GRAVID: An Indigenous m-Health Tool for Smart & Connected Communities

Ayomikun S. Akinseinde, Joke A. Badejo, Rejoice L. Malgwi
Department of Electrical & Information Engineering,
Covenant University
Ota, Nigeria
ayomikun.sam@gmail.com, joke.badejo@covenantuniversity.edu.ng, rejoice.malgwi@stu.cu.edu.ng

***Abstract*—The rapid proliferation and ubiquitous nature of mobile technology within the emerging Internet of Things (IoT) driven smart and connected communities (SCC) paradigm promises a unified framework for tackling community-based health challenges. Maternal and child mortality remains a major public health problem in sub-Saharan Africa, with one of its leading cause being inadequate provision of nutrients (or under-nutrition). This paper presents an indigenous mobile health (or mHealth) solution, named *GRAVID,* to address the gap of unavailability of context-based information on nutrition, medical, drug and substance use appropriate to meet identified needs of gravid women and subsequently their babies (for 5 years); within the African context. *GRAVID* also provides a monitoring tool for healthcare givers to track the progress of the gravid woman they oversee. The project was implemented with Android software development kit (SDK) for cost-effective development and widespread community coverage. It is intended that this solution will also provide a source of collecting data to update necessary information as well as addressing related community-based issues to reduce the maternal and child mortality rates.**

Keywords— Maternal and Child health, Nutrition, Mobile Health (or mHealth), Smart & Connected Communities

I. INTRODUCTION

Despite being one of the top priorities of the millennium development goals by 2015, maternal and child mortality remains a major public health problem in sub-Saharan Africa and especially in Nigeria being the most populous Africa. In estimates from UNICEF and WHO, about 80% of global maternal and under-five children deaths is said to occur in sub-Saharan Africa and South Asia with Nigeria also among the top-five high-burden countries in the region [1][2].

WHO reports that inadequate provision of nutrients (or under-nutrition) is one of the leading causes of this high mortality rate. Most of the casualties of pre-birth maternity are usually women who have many babies in short time spans under malnutrition and poor hygienic conditions, women who live in rural areas where there are inadequate infrastructures, lack of professional caregivers and little or no access to medical treatment; or women who are have little or no access to proper pregnancy-related knowledge, child-and significant vaccinations or procedures that will keep them from contracting deadly infections that could lead to complications during and after pregnancy [3][4].

It is also a known fact that the appropriate intake of food and substances with adequate nutritional quality is highly crucial to the physical and mental development of the baby as well as long-term health of the mother. Hence, it is highly imperative to provide nutrition-related information on foods readily available within their community to increase the chances of a healthy pregnancy as well as children survival in this high-burdened region.

However, the rapid proliferation and ubiquitous nature of mobile technology within the emerging IoT-driven SCC paradigm promises a unified framework for tackling community-based health challenges. Mobile health (or mHealth) solutions have strengthened community-based health systems — linking critical interventions and services from antenatal care to immunization to nutrition, thereby improving the quality of healthcare service delivery to benefit all citizens in diverse and heterogeneous communities [5]-[9]. This paper therefore, presents an mHealth solution to improve access to prenatal, neonatal and postnatal health information and services.

The mHealth solution, named *GRAVID,* is an indigenous smart application that addresses the gap of unavailability of context-based information about food, nutrition, medical, drug and substance usage appropriate to meet identified needs of gravid women and subsequently the child (< 5 years); within the African context. *GRAVID* also provides a monitoring tool for the healthcare givers to track the progress of the gravid women they oversee and especially the high-risk pregnancies and children [10].

The rest of this paper is organized as follows. Section 2 reviews the effectiveness of mHealth tools. Section 3 details the architecture of the proposed mHealth solution while Section 4 presents the implementation and testing results. Finally, some concluding remarks and directions for future work are given in Section 5.

II. EFFECTIVENESS OF MOBILE HEALTH TOOLS IN MATERNAL AND CHILD HEALTHCARE USE

One of the solutions proffered by the SCC framework is to unlock transformational progress on the important challenge of community health and societal wellbeing via building smart applications [17]-[19]. Currently, there are evidences of marked improvement in maternal and child healthcare service delivery strengthened by mHealth solutions. An extensive

literature survey conducted in [6] established the effectiveness of mHealth tools in improving the use of antenatal care, postnatal care and childhood immunizations through behavior change in low- and middle-income countries. The mHealth solutions provide ubiquitous technology which tackle challenges often encountered in these countries such lack of health information, difficulty in tracking patients, limited training for community health workers etc. [10]-[14].

