artefact's functionality and its ability to address the identified problem through methods such as experimentation, simulation, or case studies. Evaluation, on the other hand, examines the artefact's effectiveness, rigor, and overall contribution to achieving the research objectives. The final phase is communication, which focuses on disseminating the research findings with relevant audiences, such as scholars and practitioners. It involves articulating the problem, its significance, the artefact, its utility, novelty, and the rigor and effectiveness of the research process. See Figure (1).

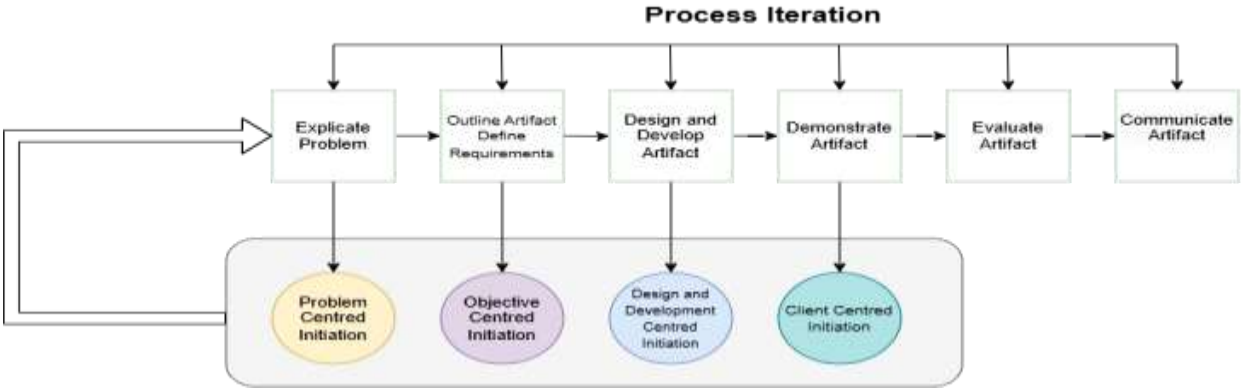

Fig 1: Design Science Research Process Model. Source: Peffers et al., (2007).

Persuasive Strategies

Persuasive strategies are behavior-change techniques which are implemented on systems to motivate desired behaviors from potential users of that system. The Fogg's 8-step design process [2], and the Persuasive System Design (PSD) model [3] are the two most popular models of persuasive design. Specifically, the Fogg's 8-step design processes are:

a. Choose a simple behavior to target
b. Choose a receptive audience
c. Find what is preventing the target behavior
d. Choose an appropriate technology channel
e. Find relevant example of persuasive technology designs
f. Imitate successful examples,
g. Test and iterate quickly, and
h. Expand on success.

Besides, the persuasive strategies of the PSD designed by [3] are categorized into four (4) groups:

i. **Primary Task**: The principles under this group support the user to carry out their primary task. They are Reduction, Tunneling, Tailoring, Personalization, Self-Monitoring, Simulation, and Rehearsal.
ii. **Computer-human Dialogue**: The principles under this group help users keep moving towards their goal or target behaviors. They are Praise, Rewards, Reminders, Suggestions, Similarity, Liking, and Social Role.
iii. **System Credibility**: The principles under this group help describe how to design a system so that it is more credible and thus more persuasive. They are Trustworthiness, Expertise, Surface Credibility, Real-world Feel, Authority, Third-party Endorsement, and Verifiability.
iv. **Social Support**: The principles under this group motivate users by leveraging social support to help them perform target behaviors. They are Social Learning, Social Comparison, Normative Influence, Social Facilitation, Cooperation, Competition, and Recognition.

For the full details on how each of these strategies in each of the group's functions, please see [3].
These strategies are operationalized in persuasive technologies to motivate desirable behaviors from potential users. Also, they will offer solutions to other identified problems via providing channels for: effective data collection, management and planning, customization of the system to serve various categories of users, quick influential messaging system for effective communication purposes, and optimized information source for feedback and report generation, robustness and ability to scale, monitoring and routine support, etc.
The aforementioned persuasive models will be combined and used in this dissertation. This is because changing attitude and behavior opens the way to solving other problems. The Persuasive Technology (PT) application which will be developed in this work will integrate the Fogg's 8-step design process together with relevant persuasive strategies of the PSD model to design and implement the Persuasive Technology based- Model for Maternal Health. The diagram in Figure 2 shows the generic steps in persuasive system development.

Fig 2- Generic Steps in Persuasive System Development. Source: [3]

User-based Study

There is a need to establish what the obstacles (attitudes and behaviors) to adopting proper maternal information and health-seeking behaviors amongst expectant and nursing mothers are? The researcher believes that understanding the impact of poor information and health-seeking behaviors amongst expectant and nursing mothers will be helpful in uncovering what strategies could be employed in the design of an intervention which could motivate them to adopt or perform target behaviors. Therefore, this study addressed the following research questions:

1. What are the attitudes/behaviors to adopting proper maternal information and health-seeking behaviors amongst women?
2. What persuasive strategies can be employed to tackle these attitudes?
3. How can these persuasive strategies be implemented in a maternal health intervention to motivate potential users to adopt proper information and health-seeking behaviors?

To address these questions, the researcher conducted a user-based study to assess the attitude and behaviors of expectant and nursing mothers towards their health and that of their babies.

Research Questions and Data Collection

This is the data gathering stage. The initial studies focused on investigating the maternal and child health processes and procedures in a typical health facility. This is to uncover the hindrances (attitudes and behaviors) to adopting appropriate information and help-seeking behaviors. The researcher used semi-structured interviews and observations of the healthcare processes and brainstorming possible automated solutions.
To address research question we interviewed expectant/nursing mothers and caregivers after the first three months of their antenatal visits (first trimester) to understand the obstacles that hinder expectant mothers from adopting proper maternal information and health-seeking behaviors amongst women. The interview involved seventy-three (73) research participants comprising 20 expectant mothers, 30 nursing mothers, and 23 nurses and midwives. In this study, we tried to ascertain the health status of the expectant/nursing mothers via the medical register of the health facility. We got consent from the health facility management to access their register after a thorough

consideration of our ethical clearance certificate for this study, which was obtained from the department. Moreover, questions focused on information and help-seeking and experiences with expectant/nursing mothers, organizational processes at the maternal healthcare facility, challenges to caring for expectant/nursing mothers and basic information technology knowledge. We adapted the questions from [4] and modified them to suit the domain of our study; maternal healthcare. Below are some of the interview questions we asked the caregivers and expectant/nursing mothers and they are as follows:

1. Do you own smart/mobile phones or computers?
2. Do you have internet service on those devices?
3. Have you ever used these devices to send and receive SMS, video or voice messages?
4. Tell me about your experiences with expectant/nursing mothers and/or caregivers?
5. How do you store the expectant/nursing mother's health history and who has access to it?
6. Outside caring for expectant/nursing mothers, do you do other healthcare tasks?
7. What is the importance of antenatal and postnatal visits to the expectant and nursing mothers?
8. Tell me about the causes and symptoms of pregnancy and childbirth related to poor health and deaths.
9. What are the possible solutions to pregnancy and childbirth related poor health and deaths you have sought in the past?
10. How free are you to discuss your pregnancy and childbirth related issues with other people, why and why not?
11. Where did you find answers/help to your pregnancy and childbirth questions?

