La Merveille Des Femmes

Women's Health Doctor Database
Final Project Report

Group 14:
Aleide Hoeijmakers (2546927)
Judith Klepper (2590080)
Roos Verwolf (2519733)

GitHub links:
https://github.com/a-hoey/KasaDaka-VSDK (for the vsdk application and interface)
https://github.com/a-hoey/ICT4D (for the voiceXML application and .wav files)

Webinterface link:
http://radiant-garden-33796.herokuapp.com/lmdf/lmdf

Voice service number:
020-3697664

Version	Date	Modification	Authors
0.1	April 2018	Document creation	Roos, Aleide, Judith
0.2	Mei 2018	Document extension and improvement	Roos, Aleide, Judith
0.3	Mei 2018	Document finalisation and improvement	Roos, Aleide, Judith

1. Introduction

For the course ICT4D at the Vrije Universiteit Amsterdam, a system was developed that could be helpful in rural parts of Mali. It was decided not to choose a predefined use case but to come up with a new subject because the developers of this system had a mutual interest in ICT and health (or in other words eHealth). Therefore, a system was created that was related to eHealth. It was chosen to focus on expanding the knowledge of physicians who treat pregnant women because of the high fertility rate but unfortunately low resources in this area. Our goal is to create a system that should act as a learning platform. The following section describes the context and problem statement in more detail. The remaining sections describe a use case, the system design, installation and demonstration guide, the scope and fidelity of the prototype, an implementation, deployment and sustainability plan, and a user study. The report ends with an evaluation, discussion, conclusion and future work.

2. Context and theoretical background

In sub-saharan parts of Africa women have great responsibility towards their family members, they're the main caregivers for sick or disabled members of the family and they experience a high workload in childbearing and nurturing. This region has the highest fertility rate of the world, estimated at 5,2 children. Sadly, there is a shortage of skilled care and clinical facilities that could affect the health of women, especially the predominantly rural population as the majority of the healthcare services are urban centred (World Health Organization, 2012). The maternal mortality ratio in sub-saharan Africa was estimated at 900 maternal deaths per 100.000 live births in 2005. At that point in time, it was the highest number worldwide (WHO, 2007). Because of no skilled professional present to help with delivery, some mothers bleed to death after giving birth. Due to complications, more than half of maternal deaths occur within 24-48 hours after delivery. Emergency obstetric care is necessary as it is estimated that around a quarter of maternal deaths could have been prevented (WHO, 2012). In the cohort, Bankoni, Bamako, Mali pregnancies occur at a young age: 18% of 4717 pregnant women during the years 1989-1994 were 18 years old or younger (Etard et al., 2005). In a later study done by Künzel et al. (1996) the incidence of young mothers was lower but it remained high (9.8%). Mali also suffers from a high infant mortality rate (28%) which could be due to the low amount of prenatal visits (10.6%), and ultrasound examinations. Preeclampsia affects about 8-10% of all pregnancies in africa, and because of the lack of knowledge they cannot take preventative measures which can result in maternal and infant death (Vata et al., 2015). Pregnant women in Mali are also at risk for malaria. This infection can have negative consequences like maternal anemia, low birth weight (LBW) from prematurity and intrauterine growth retardation (IUGR), and infant mortality linked to preterm-LBW and IUGR-LBW. This study estimated that each year 75.000 to 200.000 infant deaths are associated with malaria infection in pregnancy (Steketee et al., 2001). Important risk factors for malaria infection in pregnant women are living in a rural area, earlier gestation age, and young age rather than parity (Dicko, 2003). According to Bove et al. (2012) who examined women health in urban Mali and interviewed 324 women, nearly all pregnant women delivered at a health center or hospital (98%). However, these rates are based on the population of urban areas of Mali and unfortunately, facilities like hospitals are usually not available in rural areas making the rural population even more prone to health problems. If the distance to a health center is too big, this could result in the lack of prenatal care and delivery assistance by trained medical personnel (Gage, 2007). As stated above, appropriate health care is very important because it can prevent disastrous outcomes like maternal or infant death. According to Nyamtema et al. (2017) who introduced E-Health strategies in rural Tanzania, maternal health care in underserved remote areas can be improved by mobile teleconsultations for obstetric emergency care, an audio teleconferencing model and an online eLearning platform. E-Health can help in broadening knowledge and skills of care providers. The current project aims to reduce maternal and infant mortality rates and provide overall better health care by implementing an ICT

system that supports physicians who help pregnant women in rural areas of Mali. It does so by creating a database for physicians with helpful information regarding pregnancies. This way, they can learn from each other, and expand their knowledge in order to provide better healthcare.

3. Use Case Description

0.Name

La Merveille des Femmes

1. Summary of Key Idea

Provide physicians with health information support and a database with specific case information. The physicians can call the number of La Merveille des Femmes to request information about pregnancy diseases or add information to the database to share their experience/knowledge. The designed system contains two aspects, a database with a web interface and a voiceservice. The web interface shows all information and cases in the database and serves as a learning platform for doctors to view cases. The voice service gives more general information about certain diseases and symptoms and has an option to add cases to the system in order to extend the database. This way physicians can add information about patients right away.

2. Actors and goals

Actors	Operational goals
Physicians	Request from or add knowledge to the database.
System Owner	Keeps the system running

3. Context and scope

The goal of this project the goal is to help physicians learn about pregnancy diseases in order to expand knowledge and better diagnose and treat pregnant women. By adding cases and be able to look up other cases, it is possible to expand the knowledge of the physicians that provide healthcare. By sharing information about specific pregnancy cases, other physicians are able to learn from this and apply this new knowledge in order to provide better care. At this moment, the scope is sized down to malaria and preeclampsia during pregnancy. How the system works in more detail will be described in the following sections. External stakeholders are the physician and the system owner. The goal of the system owner should be to keep the system up and running and to check for misuse of the system. The system owner needs to speak English and French as the system owner has to listen to the added cases and add the information to the database. The goal of the physician is to study the information that is provided in the database to improve his or her expertise on pregnancy diseases and complications. The second goal is to improve and expand the database by adding information about specific pregnancy cases that could help other physicians. Success for this scenario would be measured in terms of if physicians call to request or add information and by a growing database. Crucial to succeed is first, a clear and well communicated system. Second, physicians should be provided with phones and need to speak English or French (as these are the only two languages the system currently runs on). Lastly, it is also important that physicians accept the system and want to use it. The current system focuses solely on pregnancy cases. However, the scope can be broadened in the future. More topics can be included to eventually create a health database for all kinds of symptoms and diseases. It should be noted that the diseases that are now in the system, being malaria and preeclampsia, are examples of

diseases women could get during pregnancy. Other diseases and treatments should be added to the database by physicians.

