An expert system to provide sexual and reproductive health educational contents for young deaf women

C. Oyola-Flores, Y. Robles-Bykbaev, V. Robles-Bykbaev,
P. Ingavélez-Guerra, and J. Galán-Montesdeoca
GI-IATa, Cátedra UNESCO Tecnologías de apoyo para la Inclusión Educativa,
Universidad Politécnica Salesiana, Cuenca, Ecuador
Email: coyola@est.ups.edu.ec, {zrobles,vrobles,pcingavelez,jgalan}@ups.edu.ec

***Abstract*—Currently, the community of deaf women must face lack of several resources related to their personal and professional development: (i) the lack of bilingualism (sign language and written language), (ii) the lack of an appropriate knowledge about local sign language, and (iii) the scarcity of educational plans about of Sexual and Reproductive Health (SRH). This situation triggers several problems such as transmission of sexually transmitted diseases, unwanted pregnancy in adolescence, sexual violence, and complications during pregnancy. For these reasons, in this paper, we present an ecosystem and an educational methodology aimed on improving the access to SRH programs as well complementing the engineering academic curriculum. Our proposal was put to test with 3 (deaf) human experts of the Federation of the Deaf of Azuay. The results are encouraging and have shown that it is necessary to implement educational programs in universities and colleges.**

***Keywords*—Deaf women; Engineering; Sexual and reproductive health; Higher education.**

I. Introduction

The current corollary "a higher level of educational instruction represents a greater knowledge of issues such as Sexual and Reproductive Health" (SRH) is not fully applicable to people with disabilities. This situation responds to several factors, being one of the most relevant the next: the educational system as such presents a lack of methodologies and didacticism appropriate to provide the educational contents from the perspective of the inclusion. Namely, the educational establishments are more concerned about developing contents instead of worrying about if those contents really are being properly assimilated by those students who present some type of disability.

We do not deny that some curricula include topics related with SRH, however, these contents and their assimilation process have not yet reached a level to viewing education as an integrative process, and even less, to consider that education is really inclusive. The integration involves not leaving out of from school and community life any person or group that it is being excluded. However, inclusion is to build with them their learning for which the educational proposal must respond to the needs of each and every one [1].

Today, deafness continues to occupy second place at the quantitative level among sensory deficits. It usually occurs with high incidence in early childhood, going unnoticed in cases of mild and moderate deafness, which causes cognitive-linguistic and severe delays in many cases. From a cultural point of view, deaf people are considered a minority group who have their own culture, this factor is a determining factor in social and educational development, giving rise to a situation of social exclusion.

Because of this, many deaf people who have finished primary school suffer from functional illiteracy or have serious difficulties in understanding texts and in expressing themselves correctly. One way to overcome the deficiencies included in the communication that implies the auditory deficiency, is to use alternative languages, same alternatives that allow a deaf person to communicate within a population of listeners. In this line, the prevalence of Sign Language constitutes a communication architecture with a great work of Linguistic, social and cultural implementation [2].

Indistinctly of whether the degree of hearing loss does or does not determine the mode of communication, many people with deep prelinguistic deafness use Sign Language as their "Mother Language". It should be noted that this language is accepted not only by deaf people, but also by those whose it under a family, affective or work aspect [3].

In view of the foregoing, in this paper, we present an expert system that is integrated into a web platform that provides educational contents of SRH for deaf women. Some of the most important features of our proposal are described below:

- The web environment provides educational videos in Sign Language for all SRH contents.
- The expert system suggests several educational contents to the users of the platform, according to their knowledge of three major categories and 31 sub-topics.
- The platform contains several services where users can interact with their peers, and learn new concepts through interactive activities and exercises.
- The system automatically monitors the users' progress with the aim of providing new contents and learning plans.
- The users can access the platform as well as the expert system from different kinds of electronic devices (computers, smartphones, and tablets).
- The system relies on a social network platform approach where the users can decide which contents share and with

978-1-5386-8131-2/18/$31.00

who.
- The multimedia material was developed using the Ecuadorian Sign Language. However, it is possible incorporating other variants such as those used in Columbia, Spain, etc.

This paper is organized as follows. In Section 2 we present some cooperative proposals focused on the support of accessible and educational material in the context of health in sign language. Section 3 describes the general structure of the system as well as the expert system. The study conducted with three (deaf) experts and carried out in Cuenca city is presented in Section 4. Finally, Section 5 presents some insights for the debate and future work.