These questions were administered to the research participants directly. The administration of the questions was done at several locations such as their homes, business premises, church and community meetings as well as local birth homes. For the research subjects who were not literate enough to comprehend the English language, the researchers took it upon themselves to ask them questions in the local language (Igbo) and recorded their answers on tape. These were later transcribed and translated for use in our study. For the participants who were literate but hardly had time to answer our survey questions, we waited patiently until they could have time and went some steps further to help them to both write out and record their answers on the go. These were later transcribed for use in our study. All in all, we were able to collect data from 73 research participants during our study.

Data Analysis

In this section, we briefly describe the data analysis conducted on the data we collected during our user studies. Following the successful collection of our qualitative data, we employed the thematic analysis approach [5], to analyze data collected. During thematic analysis, the researcher or the research team does a detailed review of the data and tries to extract important points or themes which were identified from the responses received from the survey participants. These points are subsequently categorized into several related groups with unique or similar attributes as the case may be. The categories help the researchers to understand trends, directions and needs associated with the specific objectives of the study. In this study therefore, we separately coded the data and identified key themes from the interview responses associated with our research questions. At the end of separate coding, we integrated and iteratively analyzed and coded the themes to derive insights from the study. The following themes emerged from the data analysis and they include: Lack of basic maternal healthcare infrastructure, negative perception and ignorance due to culture and social values, poverty and economic status, as well as religious and cultural beliefs. We also identified the need for automated support as one the key themes of the data. These themes thus motivated the design of our persuasive technology for maternal health.

Observation from Data Analysis

This section presents the results of the user study that was done to identify the challenges or obstacles to adopting proper maternal health and information-seeking behaviors amongst expectant and nursing mothers in a typical local healthcare facility. The findings from our preliminary studies uncovered various social, cultural and religious factors that affect the adoption of proper maternal information and health-seeking behaviors amongst women. Additionally, the socio-economic status of the women had limiting effects on the acceptance of appropriate maternal and child health behaviors amongst the indigenous people. Other factors identified during our studies include negative perception and outright ignorance on the part of the expectant and nursing mothers, as well as on the part of the husbands and relations of those local women. We also discovered that the expectant and nursing mothers and their relations, as well as nurses and midwives own low-end smartphones which can play audio and video messages, and can access the internet. Although electric power supply and internet services in rural areas are generally epileptic, we see that they make use of these digital gadgets notwithstanding. Below, we discuss in specific terms, some of the common factors that hinder or de-motivate expectant and nursing mothers from accessing quality maternal and child healthcare services, cum adopting appropriate health and information-seeking behaviors.

Factor 1 - Pitiable Basic Maternal and Child Healthcare Infrastructures

First, the results from our study uncovered that most of the maternal health facilities; especially those that are well-equipped and well-staffed, are only available in the cities. Proximity to the location of these health facilities is a big factor as they are very far away from the local settlements where the expectant and nursing mothers could easily have access to as at when required. Secondly, the fact that most of the roads leading to the city centers are in very poor and deplorable states is a big turn-off for vehicle owners and transporters to consider plying. This leaves the expectant and nursing mothers with no other option than to trek long distances to the city if they want to receive quality maternal health services. Ideally, establishing a well-equipped maternal health facility in a community where there are readily available and caring health maternal staff could potentially motivate expectant and nursing mothers in that community to adopt desirable health and information-seeking behaviors. Most assuredly, without the stress of trekking long distances to the cities in search of quality maternal health services, these women would be encouraged to attend antenatal and postnatal sessions at the nearby community maternal health facilities where they would receive similar quality health checks and care for themselves and their unborn/new born babies. However, studies have shown that many of our local communities do not have the luxury of hosting a well-equipped and well-staffed maternal health facilities [6]. Therefore, there is the need to think outside the box and discover easier and cheaper ways through which the expectant and nursing mothers in local communities can access maternal and child healthcare and services from health facilities located in the cities without being physically present over there. Studies have shown an ever-growing penetration of internet services across our local communities [7]. The pervasiveness of certain emerging technologies and gadgets such as smartphones and specialized mobile apps could be employed to promote social engagement and collaboration as well as social learning [8], [9], [10]. The aforementioned points opens the door for all stakeholders in the maternal and child healthcare loop including maternal healthcare providers, expectant and nursing mothers, government and non-governmental agencies, and technology designers to collaborate and come up with automated interventions to support and improve the maternal and child health information and health-seeking behaviors of the people.

Factor 2 - Negative Perceptions and Ignorance of the People:

Secondly, the results from our study uncovered that there are obvious incidences of negative perception and outright ignorance on the part of the expectant and nursing mothers, as well as on the part of the husbands and relations of those local women. It was observed and discovered from the studies that many of the women lack basic knowledge of the appropriate and clinically approved maternal healthcare needs. They usually take for granted, some of the early, middle and later signs of pregnancies, as well as what drugs and healthcare advices they need to receive in order to lead a healthy life throughout the duration of their pregnancy and after. Furthermore, because some of these expectant and nursing mothers have had age-long traditional orientations and knowledge about pregnancies, they will continue to adopt those traditionally available maternal and child healthcare practices which are considered clinically unhealthy and inimical to the wellbeing of the mother and fetus/newborn. Moreover, this poor attitude to maternal and child healthcare and information-seeking is compounded by the tacit support of ignorant husbands and relations of those expectant and nursing mothers. These women are reminded directly or indirectly about the consequences and otherwise of going against the social, cultural and religious values of the people in seeking maternal and child health services. These values include: giving birth at home shows maternal strength (the strength of the woman amongst her peers). It is also believed that giving birth at home honors the gods and ancestors; promotes the acceptability and value of the family that the woman comes from and is married to. These are very difficult situations to manage as there have been unconfirmed and confirmed reports of severe punishments to expectant and nursing mothers who went against the social, cultural and religious values of her community and families. These punishments involve physical and emotional abuses, denials by families and relations, divorces and banishments as the case may be. The community laws or customary laws have been unable to protect these women from such abuses since these laws are integral parts of the community's life and living. Therefore, there are great needs for massive orientations and fundamental change in the belief system of the people towards maternal and child healthcare and services. The challenges associated with the high incidences of negative perception and outright ignorance on the part of the expectant and nursing mothers, as well as on the part of the husbands and relations of those local women could be tackled via focused and continued information dissemination about the value cum advantages of patronizing specialist maternal and child healthcare facilities. Healthcare providers and concerned persons would have to find easier and cheaper ways through desired orientations and maternal and child healthcare information need gaps could be bridged locally amongst these groups of women and their husbands and relations, without having to travel long distances to the specialized maternal health facilities located in the cities. Yet again, the growing popularity of mobile technologies and specialized mobile apps creates opportunities for users to feel norm, learn new things from one another and from specialized sources [11]. Through this way, these technologies engender and promote normative influence, social engagement and social learning [12], [13]. These above-

mentioned points opens the door for all stakeholders in the maternal and child healthcare loop including maternal healthcare providers, expectant and nursing mothers, government and non-governmental agencies, and technology designers to collaborate and come up with automated interventions to support and improve the maternal and child health information and health-seeking behaviors of the people. These automated solutions will ultimately dispel and disabuse the minds of these local women and their relations, correct and refocus their perceptions to the appropriate maternal healthcare necessities and motivate them to adopt proper behaviors to their health and that of their fetus/new born.