4. Use case scenario script

This section represents a possible script:

1. Physician calls La Merveille des Femmes to request information about certain symptoms a patient of his experiences during her pregnancy.
2. The system prompts to the user: "Welcome to La Merveille des Femmes. Press 1 for English, press 2 for French. Bienvenue à la Merveille des Femmes. Appuyer sur un pour l'anglais, appuyer sur deux pour le français."
3. Physician presses 1 to continue in English.
4. The system prompts to the user:"Welcome to La Merveille des Femmes. Would you like to listen to existing information in the database or add new information to the database. To select: listen, press 1. To select: add, press 2."
5. Physician presses 1 to listen to information in the database.
6. The system prompts to the user: "Do you want to hear information about Malaria or Preeclampsia? To select: Malaria, press 1. To select: Preeclampsia, press 2. To select: previous menu, press 3."
7. Physician presses 1 because he diagnosed his patient with Malaria.
8. The system prompts to the user: "Malaria is a potentially life-threatening disease caused by infection and transmitted by a mosquito. Only a blood test can help determine the exact infection. If you would like to hear the corresponding symptoms of malaria, press 1. To go back to the previous menu, press 2. To select: symptoms, press 1. To select: previous menu, press 2."
9. Physician presses 1 to hear the corresponding symptoms.
10. The system prompts to the user: "The most common symptoms for Malaria and pregnancy are: High fever and sweating or feeling chills, Nausea, Cough, Headache, Vomiting, Muscle pain, Diarrhea, Jaundice, Respiratory distress, Splenomegaly (enlargement of the spleen), Pallor (pale appearance), General malaise. This concludes the info about Malaria and pregnancy. If you wish to go back to the instructions menu press 1. Otherwise press 2 to end this call. Thank you for using La Merveille des Femmes. To select: previous menu, press 1. To select: end call, press 2."
11. The physician ends his call by pressing 2.

5. Interaction and communication

Appendix A shows the call flow diagram of the interaction and communication of the system.

6. Information concepts

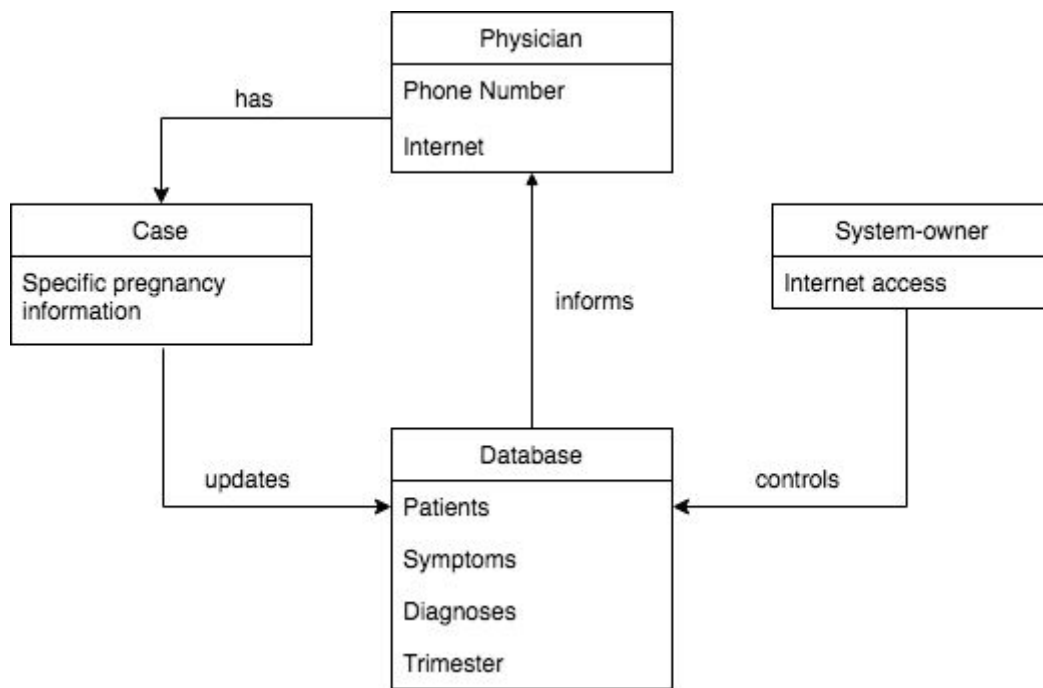Figure 5 shows the class diagram of the system, the information concepts.

Figure 5. Class diagram of static structures

7. Technology infrastructure

For this system to work, there are multiple technical requirements. First of all, this system is a phone based system. Users can call a number to reach a server, where the physician goes through a choicemenu and can request from or add information to the database. It is crucial for potential users to have access to a phone and to be provided with the number of La Merveille des Femmes (the number could be passed on through affiches, radio, or face to face marketing). Secondly, in order for the system to work and to create and maintain a database, there should be a computer available with internet access. The system will work on KasaDaka which is built on a Raspberry Pi computer. It will also use an open source framework called Asterisk. This framework can turn a computer into a communication service.

8. Cost considerations

The implementation of such a system of course comes at certain costs. First of all, the system needs to be implemented and understood. This means there has to be system owner, who has to keep the system up and running, and check for misuse. This person needs to be paid. The system needs to be explained to the system owner as well as the physicians. This will take some time and means that the developers should go to the location where the system will be used. The physical system, consisting of at least one computer with internet access for the system owner, should be installed at his or her workplace. Also, the availability of mobile telephones is necessary for physicians that want to use the system. Whenever the system is expanded it is also important that the phone network is able to carry the capacity and that phones are always usable (charged, in range).
These cost can be carried, either by the national government, or collected as money for charity by the developing party.