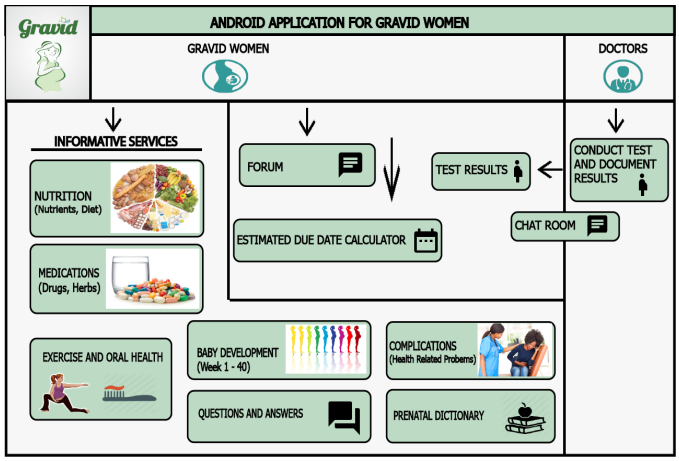

Fig. 1. Architecture of the proposed mHealth solution for pregnant and nursing women named GRAVID

Preliminary studies provided the basis for the personalized and localized content development for a suitable mobile application for health care for pregnant mothers, due date calculation, calendar, and growth of fetus, complications, medication, drug and health alerts as well as child care information for women with young children who are less than five years [6]-[9][14]-[16]. Even though there are various online resources to support maternal and child health as in [16], the proposed application is tailored towards facilitating low cost intervention for prenatal, neonatal and postnatal context-based health information and services thus strengthening the primary health care system. This mHealth solution presents the needed resources ranging from simple short messages to multimedia content to patients, relative and community-health workers.

III. Architecture of Proposed mHealth Solution

The architecture of the proposed indigenous smart application named *GRAVID* is presented in *Fig. 1*. The mHealth solution allows a registered gravid woman to set her due date, view weekly baby development in milestones, view related nutrition information, join a gravid-women or nursing-mothers forum for discussions, view records of previous pregnancies if any, view records of previous antenatal visits, read physician's review and prescription as well as other related information. A use case diagram is provided in *Fig. 2* to model the user's interaction with the system and *Fig. 3* shows the activities involved in a process in an activity diagram. The major activities are Home, Nutrition, Medications, Complications, Health, Baby, Settings, About, Search, Register, Login, Forum, Diagnose etc.

The user is serviced by a database hosted on the device to reduce the need for Internet data plan for a number of features. The content provided will be updated regularly and as allowed by the user. *GRAVID* also provides a monitoring tool for the healthcare givers to track the progress of the gravid women and children they oversee especially the high-risk patients.

It is intended that this solution will also provide a source of collecting data to update necessary information as well as addressing related community-based issues to reduce the maternal and child mortality rates.