Factor 3 - Poverty and Other Related Factors

Thirdly, the results from our study uncover that poverty and other related economic factors play crucial roles in de-motivating expectant and nursing mothers in rural communities from accessing clinically approved maternal and child healthcare services from specialized maternal healthcare facilities. The usually exorbitant high hospital bills associated with antenatal, actual birth, and postnatal healthcare services would discourage these women from seeking appropriate information and services for their health and that of their fetus/newborn. Theoretically, the challenges associated with the high-cost high hospital bills and other related maternal healthcare services in specialist health facilities could be addressed by the reduction or subsidization of the bills by government agencies or concerned non-governmental organizations (NGOs) and international partners. But that option is highly unsustainable as governments, NGOs and other partners have several other projects outside maternal health interventions where allocations of funds are also needed. Therefore, a new approach is desirable. There is an urgent need for all stakeholders in the maternal and child healthcare management loop to think outside-the-box and come up with better strategies and avenues to make maternal and child healthcare services affordable and accessible to local women in the remote communities of the world. Even where the health facilities are not physically situated in the local communities, cheap and easy-to-use technology interventions could be designed to provide free or cost-effective virtual support and services to expectant and nursing mothers in the community. This intervention would motivate them to easily adopt appropriate maternal information and health-seeking behaviors which is within their budget and from the comfort of their homes.

Factor 4 - Erroneous Religious and Cultural Beliefs:

Furthermore, the results from this study reveal that many of the respondents think that *"safe delivery is only a function of belief in God"* and *"God has promised they shall deliver their babies like the Hebrew women in the bible"*. On the other hand, some of the respondents failed to attend antenatal sessions and engage in proper health and information-seeking behaviors due lack of time and outright carelessness. These attitudes deter them from seeking proper health checkup during pregnancy. The rising rate of pregnancy and childbirth-related deaths in developing African nations confirms this finding [14],[1]. In addition, we discovered through our study that many of the women make use of mobile phones and computers, while some have internet access. These findings are essential because research has shown that ICT4D has created opportunities for users to connect, share, collaborate and learn new things [14],[15].

Factor 5 - Ownership of Low-end Smartphones:

Before now, mobile telephony services were completely absent in rural communities. But in recent times, many mobile networks service providers are installing network masks and transmitting signals right into the villages. The findings from our study show that this has encouraged many of the expectant and nursing mothers and their relations, as well as nurses and midwives to own low-end smartphones. These mobile devices can play audio and video messages, and can access the internet. Although electric power supply and internet services in rural areas are generally epileptic, we see that they make use of these digital gadgets notwithstanding. Studies have shown an ever-growing penetration of internet services across our local communities [16], [17]. The pervasiveness of certain emerging technologies and gadgets such as smartphones and specialized mobile apps could be employed to promote social engagement and collaboration as well as social learning [10]. The aforementioned points opens the door for all stakeholders in the maternal and child healthcare loop including maternal healthcare providers, expectant and nursing mothers, government and non-governmental agencies, and technology designers to collaborate and come up with automated interventions to support and improve the maternal and child health information and health-seeking behaviors of the people.

Mapping Results to Corresponding Persuasive Strategies and Design Guidelines for Developing a Persuasive Technology for Maternal Healthcare

The main aim of the Dissertation is to design and implement a persuasive technology based- model for maternal healthcare in Nigeria. Recent studies in the Human-Computer Interaction (HCI) and other related domains have shown that mapping results to practical design strategies is one of the most credible ways of translating research findings (from user studies) into design guidelines that can be used to develop user-centered interactive system solutions [8], [4]. The researcher maps each of the factors affecting the adoption of appropriate maternal health seeking behaviors amongst expectant and nursing mothers in rural communities to their corresponding persuasive

strategies. In addition, for each or group of the strategies mapped, the researcher discusses innovative and cost-effective guidelines which can be employed to design system interventions which have the capacity to motivate attitudinal and behavioral changes in the health and information-seeking behaviors of expectant and nursing mothers in rural African communities.

Factor 1 – Mapping & Design Suggestion

Ideally, the challenges associated with the absence of Basic Maternal and Child Healthcare Infrastructures in our rural communities can be solved through the provision of standardized and well-equipped maternal and child healthcare facilities across the rural communities. These facilities will be located within 5 to 10 minutes walking distances from the community centers. The community health facilities which will have readily available and caring health maternal staff will potentially motivate expectant and nursing mothers in that community to adopt desirable health and information-seeking behaviors and have access to it as at when required. They will not need to trek nor travel through long distances and through very bad roads to the cities to receive quality maternal healthcare services (antenatal and postnatal sessions) for themselves and their unborn/new born babies. These are the primary needs and necessities. However, it is hardly so. The rural communities do not have the luxury of hosting well-equipped and well-staffed maternal healthcare facilities. As result, most of the expectant and nursing mothers in these communities would go on with their local but non-clinical ways of managing pregnancy and childbirth or continue with their negative attitudes to maternal health, which eventually results in pregnancy and childbirth related deaths. Therefore, **a** new approach is needed to tackle this challenge. This new approach could be achieved through the design and operationalization of relevant persuasive strategies on an integrated online real-time application (mobile and desktop) for maternal and child healthcare service. As a result, we map these points to the primary task support strategies of the persuasive system design (PSD) principles [3]. The primary task category is made up of persuasive strategies which support users to carry out their most important tasks. They include: reduction, tunneling, tailoring, personalization, self-monitoring, simulation, and rehearsal. Specifically, the reduction strategy (which reduces complex behaviors into simple tasks) is demonstrated in the actual design and deployment of the new system. It ensures that expectant and nursing mothers in rural communities could remotely have access to (from the comfort of their homes and through their low-end mobile phones) quality maternal healthcare and services from designated health facilities in the cities. This strategy directly reduces the efforts of trekking or travelling long distances and through very bad roads to access antenatal or postnatal services in the cities. The tunneling strategy (which guides users through a process or an experience) should be implemented on this new system by offering maternal and child health information and/or treatment opportunities after the users have answered some questions (via text messaging or oral calls or video calls) about their body or pregnancy signs and symptoms. The tailoring strategy (which tailors information and services to the needs of users) should be implemented on this new system by offering special maternal and child health information contents for the various groups of users of the new system, for example antenatal (expectant mothers) and postnatal patients (nursing mothers). The personalization strategy (which offers personalized contents and services to users) should be implemented on this new system by displaying information relevant to the logged-in user at a time. The system may provide a unique identification card number to the women at the point of registration. This interface will show contents that are pertinent to the expectant mothers. For example, through personalization, the logged-in user (expectant or nursing mother) can be able to visualize and compare her attendance to that of other women performing the same task. She can equally react or send personalized feedback by using any of the three keys: contented, astonished, and discouraged. The self-monitoring strategy (which helps users to keep track of one's performance) should be implemented on the new system by allowing users (expectant or nursing mother and healthcare personnel) to keep track of the number of times/days that they attended antenatal or postnatal sessions as the case may be. This enables them to know when they are doing well or not. The simulation strategy (which helps users to see the link between cause and effects) should be implemented on the new system by providing opportunities for the expectant or nursing mother to see the pictures or videos of similar others who were committed to adopting appropriate maternal and child health-seeking behaviors and those who were not committed, along with their respective consequences. These primary task strategies are effective in supporting and motivating users to carry out their most important tasks without the use of force. They will help expectant and nursing mothers in rural communities to overcome the primary difficulties associated with accessing quality maternal health services.