Moscow method for use case 1

Must	Should	Could	Won't
Have a calling service	Store new pregnancy information in database	Indicate how urgent something is	Give direct medical advice to doctors or pregnant women
Have a system-owner that report all new cases into the system	Retrieve pregnancy information from database	Give information about experts in a certain area based on keywords	Add cases to the system automatically
Have an info menu in the voice XML with data from database	Provide the user with different language options	Have an interface that is accessible via a laptop	
Have an add menu in the voice XML to enter data in database			

4. System design

This part will discuss the functional requirements of the system. For every requirement the expansion of assignment 3 has been added. In the scope and fidelity section the implementation of the requirements will be discussed.

4.1 Functional Requirements

The La Merveille des Femmes system will have the following functional requirements:

Requirement ID	Requirement Definition
1.1	The system shall provide a calling service via KasaDaka
1.1.1	The calling service will be available in English and French
2.1	The system shall save information added by the physicians
2.2	The system shall provide physicians with information about diseases
3.1	The system shall provide an interface which physicians can use as a learning platform

Requirement 1.1 Calling service

The system will have a calling service. Physicians are able to call a telephone number at all times. The service will be implemented on KasaDaka so that information can be shared or added to the system without internet connection. The implementation on a platform like Kasadaka is a functional requirement, since the application will be built to be used in rural areas.

Changes assignment 3: To finalize the voice service a spoken user element was added. The main feedback for assignment 2 was that the add and listen function ends up in the same question. In assignment 3 we have clearly divided add and listen; also the question "in which trimester is the patient" is only asked when adding to the database.

Requirement 1.1.1 Different languages
The system will provide the user with the language options English or French. These are the main languages for the system at this moment, however when needed the system could be expanded in more languages.

Changes assignment 3: French was added to the web interface. The voice application already had both English and French as an option.

Requirement 2.1 Information storage physicians
The system stores information on its database after a phone call with a physician. The goal of this requirement is that eventually a comprehensive database is created. The database will consist of data of a case number, age of the patient, a diagnosis, information about the trimester of the patient, the symptoms and case specific information. The physicians should at least give one symptom that was decisive for the diagnosis. Figure 6 shows an early version of the database (end assignment 2). In figure 7 the final version is shown. An obvious change is the comment section, were case specific information can be added.

Figure 6. Database input La Merveille des Femmes screenshot (early version)

Figure 7. Database input La Merveille des Femmes screenshot
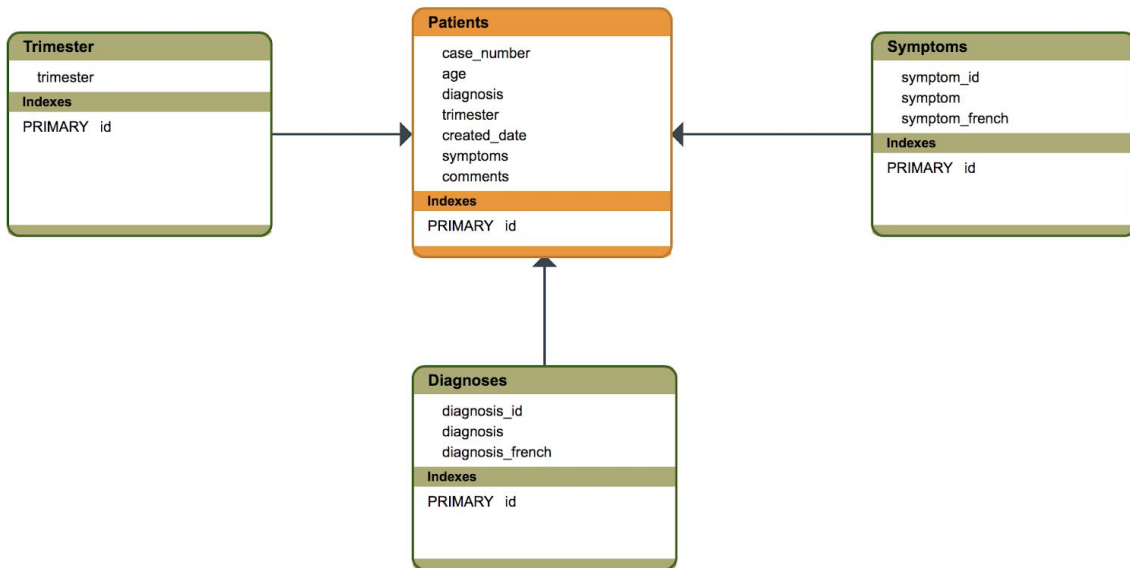
Figure 8. Database model

Changes assignment 3: The input variables were changed and the database was expanded by using ForeignKey (diagnosis/trimester), ManytoMany fields (symptoms), textfields (comments). In early versions we only used the Charfield in our models.

Requirement 2.2 Information retrieval physicians

The system will be able to provide physicians with general information via the phone. This information includes most seen symptoms and treatments of different diseases. It also shows how physicians can diagnose a patient.

Changes assignment 3: Since Django limits the idea of text to speech or at least giving case specific information on the phone, it was decided to change the information retrieval requirements. The system will now be able to give disease specific information.

Requirement 3.1 Database interface

The system will also have an interface that can be used on a laptop/computer. This should give the same information as when calling by phone, however the interface also includes case specific information. The functional requirement is to show the last known cases with a certain diagnosis and to show the associated symptoms for a specific case. In this way, offering the physician's a learning platform. A similar approach was applied and tested by Nyamtema (2017) in the underserved rural areas of Tanzania. The results of this research have reported an increase of 43-89% in knowledge and skills by physicians (in the paper referred by 'health care provider'). A screenshot of a very early version of the interface is shown in figure 9. This interface was deployed on a seperate django application and still needed to be integrated with the VSDK application. The template is written in such a way that it shows information from the database directly. **(end of assignment 2).** Figure 10 shows the latest version of the interface. It is now implemented on the KasaDaka framework. The template can be viewed in English and French.

Figure 9. Database interface screenshot (early version)

Changes assignment 3: A new style of templates was created for the web interface. Also internally some changes were made. The interface is now able to refer to specific cases. Every case was given a primary key, the URL refers to the key instead of a new html page.