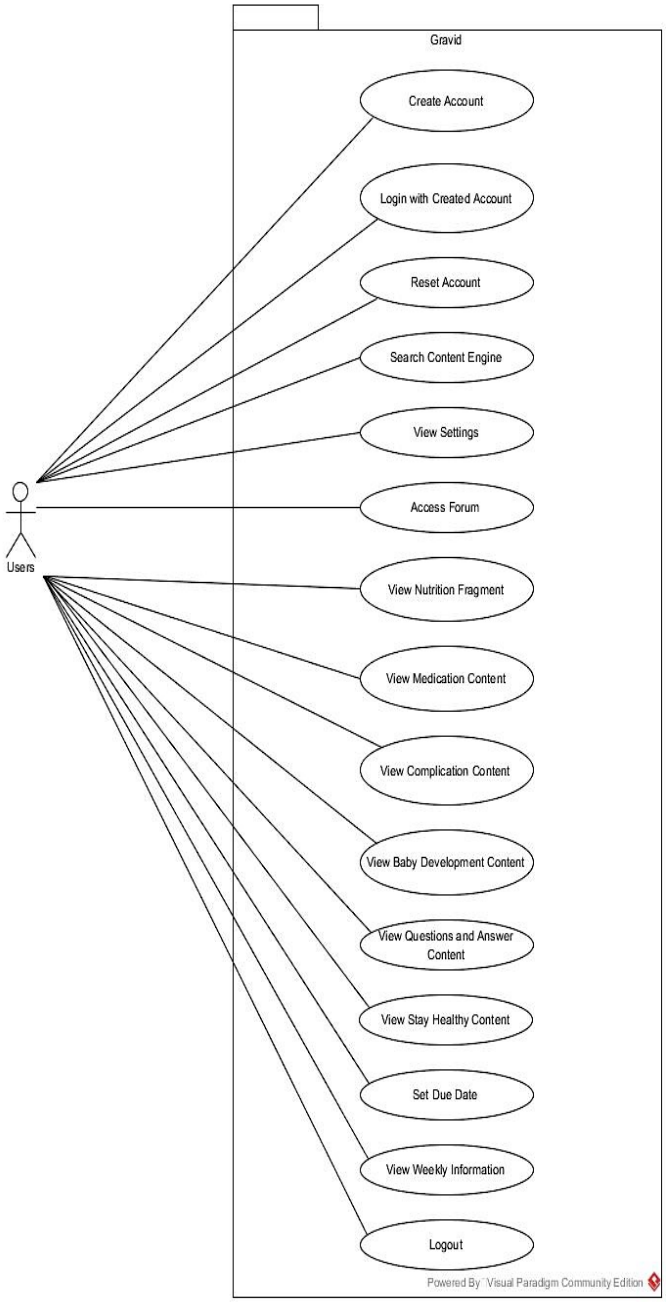

Fig. 2. The Use Case Diagram for GRAVID

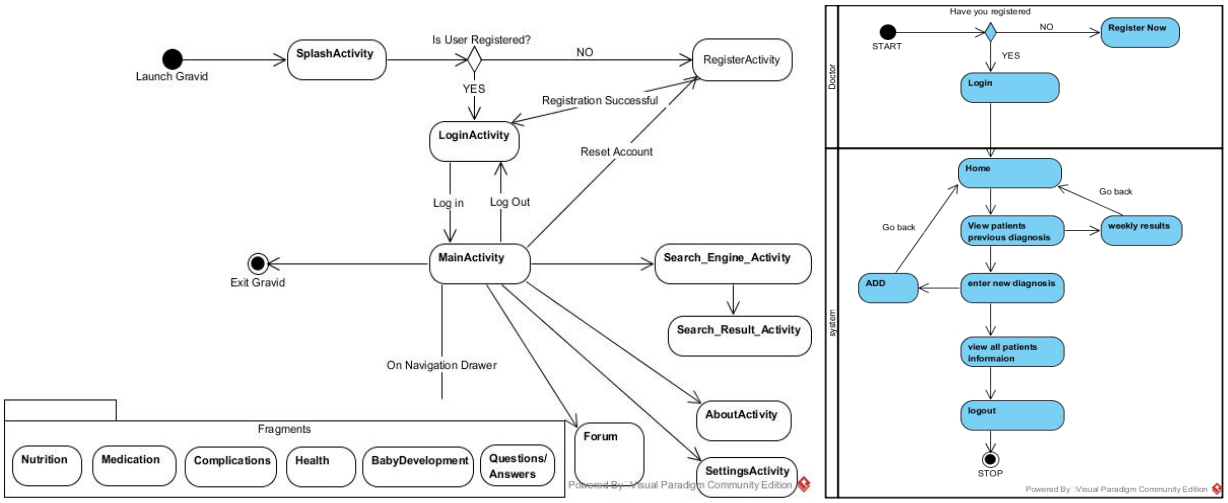

Fig. 3. The Activity Diagram for *GRAVID*

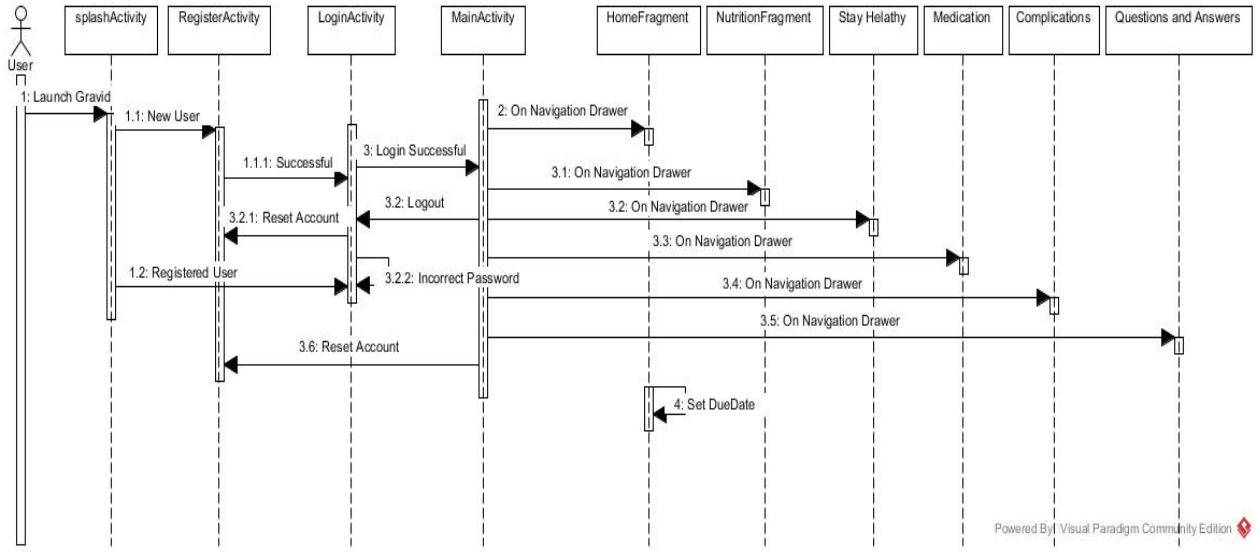

Fig. 4. The Sequence diagram for *GRAVID* Application Content

IV. System Implementation and Experimental Results

The proposed indigenous smart application was implemented with Android software development kit (SDK), an open source development tool for mobile application, for cost-effective development and widespread community coverage. The minimum hardware requirement for the proper operation of the software developed includes a mobile computing device running Android Operating System 4.03 or higher, with at least 1GHz processor and 512 MB RAM. It is preferred that the screen size should be at least 3.5 inches wide.

Fig. 5. The Graphical User Interface (GUI) for *GRAVID* Registration Menu

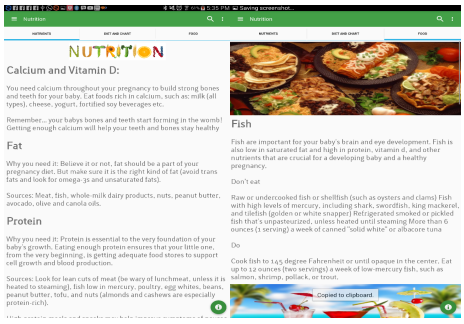

Fig. 6. The Graphical User Interfaces (GUIs) for *GRAVID Nutrition Page*

A sequence diagram as showed in Fig. 4 models the interactions between the actors and the objects within a system and also the interactions between the objects themselves. The interactive GUI of GRAVID is presented in *Figs. 5 & 6*. The first phase of *GRAVID* was deployed and tested on the commonly used Android phones as well as tablets to ensure its functionality and efficiency.

V. Conclusions and Future Works

In this paper, a mobile Health solution named *GRAVID* was proposed to address the gap of unavailability of context-based nutritional, drug and substance abuse as well as medical information of gravid women and subsequently their babies (for 5 years); in Africa. The indigenous smart