Factor 2 – Mapping & Design Suggestion:

The challenges associated with negative perceptions and ignorance amongst expectant and nursing mothers, as well as the husbands and relations of those women in the local communities could be tackled through continued information dissemination and orientations about the value and advantages of patronizing specialist maternal and child healthcare facilities. In the past, several strategies such as the use of traditional media and manual persuasion have been used to motivate women to embrace appropriate maternal and child healthcare seeking behaviors.

However, these programs and strategies have not been successful as many of the expectant and nursing mothers would choose to continue with their unhealthy ways and lifestyles which are inimical to their health and that of their unborn/new born baby. Therefore, healthcare providers and all concerned agencies would have to adopt a new, user-friendly and cost-effective approach to deliver timely, personalized and healthy maternal and child healthcare information to the women. Some of these could involve a communal way of sharing healthy pregnancy and baby nursing tips to the women. The women will be given opportunities to ask questions and receive feedback from professionals (doctors, nurses and midwives). This new approach could be achieved through the operationalization of relevant persuasive strategies on an integrated online real-time application (mobile and desktop) for maternal and child healthcare service. As a result, we map these points to certain social support, dialogue support and system credibility support strategies of the persuasive system design (PSD) principles [9]. The social support category describes how to design an interactive system such that it motivates users by leveraging social influence. Some of the relevant strategies under this group are social learning, social comparison, normative influence and recognition. The dialogue support category describes how to design a system such that it provides some degree of system feedback (through verbal or other forms) to the users. Some of the relevant strategies under this group are reminders, suggestion and social role. The system credibility support category describes how to design a system so that it becomes more credible. Some of the relevant strategies under this category are expertise, authority, and third-party endorsement [9]. Specifically, the social strategies could be implemented as follows: The ***Social Learning Display***: This strategy is usually implemented in such a way that users will be able to observe other's performances, learn new things and find out best practices which they could passively learn from [18]. Specifically, we plan to operationalize our *social learning display* to show a graphical view of the number of pregnant women and the points earned for frequent and timely attendance to antenatal sessions each month, see figure 3.

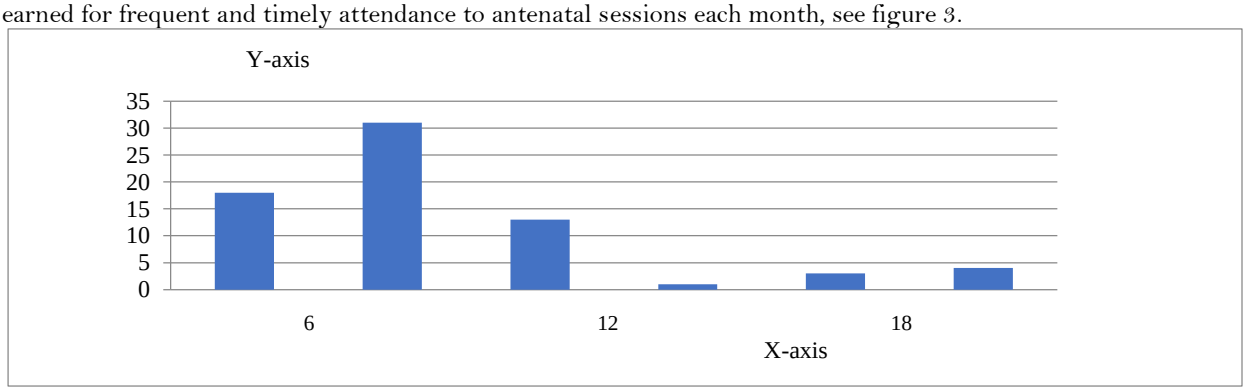

Fig. 3 Proposed Social Learning Performance Display

The Y-axis depicts the number of users while the X-axis depicts the performance points based on the number of visits to antenatal care sessions. We expect that the display will help to model the attitudes of pregnant women towards their antenatal care visits and support them to adopt positive maternal healthcare behaviours.

Social Comparison Display

We plan to operationalize this strategy via an instant messaging component. This feature will allow users to share and compare information related to their maternal health (good health of the mother and the child). Here, the logged in user of the system will see a display of her real name and her own maternal healthcare progress information shared on the application. However, she would only be able to see the maternal healthcare progress information of other registered pregnant women with pseudo-names. The display will be limited to like seven users per screen to make it easier for the logged in user see and compare her performance with that of other expectant mothers registered in the system. The logged-in user will also have the opportunity to send personalized feedbacks (reaction) using any of the three keys: Okay, Surprised, and Oh No. The app will be automatically updated with new records such that users could have the opportunity to compare attendance as time progresses.

Normative Influence Display

This strategy entails leveraging social or peer pressure to increase and motivate a user to perform or adopt a target behavior. We plan to implement normative influence by allowing users to use their mobile devices to view pictures of newborn babies with serious health problems and deformities due to the mother's inability to attend antenatal care frequently and timely. We hope that this display will awaken their consciousness on the dangers of absenting or irregularly attending antenatal care (ANC). Also, we plan to use this display to encourage the delivery and receipt of essential maternal healthcare services such as malaria treatment, immunizations, and health counselling. Besides, since our proposed system is an integrated platform (mobile and desktop system), we plan to ensure that the aforementioned displays are also shown on a public LCD (Liquid Crystal Display) located in a strategic location in

the antenatal section of the maternal healthcare facility, where everyone can see it. We are confident that these persuasive displays will potentially increase the likelihood that a user will adopt or perform target behaviours.