4.2 Prototype scope and fidelity

Based on the feedback of assignment 1 it was decided to take a different approach and not just expand but completely change the system for assignment 2. Because of this, the use case needed to be rewritten. It was also decided to remake the .xml files that were connected with Voxeo. The feedback of assignment 2 was very positive. The functional requirements that were made for assignment 3where feasible in the given time window. Despite the fact that many challenges were encountered, all the functional requirements were fulfilled.
For the implementation of this prototype it was chosen to use two examples of pregnancy diseases that occur in rural Africa. It was chosen to use malaria and preeclampsia, because these two diseases came up when talking to a physician about pregnancy complications in rural Africa. More information about both diseases and the symptoms can be found in the system (via web interface, voice service or information in the call flow (see Appendix A)). For the system to be accurate multiple sources were used. The information about Malaria on the web interface and on the voice service is found in an article of Kayentao et al. (2005). The information in the system about preeclampsia was found in Vata et al. (2015).

6. Installation and demonstration guide

See appendix D for the user manual.

admin log in:
Username: System_owner
Password: lmdfict4d

7. Demonstration scenario and questions

See appendix C for questions and the movie for two different demonstration scenarios.

8. Implementation, deployment and sustainability plan

This section proposes an implementation, deployment and sustainability plan for La Merveille des Femmes. Also the ethical considerations for the system are discussed.

8.1 Implementation and Deployment plan

As written in the Buyers' guide to sustainable ICT infrastructure, a careful planning of infrastructure will help in avoiding most problems. However, providing training and support during deployment is also important to make your ICT application a success. If the application would be deployed in Mali the following steps need to be taken. The first and most important step is to get funding as the project wouldn't be able to start without it. This could be public (government) or private funding.

The second step is to find a system owner who speaks english and french and provide him or her with a computer. Training is a really important, the system owner must be able to fix problems that arise. This system owner needs to be paid as he plays a big role in keeping the system up and running. He or

she needs to listen to the messages that people want to add to the database, change it to text in both languages and update the database.

As a last step, once the system is set up, physicians/potential users need to be informed about the system. The first users also need a short basic training of how they can use the system and how they can benefit from it. A user manual was made to provide a basic explanation. After the pilot phase, the number of La Merveille des Femmes could be passed on through affiches, radio, or face to face marketing. The pilot phase gives the opportunity to test the system, to see if certain problems arise, and to see if physicians are willing to adopt the system and find it useful. Of course, the developers need to set up and lead the project in Mali, at least during the pilot phase. The aim of the project is that the database will expand, even after the pilot phase, and that physicians keep using it.

8.2 Sustainability

Unfortunately, ICT for development projects have a high rate of failure. To quote Salis et al. (..): "*The success of a business model depends primarily on the immediate benefit of the service to its end-user, and on its affordability*". If this project would be implemented in Mali it's important to take the sustainability into account. The goal is that the project can survive after the pilot phase so it's essential to create a sustainability model to estimate the outcome. La Merveille des Femmes is a socially driven project, the funding has to come from donors, NGOs or the government. Three dimensions of sustainability can be distinguished: social and cultural sustainability, economic sustainability, and institutional sustainability (Nawi et al., 2013). The three dimensions of sustainability for this project will be discussed below:

Social and Cultural Sustainability
This dimension takes the context in which the project operates and the impacts of the project into account. As the context is Mali certain aspects need to be considered. The physicians, the end-users, have to adopt the system and hopefully see the benefits of the application because when they do they will become active in seeking ways to keep the project running. They become invested in the project because of their own vital self-interest. In Mali, less than 10 percent of all physicians practice in a rural environment (Lamiaux, Rouzaud & Woods, 2011). According to the World Bank, the number of physicians per 1000 people in 2010 was 0.085. This is an extremely low number. Because there are so few physicians in Mali and even fewer in rural areas, they have a lot of responsibility and the need to keep educating themself becomes even bigger. By providing a platform where they can share their knowledge and learn from other physicians, they can educate themselves in an easy and effective manner.

Economic Sustainability
This dimension takes the financial self sustainability into account, the level of expenditure that can be sustained in the long term. Once the project is set up with funding from a development organisation, the costs will be reasonably low to keep it running. The project can even run without a system owner because the database will stay accessible. However, to expand the database with new cases and solve any problems that may arise with the system, a system owner is necessary. Best possible outcome would be consistent funding from the government. Because the system is beneficial for the health system in Mali (improve the knowledge of physicians so they can provide better healthcare), funding from the government could definitely be an option.

Institutional Sustainability

This dimension takes the structures and processes of an organisation and if they are able to perform their functions over the long term into account. The system needs a collaboration and participation of different stakeholders. Fortunately, only the system owner needs to actually work with (instead of just use) the system. Because this is a one man's job, it is anticipated that he or she will function well and keep functioning well after the pilot phase after a good training of how to work with the system.

Technical sustainability

The system would be deployed in rural Mali, an area with other technical resources than for example the Netherlands. An extra sustainability dimension, the technical sustainability, could be in order. It has to be taken into account that the internet connectivity might not be stable at all times. Fortunately, the system also works without an internet connection. It is only necessary to have internet access when the database needs to be updated and this is up to the system owner.

8.3 Ethical considerations

Because the system covers health, ethical issues need to be discussed. Important to note is that the system does not give advice, diagnose a patient or give a treatment plan. Although information is added by skilled and trained physicians, the correctness of this information is not known for sure. It is the responsibility of the system owner to check for misuse and wrong information but also a shared responsibility of the physicians themselves. The medically trained and qualified professionals should always validate the information from the database and not take it as absolute truth. They are in the end accountable for their own actions and should not diagnose and treat patients purely based on the information provided by the system. Because it is a shared platform, it could be possible that wrong information ends up in the database. The application cannot be hold responsible for the medical information it provides but must solely be seen as a valuable source for physicians who want to expand and share their knowledge.

9. User study

To assess the system, it was chosen to do observational research to check for potential problems. Unfortunately, this couldn't be done in Mali, the true context. Despite not being able to have meetings with users in their own environment and where the system will be used, it is still useful to conduct a user study with a Dutch physician. If this physician would encounter certain usability problems, the feedback would be noted and the system changed accordingly. These adaptations will improve the user-friendliness of the system.

The user study consisted of:
- observation
- interview
- evaluation

In this user study, two physicians participated, both were given the user manual (Appendix D) before visiting the web interface and calling the voice service. Both physicians found the user manual to be informative and found to be enough as an explanation for the current system.