application was developed with Android software development kit (SDK), an open source development tool for mobile application, for cost-effective development and widespread community coverage. *GRAVID* also provides a monitoring tool for caregivers to track the progress of gravid women, newborns and young children especially high-risk pregnancies and children.

The subsequent phases will be deployed with regular updates from national health professionals (such as nutritionists, midwives) to enhance prenatal, neonatal, postnatal and young child (<5 years) care services in the community. *GRAVID* can be used by community health workers to collect field-based health data, send alerts and reminders, facilitate health education sessions, and conduct person-to-person communication as indicated in [7]. Also the application can be further enhanced with highly secure cloud computing services such as Storage-as-a-Service (STaaS).

Acknowledgment

The authors appreciate Visual Paradigm International for the free trial version of their tools, which was used for creating all UML diagrams in this paper. The authors also appreciate all medical and nutrition experts who provided useful information directly or indirectly.

References

[1] United Nations Foundation (2016). *Saving lives, protecting futures: Progress report on the Global Strategy for Women's and Children's Health 2010-2015*. [Online]. Available: http://www.everywomaneverychild.org/images/March_17_EWEC_GSR_Layout_v08_LR.pdf.

[2] United Nations Children's Fund (UNICEF). (2015). *Levels & trends in child mortality: report 2015*. [Online]. Available: http://www.childmortality.org/files_v20/download/IGME%20report%202015%20child%20mortality%20final.pdf .