Recognition Display

We will implement recognition in our new system by allowing users to view through their mobile devices, a list of expectant mothers who have regularly attended antenatal visits over a given period, and have successfully performed assigned target behaviours. The system will also publish personal success stories of successfully delivered mothers and what they did to achieve that feat. Again, since our proposed system is an integrated platform (mobile and desktop system), we plan to ensure that the recognition displays are also shown on a public LCD (Liquid Crystal Display) located in a strategic location in the antenatal section of the maternal healthcare facility, where everyone can see it. Progressively, the list will be automatically updated using attendance points entered for each user after three months calculation of how frequent and timely are the antenatal visits of these pregnant women. The dialogue support strategies could be implemented as follows: The **reminder strategy** (which reminds users of their target behaviors) should be implemented such that the app sends text messages to its users (expectant and nursing mothers) as daily reminders to take their drugs or perform exercise or something related to their health and that of their new born per time. The **suggestion strategy** (which offers fitting suggestions to users) should be designed such that the app suggests healthy eating or lifestyle habits or tasks for the users (expectant and nursing mothers) through the duration of their pregnancy and baby weaning. The **social role** (which adopts a social role or support to the users) should be designed such that the maternal and child health app has a built-in virtual specialist which supports communication between users and the healthcare professionals. The system credibility support strategies could be implemented as follows: The **expertise strategy** (which ensures that a system incorporates expertise) should be designed such that the app provides information specifically about maternal and child healthcare services. The **authority strategy** (which leverages roles of authority figures) should be designed such that the app is regularly updated with context-specific suggestions and instructions from government health offices and other maternal and child healthcare specialists. The **third-party endorsement strategy** (which makes a system persuasive via the display of endorsements from respected figures) should be designed such that the app shows a logo or badge of the government's health agency and/or endorsements from hospitals affiliated to it.

Factor 3 – Mapping & Design Suggestion:

The challenges associated with **poverty and other related economic factors** (high-cost high hospital bills and other related maternal healthcare services in specialist health facilities) amongst expectant and nursing mothers could be addressed by the reduction or subsidization of antenatal and postnatal healthcare bills. But that option is highly unsustainable as governments, NGOs and other partners have insufficient funds to allocate to all healthcare needs. Therefore, a new approach is desirable. This new approach could be achieved through the design and operationalization of relevant persuasive strategies on an integrated online real-time application (mobile and desktop) for maternal and child healthcare service. We believe that where the health facilities are not physically situated in the local communities, cheap and easy-to-use technology interventions such as our proposed persuasive technology for maternal health will provide cheaper and cost-effective virtual healthcare supports and services to expectant and nursing mothers in the community. This intervention would motivate them to easily adopt appropriate maternal information and health-seeking behaviors which is within their budget and from the comfort of their homes. As a result, we map these points to the reduction strategy [3]. The reduction strategy is one of the primary task categories of the PSD techniques which reduce complex behaviors into simple tasks. This strategy is demonstrated in the actual design and deployment of the new system. It ensures that expectant and nursing mothers in rural communities could remotely have access to (from the comfort of their homes and through their low-end mobile phones) quality maternal healthcare and services from designated health facilities in the cities. This strategy directly reduces the efforts of trekking or travelling long distances and through very bad roads to access antenatal or postnatal services in the cities.

Factor 4 – Mapping and Design Suggestions:

The challenges associated with Erroneous Religious and Cultural Beliefs are age-long problems. In the recent past, several strategies such as the use of traditional media and manual persuasion have been used to motivate women to embrace appropriate maternal and child healthcare seeking behaviors. However, these programs and strategies have not been successful as many of the expectant and nursing mothers would choose to continue with their unhealthy ways and lifestyles which are inimical to their health and that of their unborn/new born baby. Therefore, healthcare providers and all concerned agencies would have to adopt a new, user-friendly and cost-effective approach to deliver timely, personalized and healthy maternal and child healthcare information to the women. Some of these could involve a communal way of sharing healthy pregnancy and baby nursing tips to the women. The women will be given opportunities to ask questions and receive feedback from professionals (doctors, nurses and midwives). This new approach could be achieved through the operationalization of relevant persuasive strategies on an integrated

online real-time application (mobile and desktop) for maternal and child healthcare service. As a result, we map these points to certain social support and dialogue support strategies of the persuasive system design (PSD) principles [3]. The social support category describes how to design an interactive system such that it motivates users by leveraging social influence. Some of the relevant strategies under this group are social learning, social comparison, normative influence and recognition. The dialogue support category describes how to design a system such that it provides some degree of system feedback (through verbal or other forms) to the users. Some of the relevant strategies under this group are reminders, suggestions and social roles. The social support and dialogue support strategies should be implemented as described in **Factor 2 above.** When these strategies are implemented on the app, they will be effective in promoting healthier and positive attitudes and acceptable maternal lifestyle. They will help and support the users to understand new and better ways to manage their pregnancies and nursing of babies with a view to improving their health and that of their unborn/newborn children.

Factor 5 – Ownership of Low-end Mobile Phones

The ownership of mobile phones amongst expectant and nursing mothers in the community has created opportunities for to have access to information outside their locality. The mobile devices can play audio and video messages, and can access the internet. Although electric power supply and internet services in rural areas are generally epileptic, we see that they make use of these digital gadgets notwithstanding. The pervasiveness of certain emerging technologies and gadgets such as smartphones and specialized mobile apps could be employed to promote social engagement and collaboration as well as social learning [4]. Therefore, the design, development and implementation of the persuasive technology for maternal health become an important invention that will support and improve the maternal and child health information and health-seeking behaviors of the users. It allows them to access maternal health services and information at the tip of their fingers. It allows them to receive collaborative care and personalized services from the comfort of their homes.

The Proposed System

The researchers analyzed the current operating processes of the existing system to discover the merits and demerits of the system. Based on the results of the initial investigation in section 7.0, there is a great need for a new approach to motivate citizens to modify their attitudes and behaviors to the environment devoid of coercion. This fresh approach can be realized through the powers of technologies and persuasive strategies (human-computer persuasion). Therefore, the researcher proposes to design as well as implement a persuasive technology which will have the ability to motivate expectant mothers to change their attitudes and behaviors towards maternal healthcare to maintain a good health throughout their pregnancy journey.

Analysis of the Proposed System

The new persuasive platform for maternal care is integrated with a behavior change support system (BCSS) component to motivate the expectant and nursing mothers to modify their behavior. It could also help to foster long-term and enduring change in them. The system is operationalized with essential persuasive strategies such as reduction, tailoring, and personalization, praise and rewards, recognition, social comparison and competition (which could be stimulated by praise and rewards), reminders, social learning, and cooperation.

Employing the Use-Case diagram, which is one of the Object-Oriented Design (OOD) models (OOM), we used classes (which are collections of related objects) to represent the interactions that would take place amongst the various components of the new system. The **Figure 8.1**below, shows the architecture of the new system drafted from the scratch. It is a high-level graphical representation of essential objects, type of data and information, as well as how they would flow around in the new persuasive technology for maternal care.