When first calling the voice service, there were still some aspects in the wrong order, this was changed. Some small and simple changes were made. After this, the first physician indicated that it

would probably be the case that most doctors already know the general information about the diseases that are now in the voice service. The other physician indicated that it would be useful to have some information in the voice service about diagnoses and treatments. For the adding of the cases, both indicated that might be better to add cases in a more structural way. When testing the web interface, both physicians told us that such a platform, where cases can be viewed, could really help to expand knowledge. Both indicated that such a web interface could serve as a learning platform. It was noted, that when enough cases were put in the database, the prevalence of diseases in specific areas can be mapped. Also, it could be reviewed whether a specific treatment works better in one trimester than in another.

The comments of the physicians were taken into account and will be further discussed in 'Future Work'.

10. Evaluation and Discussion

During the course of this project, much adaptations were made to the original idea. Not only was the scope changed from pregnant women to physicians, the system was also extended from a voice service to a learning platform. The system as it is now serves as a voice service to hear general information and a web interface that serves as a learning platform. However, some points of the current system still could be improved. For instance, the database should now be updated by a system owner, not only could this be a time-consuming task, but also the system owner should be educated and understand what the physicians mean with words in the spoken cases. The spoken input is now not structured and it could therefore be a time consuming task to extract the different elements of a case, such as symptoms and treatments.

Another problem could be language, the current system is implemented in French and English, although the national language of Mali is French, there are also local languages and dialects. It could therefore be the case that some users of the system do not understand the voice menu or the web interface. Whenever a spoken case is in a dialect or a local language the system owner is not able to understand the voice input. When implemented the system in specific areas it should be considered to include local dialects.

11. Conclusion and Future Work

This paper provides an overall description of the development of La Merveille des Femmes. Related work shows that previously deployed systems can be of great value in developing countries. However, none of the systems included a dual platform consisting of a voice service application and a web interface like La Merveille des Femmes.

The functional requirements that were set at the beginning of the project were all met. After an extensive development process, an application was created that works properly. A user study was performed by Dutch physicians that gave useful insights about the system and user experience.

The next step for this project would be the deployment in Mali. Therefore, an extensive implementation, deployment and sustainability plan was written that resulted in a user manual for physicians. If this application would be deployed in a developing country, a good business plan is necessary.

Future work would include adding a 'speech to text' feature that relieves the system owner of listening to the messages of the physicians and adding it to the database himself. He would only need to check the messages for correctness. Another improvement would be to create more structure in the 'adding information' part of the call service. Instead of just one message containing everything about the case, it could be divided into 'symptoms', 'diagnosis', and 'treatment'. This would make the process of adding a case to the database easier and more clear for both the physician and system owner. The user study with two Dutch physicians gave useful insights as well. One comment was to make better use of the retrieved data by mapping whether certain diseases are more prevalent in certain areas than in others. This could be helpful information that can result in better-suited care. The second comment concerned the information about diagnosing a patient. For this assignment it was decided not to provide the calling physician with a diagnosis plan as the correctness of the given information cannot be guaranteed. Future work could include this information by securing that the given information is correct, for example by validating this information with a professional.

This paper finalizes the work of developing an application for the course ICT4D. The developers believe that the created voice service and web interface could be helpful in rural parts of Mali.

Bibliography

Addressing the Challenge of Women's Health in Africa: *Report of the Commission on Women's Health in the African Region.* Regional Office for Africa: World Health Organization; 2012.

Bove, R. M., Vala-Haynes, E., & Valeggia, C. R. (2012). *Women's health in urban Mali: Social predictors and health itineraries.* Social science & medicine, 75(8), 1392-1399.

Collste, G. *The Internet doctor and medical ethics Ethical implications of the introduction of the Internet into medical encounters.* Medicine, Health Care and Philosophy, 5(2), 121-125. (2002).

Dicko, A., Mantel, C., Thera, M. A., Doumbia, S., Diallo, M., Diakité, M., ... & Doumbo, O. K. (2003). Risk factors for malaria infection and anemia for pregnant women in the Sahel area of Bandiagara, Mali. *Acta Tropica*, *89*(1), 17-23.

Etard, J. F., Kodio, B., & Traoré, S. (1999). *Assessment of maternal mortality and late maternal mortality among a cohort of pregnant women in Bamako, Mali. BJOG:* An International Journal of Obstetrics & Gynaecology, *106*(1), 60-65.

Gage, A. J. *Barriers to the utilization of maternal health care in rural Mali. Social science & medicine, 65*(8), 1666-1682.(2007).

Gyan, N. B., De Boer, V., Bon, A., Van Aart, C., Akkermans, H., Boyera, S., ... & Allen, M. (2013, May). *Voice-based web access in rural africa.* Proceedings of the 5th annual acm web science conference (pp. 122-131). ACM.

Inveneo, *Buyers' Guide to Sustainable ICT Infrastructure in Low Resource Settings.* November 2011

Kayentao, K., Kodio, M., Newman, R. D., Maiga, H., Doumtabe, D., Ongoiba, A., ... & Parise, M. E. (2005). Comparison of intermittent preventive treatment with chemoprophylaxis for the prevention of malaria during pregnancy in Mali. The Journal of infectious diseases, 191(1), 109-116.

Künzel, W., Herrero, J., Onwuhafua, P., Staub, T., & Hornung, C. (1996). *Maternal and perinatal health in Mali, Togo and Nigeria. European Journal of Obstetrics and Gynecology and Reproductive Biology, 69*(1), 11-17.

Lamiaux, M., Rouzaud, F., Woods, W. (2011). *Private health sector assessment in Mali : the post-Bamako initiative reality (English).* World Bank working paper ; no. 212. Washington, DC: World Bank.

Maternal mortality in 2005*: estimates developed by WHO, UNICEF, UNFPA and the World Bank*. Geneva: World Health Organization; 2007.

Nawi, H. S. A., Shukor, N. S. A., Basaruddin, S., Omar, S. F., Abdul, A., Rahman, R. A. H., ... & Jaya, B. (2013). *Sustainability Criteria Model: A Field Study of ICT4D Project.*

Nyamtema, A., Mwakatundu, N., Dominico, S., Kasanga, M., Jamadini, F., Maokola, K., ... & van Roosmalen, J. (2017). *Introducing eHealth strategies to enhance maternal and perinatal health care in rural Tanzania. Maternal health, neonatology and perinatology,* 3(1), 3.