[3] United Nations Children's Fund (UNICEF). (2015). *Committing to Child Survival: A Promise Renewed. Progress Report 2015*. [Online]. Available: http://www.unicef.org/publications/files/APR_2015_9_Sep_15.pdf

[4] United Nations Children's Fund (UNICEF), World Health Organization (WHO) and World Bank Group. (2015). *Levels and trends in child malnutrition UNICEF – WHO – World Bank Group joint child malnutrition estimates: Key findings of the 2015 edition.* [Online]. Available: http://www.who.int/nutgrowthdb/jme_brochure2015.pdf?ua=1

[5] M.J.H. Panir. Role of ICTs in the health sector in developing countries: a critical review of literature. *Journal of Health Informatics in Developing Countries vol*. 5, no. 1, 2011.

[6] J.L.Watterson, J. Walsh and I. Madeka. Using mHealth to improve usage of antenatal care, postnatal care, and immunization: A systematic review of the literature. *BioMed Research International vol. 2015*, 2015.

[7] R. Braun, C. Catalani, J. Wimbush and D. Israelski. Community health workers and mobile technology: a systematic review of the literature. *PloS one vol. 8, no.* 6., 2013.

[8] T. Tamrat and S. Kachnowski. Special delivery: an analysis of mHealth in maternal and newborn health programs and their outcomes around the world. *Maternal and child health journal vol. 16, no.* 5, pp.1092-1101, 2012.

[9] G. Byomire and G. Maiga. A model for mobile phone adoption in maternal healthcare. In Proc. *IEEE IST-Africa Conference*, pp.1-8, 2015.

[10] A. Coleman. The Use of ICT Tools (Mobile Phones) to Improve Awareness of Pregnancy Danger Signs among Pregnant Women in Rural Communities of South Africa. *J Communication vol*. 5, no. 2, pp. 203-209, 2014.

[11] D. M. West (2015). *Using mobile technology to improve maternal health and fight Ebola: A case study of mobile innovation in Nigeria*. Center for Technological Innovation at Brookings. [Online]. Available:http://www.insidepolitics.org/brookingsreports/NigeriaMHealth.pdf

[12] S. Lund, M. Hemed, B. B. Nielsen, A. Said, K. Said, M. H. Makungu, and V. Rasch. Mobile phones as a health communication tool to improve skilled attendance at delivery in Zanzibar: A cluster‐randomised controlled trial. *BJOG: An International Journal of Obstetrics & Gynaecology vol.* 119, no. 10, pp. 1256-1264, 2012.

[13] Isola O. Olusola (2011). *The use of mobile telephone in reducing prenatal maternal mortality: case study of Abiye (Safe Motherhood) project in Ondo State, Southwest Nigeria.* University of Ibadan, Nigeria. [Online]. Available: http://www.ifra-nigeria.org/IMG/pdf/sola-isola-case-study-abiye-project-repor.pdf.

[14] A. Katib, D. Rao, P. Rao, K. Williams and J. Grant. A prototype of a novel cell phone application for tracking the vaccination coverage of children in rural communities. *Computer Methods and Programs in Biomedicine vol.* 122, no. 2 , pp. 215-228 2015.

[15] B.S. Fjeldsoe, Y.D. Miller, J.L. O'Brien and A. L. Marshall. Iterative development of MobileMums: a physical activity intervention for women with young children. *International Journal of Behavioral Nutrition and Physical Activity vol. 9*, no. 1, p.1, 2012.

[16] L. Hearn, M. Miller and L. Lester. Reaching perinatal women online: the Healthy You, Healthy Baby website and app. *Journal of Obesity vol.* 2014, 2014.

[17] A. Zanella, N. Bui, A. Castellani, L. Vangelista and M. Zorzi. Internet of things for smart cities. *IEEE Internet of Things Journal, vol.* 1, no. 1, pp. 22-32, 2014.

[18] A. Solanas, C. Patsakis, M. Conti, I. S. Vlachos, V. Ramos, F. Falcone, O. Postolache, P.A. Pérez-Martínez, R. Di Pietro, D.N. Perrea and A. Martínez-Ballesté. Smart health: a context-aware health paradigm within smart cities. *IEEE Communications Magazine vol. 52, no.* 8, pp. 74-81, 2014.

[19] Y. Sun, H. Song, A.J. Jara and R. Bie, "Internet of Things and Big Data Analytics for Smart and Connected Communities," *IEEE Access*, vol. *4*, pp.766-773, 2016.