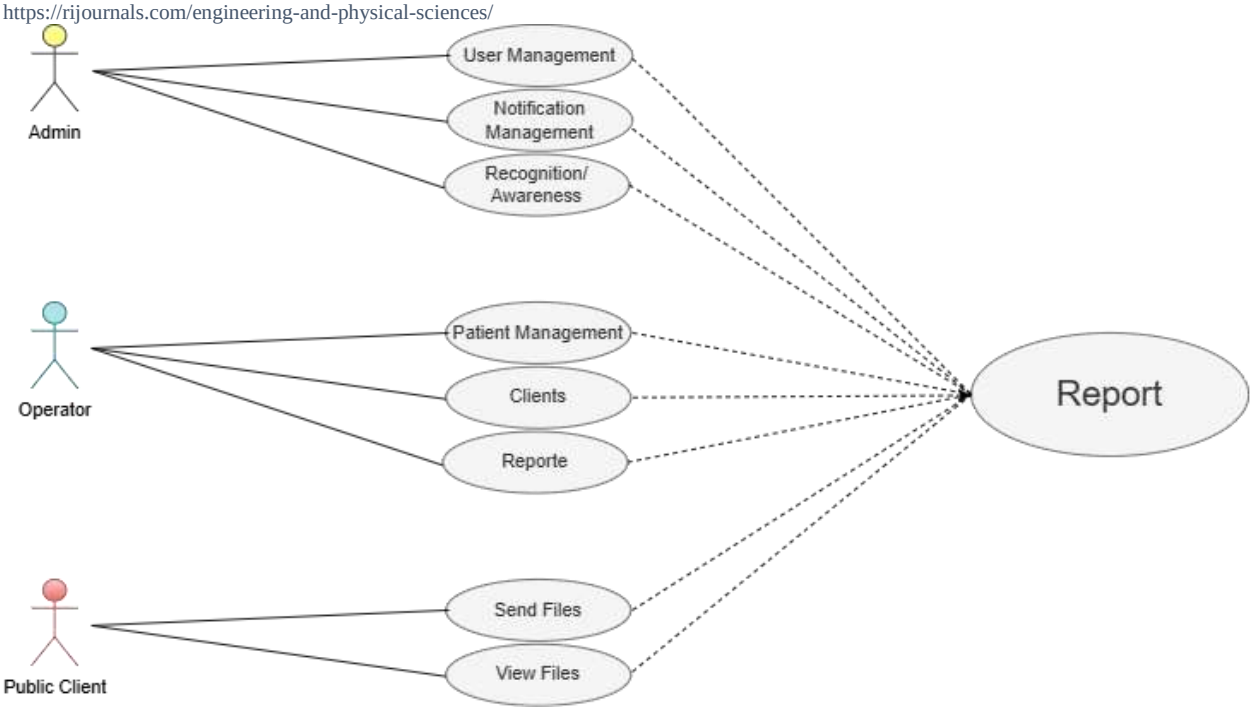

Figure 4: The Use Case Diagram for the New Persuasive Technology based Model for Maternal HealthCare

High-Level Model of the Proposed System

Figure 5 shows the high-level model (HLL) diagram of the new persuasive technology for maternal care. The new platform will incorporate all the processes and procedures described and other very important features to enhance the operations of a maternal care unit of a community health center.

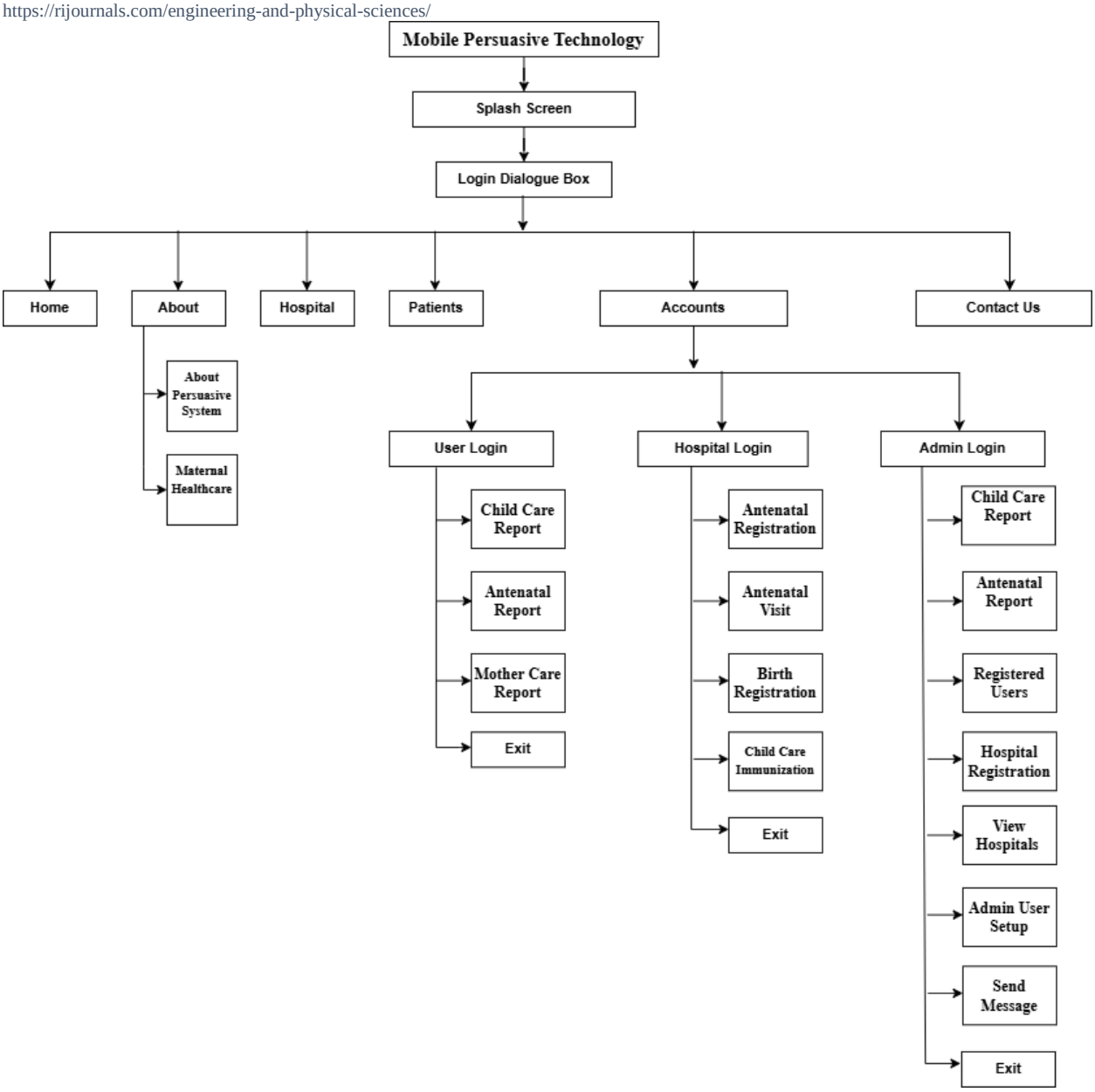

Figure 5: High-Level Model of the Proposed System

Test Data

The test data involving user's information was captured by the system captured during user studies to test the actual functionality of the system and the integrated modules. In this section, we present test samples from real case studies. We also illustrated each of the different scenarios where user data are captured at the input area of the system (GUI) to check the expected performance of the system at completion.