Salis, C., SA-Portugal-contractor, P. T. I., Eco-Mali-contractor, S., & SA-France-contractor, F. T. (2011). *VOIce-based Community-cEntric mobile Services for social development.*

Steketee, R. W., Nahlen, B. L., Parise, M. E., & Menendez, C. (2001). The burden of malaria in pregnancy in malaria-endemic areas. *The American journal of tropical medicine and hygiene*, *64*(1_suppl), 28-35.

Vata, P. K., Chauhan, N. M., Nallathambi, A., & Hussein, F. (2015). Assessment of prevalence of preeclampsia from Dilla region of Ethiopia. *BMC research notes*, *8*(1), 816.

Appendix A: call flow diagram of the system

Welcome message:
"Press 1 for English, press 2 for French. Bienvenue a Merveille Des Femmes. Appuyer sur un pour l'anglais, appuyer sur deux pour le français."

press 2

French instructions:
"........"

Are the same as the English instructions but in French.

press 1

English instructions:
"Welcome to La Merveille des Femmes. Would you like to listen to existing information in the database or add new information to the database. To select: add, press 1. To select: listen, press 2."

press 1

Choice menu add new information:
"Would you like to add information about Malaria, Preeclampsia or an other diagnosis? To select: Malaria, press 1. To select: Preeclampsia, press 2. To select: 3. To select: previous menu, press 4."

press 1

Malaria:
"Is your patient in the first, second or third trimester? To select: first trimester, press 1. To select: second trimester, press 2. To select: third trimester, press 3. To select: previous menu, press 4."

press 2

Preeclampsia:
"Here, you can record your message. Please make sure your message contains the following information: the symptoms, the diagnosis, the treatment. You can end your message by pressing any key. Please record your message after the beep, press 4."

press 3

New diagnosis:
"Here, you can record your message. Please make sure your message contains the following information: the symptoms, the diagnosis, the treatment. You can end your message by pressing any key. Please record your message after the beep. BEEP"

press 1

First trimester:
"Here, you can record your message. Please make sure your message contains the following information: the symptoms, the diagnosis, the treatment. You can end your message by pressing any key. Please record your message after the beep. BEEP"

press 2

Second trimester:
"Here, you can record your message. Please make sure your message contains the following information: the symptoms, the diagnosis, the treatment. You can end your message by pressing any key. Please record your message after the beep. BEEP"

press 3

Third trimester:
"Here, you can record your message. Please make sure your message contains the following information: the symptoms, the diagnosis, the treatment. You can end your message by pressing any key. Please record your message after the beep. BEEP"

Message:
"Your message is: plays back recorded message. Are you satisfied with your recording? For yes, press 1. To retry: press 2."

press 2

Message:
"Your message is: plays back recorded message. Are you satisfied with your message? To select: yes, press 1. To retry: press 2."

press 1

Message:
"Thank you for your message. Your message has been stored. Thank you for using the voice service of La Merveille des Femmes."

Message:
"Thank you for using the voice service La Merveille des Femmes."

press 2

---

press 2

Choice menu requesting information:
"Do you want to hear information about Malaria or Preeclampsia? To select: Malaria, press 1. To select: Preeclampsia, press 2. To select: previous menu, press 3."

press 1

Malaria:
"Malaria is a potentially life-threatening disease caused by infection and transmitted by a mosquito. Only a blood test can help determine the exact infection. If you would like to hear the corresponding symptoms of malaria, press 1. To go back to the previous menu, press 2. To select: symptoms, press 1. To select: previous menu, press 2."

press 2

Preeclampsia:
"Preeclampsia is a pregnancy complication that is characterized by the onset of high blood pressure and often a significant amount of protein in the urine. It most commonly develops during the last trimester. The only cure is delivery. If you would like to hear the corresponding symptoms of preeclampsia press 1. To go back to the previous menu, press 2. To select: symptoms, press 1. To select: previous menu, press 2."

press 1

Symptoms Malaria:
"The most common symptoms for Malaria and pregnancy are:
- High fever and sweating or feeling chills
- Nausea
- Cough
- Headache
- Vomiting
- Muscle pain
- Diarrhea
- Jaundice
- Respiratory distress
- Splenomegaly (enlargement of the spleen)
- Pallor (pale appearance)
- General malaise

This concludes the info about Malaria and pregnancy. If you wish to go back to the instructions menu, press 1. Otherwise press 2 to end this call. Thank you for using La Merveille des Femmes. To select: previous menu, press 1. To select: end call, press 2."

press 1

Symptoms Preeclampsia:
"The most common symptoms for Preeclampsia are:
- High Blood Pressure
- Proteinuria
- Swelling Headache
- Nausea or Vomiting
- Abdominal and/or Shoulder Pain
- Lower back pain
- Sudden Weight Gain
- Changes in Vision
- Hyperreflexia
- Shortness of breath, anxiety

This concludes the info about Preeclampsia and pregnancy. If you wish to go back to the instructions menu, press 1. Otherwise, you may end this call by pressing 2. Thank you for using La Merveille des Femmes. To select: previous menu, press 1. To select: end call, press 2."

Appendix B: Interview questions

Interview questions physicians in Mali

These are some questions that could be asked to physicians in Mali. The first three question were chosen for the user evaluation.

1. **What kind of problems do you see most in pregnancies for women in Mali and what are the corresponding symptoms?**
2. **What is a physicians working day like in Mali?**
3. **Do you use ICTs, such as computers or cell phones, in order to complete your daily tasks?**
4. How many physicians does each region have on average?
5. How would you diagnose a certain disease knowing the symptoms?
6. How would you eventually treat the disease?
7. Do you use the internet for consulting information?
8. Are medicine available?

Interviews physicians in the Netherlands

A Dutch physician (de Vries) was interviewed to get an idea of how physicians work in the Netherlands. This information was taken into account during the development of the system.