Login Page(s) Subsystem Test Data

Test data involving user login information were supplied to the system in order to validate the user account. Username and password were captured at the input area of the Login page and a valid input test was conducted via the click of the "**submit**" button. Access to the system was granted when valid login values were submitted while access was denied when invalid login values were submitted. This test was conducted on the three user categories of this system including User (Patient) Login, Hospital Login, and Admin Login. Moreover, we ensured that a legal boundary value such as Upper Case and Lower-Case value disagreements were addressed to ensure an error free system. The figure under shows the Login Page test scenario of an admin.

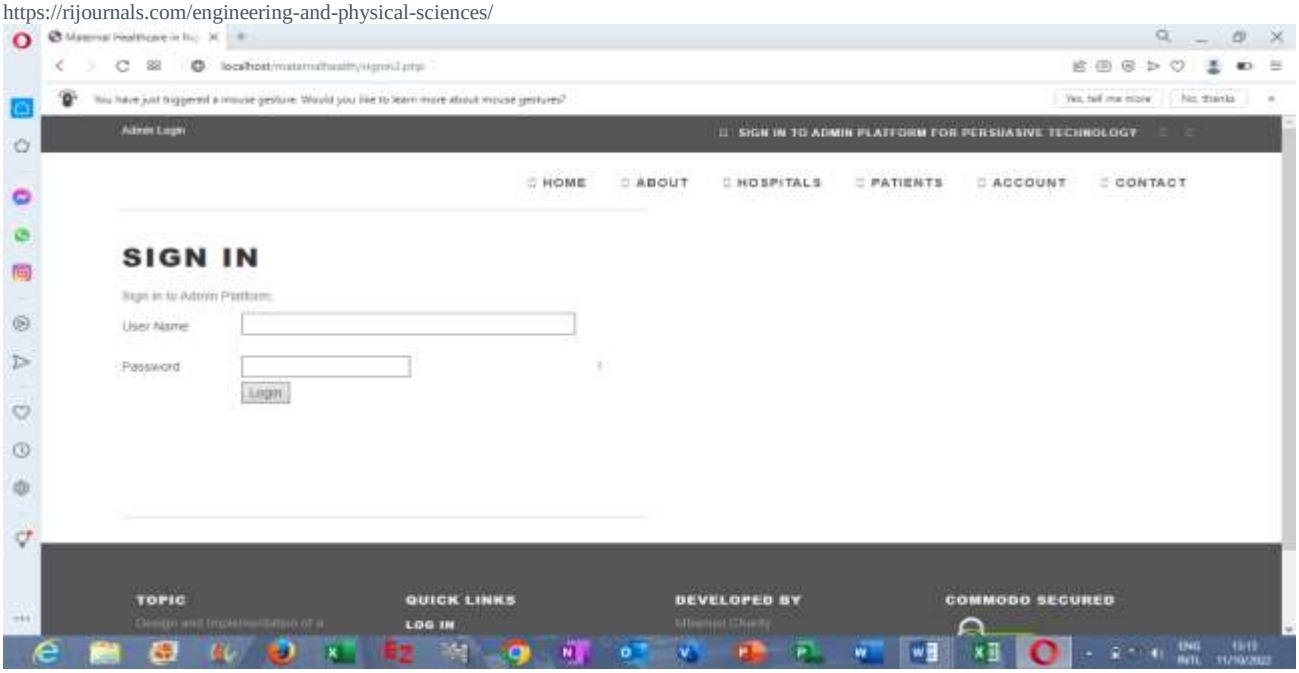

Figure 6: Login Page Test Data

Antenatal Registration Subsystem Test Data

Test data involving new registration were supplied to the system in order to test the actual performance of the system. New antenatal user information was captured at the input area of the registration page and a valid input test was conducted via the click of the "**submit**" button. Information was successfully saved/ submitted to the system's database. The figure beneath shows the Registration Page test scenario for a new user.

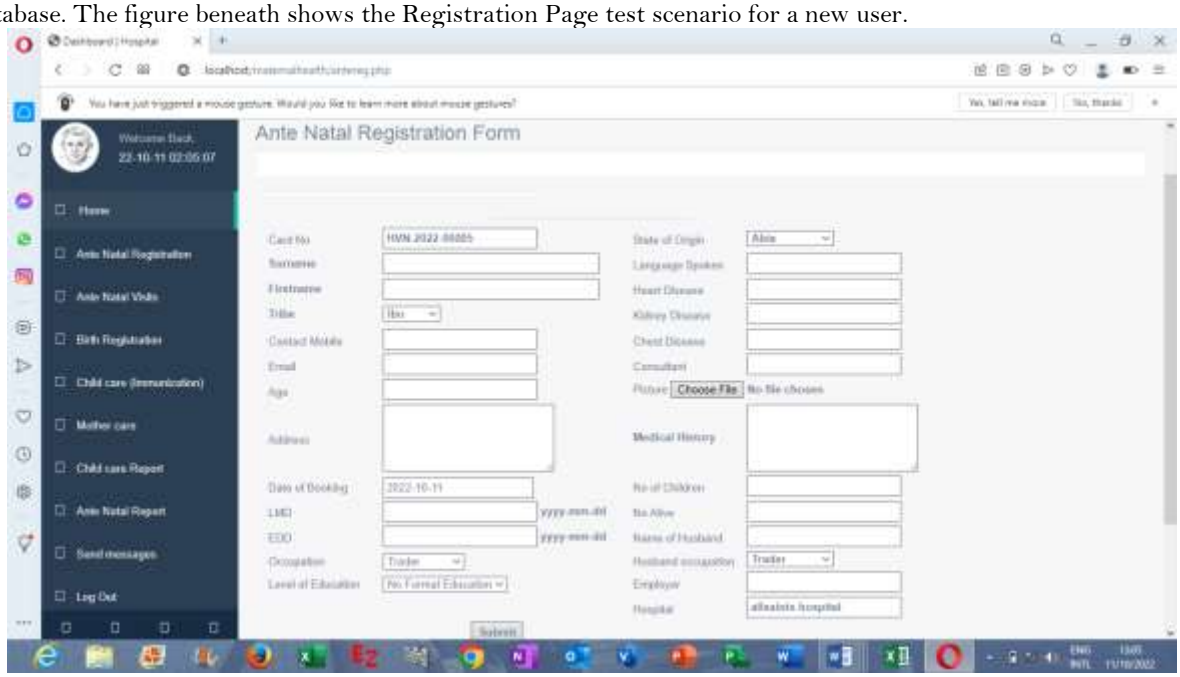

Figure 7: Antenatal Registration Subsystem Test Data

Birth Registration Subsystem Test Data

Test data involving birth registration number, location, and health officer-in-charge (attendant) as well as date and point of delivery were supplied in order to test the functionality of that design module. We subsequently selected the "**submit**" button. Information was successfully saved/ submitted to the system's database where patients could view every important details. The figure beneath shows the Birth Registration Page test scenario.