1. Who or what do you consult when you can't diagnose a patient?
   Usually I consult a colleague of mine, a book or the internet. But when I'm with a patient internet works best as it is the fastest option.
2. Do you think a platform where physicians share their knowledge could be beneficial?
   Definitely, every patient every case is unique. You can learn from each other by sharing the symptoms of the case, how you approached it, the patients progress, and eventual outcome. Unfortunately, we make mistakes too, but you can really learn from your colleagues mistakes and improve your own knowledge to prevent it from happening again.
3. During pregnancy, what are the most dangerous symptoms you have to keep an eye on?
   Bleeding, abdominal pain, swollen hands or face (sudden swelling in ankles and feet), gush of fluid, less movements by the baby, blurry vision, fever, back pain that doesn't go away, rapid weight gain, persistent intense itching, vomiting along with pain or fever.

Appendix C: Process Report

Tuesday, May 8th
After the lecture of ICT4D, we came together to discuss our approach to assignment 3. Going through the grading criteria, we decided to add a user study as a nice expansion for the report. Still, a lot of work and expansion could be done for the implementation part. For the deadline of assignment 2, we got LMDF working on KasaDaka, but still had some questions. For this assignment, we will need to add user spoken input and give general information about certain diseases and symptoms. We prepared some questions that we would like to ask during the practical sessions.

Wednesday, May 9th
During the practical sessions, we had to debug an error that occurred in the interface database. André helped us with this. We learned how we can use the print function to debug in Django. By writing print functions throughout our views.py, we found out that our template was never requested. The solution was adding a $ at the end of our URL (in url.py). André also provided us with some tips on how we could visualize the data on the interface. We were introduced to the ForeignKey and ManytoMany function for models.py.

Friday, May 11th
We came together to discuss how we would visualize the data in the interface. This was needed to build the correct models and database. We also designed the admin page in such a way that it should be easy to use for the system owner. We have made some changes in the design of the interface (expansion from assignment 2).

Monday, May 14th
We shortly discussed what to implement in the user study on Whatsapp.

Tuesday, May 15th
We came together before the lecture to work on the project. We also received the feedback from assignment 2 today. Our feedback was positive, so we did not have to make drastic changes in our plan! We worked on the report, the technical part of the interface as well as text for the interface (such as a welcome text, how to use etc). Unfortunately, there were no people from Mali that could answer our questions. After the lecture, we asked Francis for help to implement the user input element on VSDK. We tried to debug it, but on Postman it would give no errors while when calling it would give the notion 'A serious error has occurred'. We came to the conclusion that it might be an error in the application itself. To test this we need to copy the created script and test it on the Voxeo server.

Wednesday, May 16th
We made some big steps for the interface, including data from the database in views and adding a second language. We also included the LMDF interface on the VSDK platform. For the report, we searched for articles about sustainability and common complications with pregnancy, and wrote a few cases for the database.

Thursday, May 17th
We met up after the lecture to work on the report.

Saturday, May 19th
We worked on adding more symptoms to the web interface. For this we used medical study books from some friends. We decided to scope the diseases down to two: Malaria and Pre-eclampsia, because the system can be easily extended with diseases and symptoms we know for sure are relevant in our target area, Mali.

Monday, 21th
Roos adjusted sections of the report to make it more suitable for assignment 3 and worked on the sustainability section of the report and Aleide & Judith worked on the presentation.

Tuesday, May 22th
We came together to discuss how further to divide the last tasks. Aleide worked on the web interface, while Roos and Judith worked on cases for the database. Judith recorded the made cases and symptoms, Aleide added them to the database. Everything worked and we had the presentation. We did not win, but we got 3 votes, which we are okay with.

Wednesday, May 23th
Roos worked on the new call flow diagram and Judith recorded a couple of new messages for the voice service. Aleide adjusted the scope and fidelity section in the report.

Thursday, May 24th
Roos worked on the ethical considerations section of the report and created and finalized the user manual. Aleide & Judith worked on finalizing the voice service application and interface.

Friday, May 25th
Judith & Aleide recorded all .wav files again to reduce noise in the recordings. When updating the Heroku server with the finalized interface, we got an error for the patient database. We deleted some of the migrations files (found on google) and tried to migrate again (on local and Heroku). This did not seem to work, we posted the question on Slack. Eventually, it was solved by resetting the database on Heroku and upload a backup to KasaDaka. Roos adjusted the scenario script and introduction and context in the report, added 'technical sustainability', and changed the call flow **again**. We ran into an error on Heroku, when you choose the pre-recorded 'four', it says 'quatre', we changed it, exciting! We finally finished the report together and drank a beer.

Saturday, May 26th
Everyone has read the report one last time and minor adjustments were made.

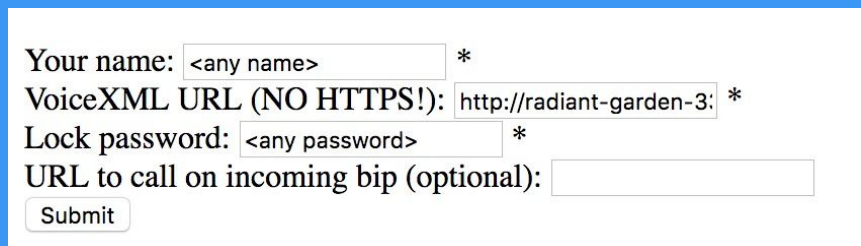**Appendix D: User Manual**

User Manual

La Merveille des Femmes

LA MERVEILLE DES FEMMES

VU

VRIJE
UNIVERSITEIT
AMSTERDAM

Contents

VU VRIJE UNIVERSITEIT AMSTERDAM

Installation for Voice Service

The application is currently using a KasaDaka-based server that can be easily accessed. Below the steps to follow to install the application:

1. Go to the link http://ict4d.kasadaka.com and log in with username: mali, and password: bamako.

2. On the site, fill in the empty fields with the following data:

   a. Your name: <any name>

   b. VoiceXML URL (NO HTTPS!): http://radiant-garden-33796.herokuapp.com/vxml/start/2

   c. Lock password: <any password>

   d. This should look like the picture on the right.

3. After submitting, double check if the Asteriks redirects to this link: http://radiant-garden-33796.herokuapp.com/vxml/start/2 . This can be found under Status: Asterisk currently redirects to: http://radiant-garden-33796.herokuapp.com/vxml/start/2

4. By calling the phone number: 020-369 76 64 you will be redirected to the voice application of La Merveille des Femmes.

Your name: <any name>   *
VoiceXML URL (NO HTTPS!): http://radiant-garden-3: *
Lock password: <any password>   *
URL to call on incoming bip (optional):
Submit

VU VRIJE UNIVERSITEIT AMSTERDAM

Voice Service

When calling La Merveille des Femmes, you will be guided through a voice menu:

1. Select your language: English (1) or French (2)

2. Choose to listen to information from the database (1) or add information to the database (2)

3. When you have chosen to listen to information:

    3.1. You can choose to listen to general information about Malaria (1) or Preeclampsia (2)

    3.2. After general information you can listen to the corresponding common symptoms of the disease (1) or end the call (2)

Voice Service (2)

4.   When you have chosen to add information:

    4.1.   Choose the topic you want to add information to: Malaria (1), Preeclampsia (2), new topic (3)

    4.2.   Leave a short message about the case containing the symptoms, diagnosis and treatment

    4.3.   The message will be played back to you. You can confirm (1), record a different message (2), or end the call (3)

VU VRIJE UNIVERSITEIT AMSTERDAM

Installation for Web Interface System Owner
\<to test application teachers - removed in original user manual\>

1. Go to the link http://radiant-garden-33796.herokuapp.com
2. login with username: System_owner and password: lmdfict4d

VU VRIJE UNIVERSITEIT AMSTERDAM

Web Interface

The link of the web interface is http://radiant-garden-33796.herokuapp.com/lmdf/lmdf. The Web Interface of La Merveille des Femmes has multiple features:

1. Home: to go back to the homepage
2. Diagnoses: contains general information about diseases
3. Symptoms: to redirect you to specific symptoms
4. Patients: contains specific case information of a patient
5. Language: English or French
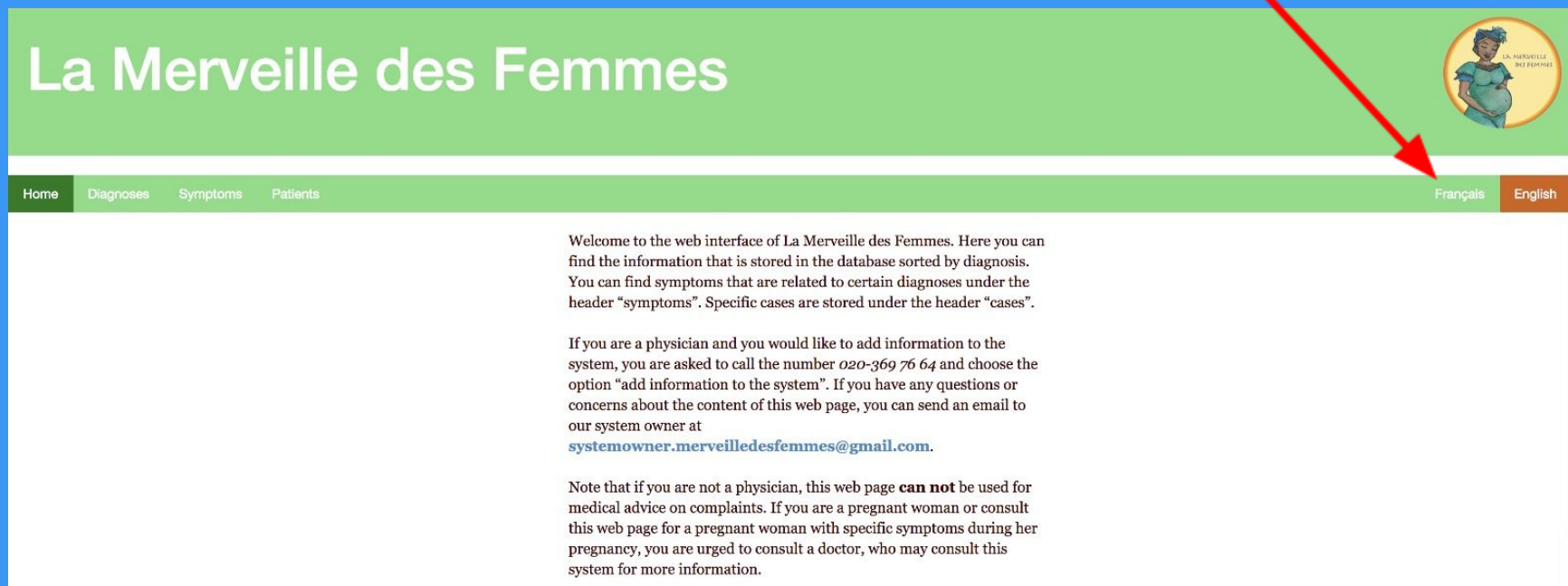
2 Diagnoses

This page provides general information about the different diseases. On the left side of the page, a description of the disease is given. The right side provides how to diagnose the disease and often seen symptoms.

La Merveille des Femmes

Home | Diagnoses | Symptoms | Patients   Français | English

Pre-eclampsia

Preeclampsia is a pregnancy complication that is characterized by the onset of high blood pressure and often a significant amount of protein in the urine. It most commonly develops during the last trimester, but it can happen in the second half of pregnancy, during labor, or even up to six weeks after delivery as well. The only cure is delivery (with an increased risk of seizures, placental abruption, stroke and possibly severe bleeding until the blood pressure decreases), sometimes with induced labor or cesarean section. When a patient is diagnosed with preeclampsia, she needs to be closely monitored until it's possible to deliver the baby.

Diagnosis

• High blood pressure/hypertension: systolic reading of 140 or greater or a diastolic reading of 90 or higher.
• Protein in urine/proteinuria: a result of 300 milligrams (mg) of protein in a 24-hour urine sample is a sign of preeclampsia.

Symptoms

• High Blood Pressure (Hypertension)
• Proteinuria
• Swelling (Edema) in face, hands or excessive in feet/ankles
• Headache
• Nausea or Vomiting
• Abdominal (stomach area) and/or Shoulder Pain
• Lower back pain
• Sudden Weight Gain (more than 4 pounds in a week)
• Changes in Vision (double vision, blurriness, light sensitivity, temporary vision loss)
• Hyperreflexia
• Shortness of breath, anxiety

VU VRIJE UNIVERSITEIT AMSTERDAM

3 Symptoms

This page provides an overview of all symptoms that are added to the database. By clicking on the <Go to case> link you will be redirected to the patient page with this specific symptoms (see chapter 4 Patients).

4 Patients

This page provides case specific information about a patient. You can always go back to the symptoms page by clicking on the link <go back>.