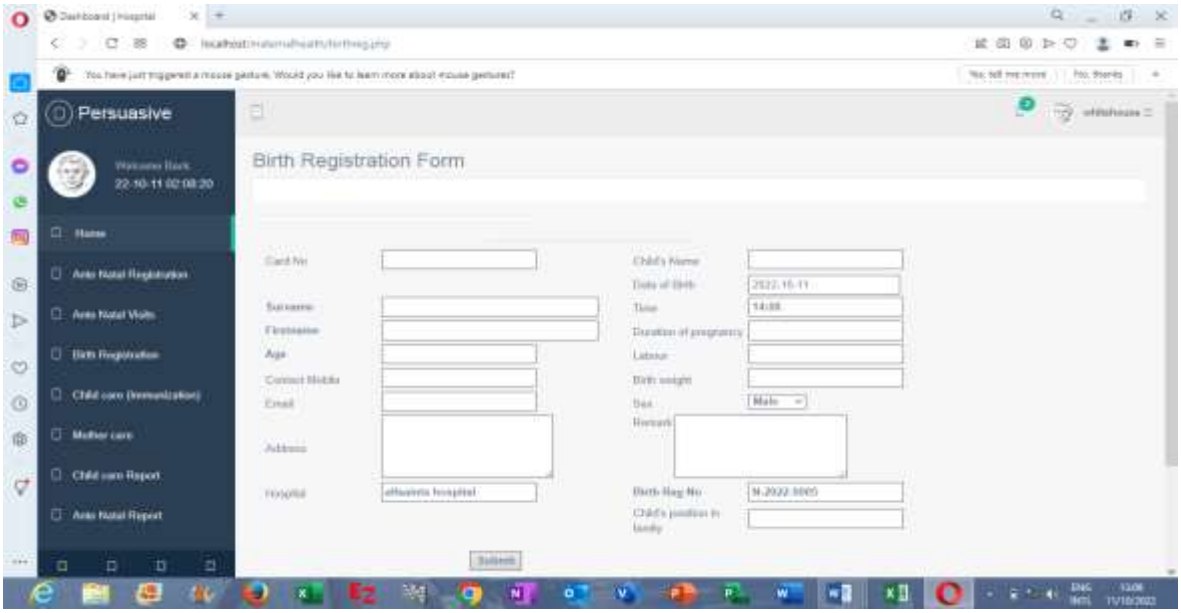

Figure 8: Birth Registration Subsystem Test

Report and Query Subsystem Test Data

Test data involving various queries and searches were supplied into the system in order to test their functionalities. The figure below shows one of the many search results or reports conducted for registered users and/or clients in the system.

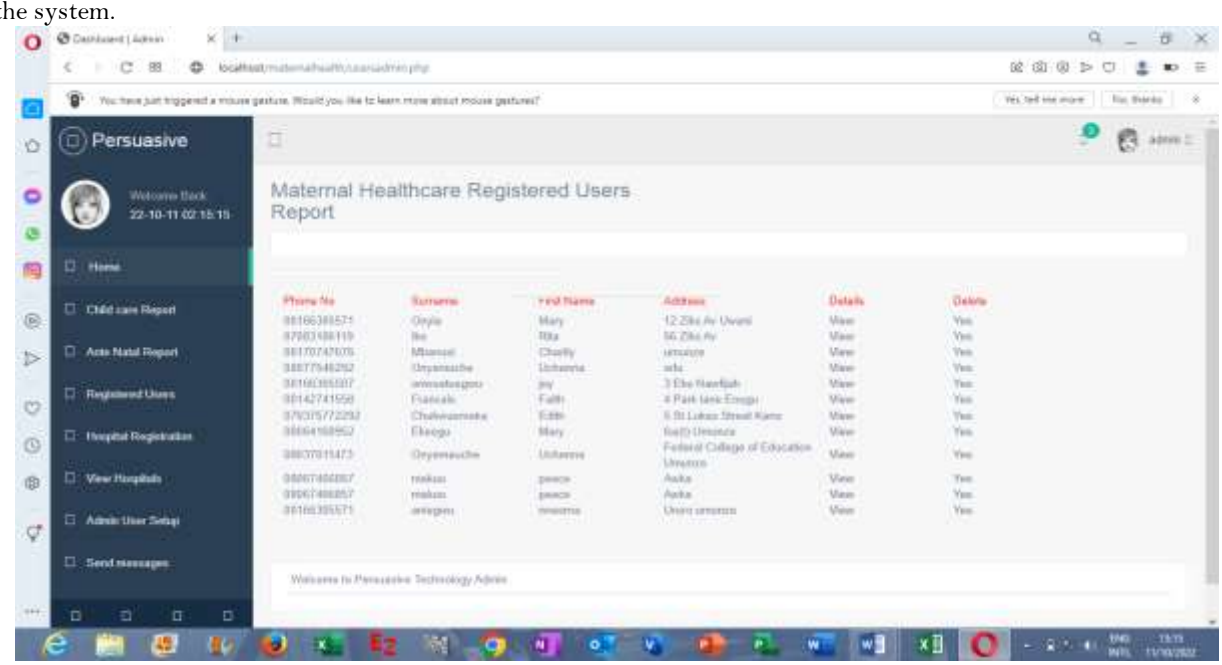

Figure 9: Query and Report Subsystem Test Data

Test Results

This section shows the expected and actual test results from the new system. It describes how the results reflect the expectations of the software. First, the test conducted for the User Login scenarios for the three user categories of this system including 'User (Patients) Login', 'Hospital Login', and the 'Admin Login' returned positive. Access to the system was granted when valid login values were submitted while access was denied when invalid login values

were submitted. This was made possible because we ensured that a legitimate boundary value such as Upper Case and Lower-Case value disagreements were addressed to ensure an error free system.

Secondly, the new user registration test returned positive results as the 'Registered Users Report' was checked to confirm that the user data was successfully submitted to the database. In addition, the various queries and searches which were conducted on the system were largely successful as we were able to view results of those queries as could be seen in appendix pages.

CONCLUSION

In the last decade, technologies have become an indispensable component of our everyday lives as they engage us with headline news and information, entertainment and education, etc. Advancement in mobile and internet technologies created a vista of opportunities for developers to create interventions that meet a variety of needs. Persuasive technology designers have exploited these opportunities to develop web and mobile apps that will potentially encourage and motivate users to change or improve their behaviors toward certain phenomena. This doctoral dissertation describes the initial investigations, design, and implementation of a persuasive technology for maternal healthcare. The study was informed by the need to encourage women to adopt positive and healthy behaviors during pregnancy and after delivery. The achievement of our study's objectives will help to reduce maternal and child mortality and promote the United Nations (UN's) Sustainable Development Goals, (SDGs) as it concerns health.

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