II. Related work

With the aim of supporting the educational process in the SRH topic, several authors developed different kinds of tools based on the Information and Communication Technologies (ICT). In the same line, it is important to mention that these proposals have the objective too of providing information to users according to their needs, without neglecting the nature, scope, and readability of the contents.

In the same line, it is important to mention that these proposals have the objective too of providing information to users according to their needs, without neglecting the nature, scope, and readability of the contents. In 2012 [4] examined 5,000 college students with the objective of determining their sexual behaviors and interest in a mobile app for sexual health. The results of this study are interesting: the majority of students were female (73%) and owned a smartphone (74%), twenty-nine per cent currently used health-related applications on their phone and 67% reported interest in using a free application that could improve/manage their sexual health.

In this ambit, [5] developed a sexuality education website that incorporates a health-chat through the short-message service. This tool represents an anonymous communication channel between the users, community and the experts on SRH. Likewise, this proposal includes guides, interactive activities, and forums where the users can obtain information related to anti-conceptive methods, sexually transmitted infections, Human immunodeficiency virus infection and acquired immune deficiency syndrome (HIV/AIDS), and gender violence. The authors carried out an experiment to validate the proposal with 39 volunteers with ages between 14 and 28 years. The results show that young persons require access to this information (considered tabu in some places). Similarly, in [6]–[9] the authors followed the same approach with the objective of increasing knowledge about prevention, treatment, care and support on SRH issues with confidential and accurate information.

In addition to these proposals, currently exists systems based on artificial intelligence that can support the decision making support for real situations provided by users (in a similar way a person attends to a medical consultation).Some of these expert systems are focused on the diagnosis of problems related to the reproductive health and can help to determine if a woman is not fertile. After the diagnosis, the system can provide different treatment options (considering the symptoms presented by the user) [10], [11].

On the other hand, [12] proposes a mobile application to provide diagnostic services for patients that present symptoms related to syphilis. To this aim, the authors used an approach based on uncertainty and fuzzy logic. The results of this research confirm that is possible using this kind of tools in two scenarios: a) for patients without access to medical attention and b) for students that want to learn about syphilis diagnosis.

The Andalusian Federation of Associations of Deaf People (FAAS), Spain, in collaboration with the Spanish Society of Family and Community Medicine (semFYC), provides a web platform (*www.semfyc.es*) with materials and audiovisual resources adapted to the Spanish Sign Language (LSE). Within the resources are recommendations on pregnancy, baby care, hypertension, vaccines, health advice. The audiovisual contents constitute the Practical Guide to Health, which aims to complement the information provided in medical consultations in an accessible way to deaf people in Spain, including in this guide precise indications to act, as well as guidance on when to consult and ask for help in matters derived from a disease [13].

III. Expert system description

With the aim of providing personalized educational contents, the platform contains a test that is used to determine how much know the deaf women about SRH. The test focuses on the three major categories described in Table I: Sexually Transmitted Diseases, Contraceptive methods, and Prenatal control. With the support of the expert system the platform automatically generates a "study plan," which consists of the sub-topics that must be learned by women.

TABLE I
Educational contents on SRH provided by our platform

Category	Description	Sub-topics
Sexually Transmitted Diseases (STD)	Details the most common diseases such as syphilis, gonorrhea, AIDS, among others, also describing the ways of contagion and how to prevent such diseases	10
Contraceptive methods	Contains information related to the types of contraceptive methods, the correct way to use them, and their benefits to prevent STD	10
Prenatal control	Covers the importance of performing prenatal check-ups and the frequency with which they should be performed	11

Moreover, Figure 1 presents a screen capture of the web platform menu (the welcome section). As we can see, our proposal uses the social network platform approach where users can share ideas, thoughts, concerns, and find support. Similarly, the platform respects the privacy of the users; only the account owner cand decide which information can be shared.

Fig. 1. A screen capture of the welcome page of the web platform.

In order to suggest which educational contents on SRH are appropriate for each woman's profile, we have defined a rule-based reasoning expert system that relies on the structure depicted in Figure 2.

As it can be seen, the main data structures used by the expert system are described below:

- *Educational categories*: to represent the different categories (family planning, prenatal care, sexually transmitted diseases, etc.) provided by our platform, we define a set of indices. This set is defined as follows (where L is the total number of categories): $\vec{EC} = \{1, 2, 3, \ldots, L\}$. In the same way, we have defined a set of indices for the contents of each category (where K is the total number of contents): $\vec{CI} = \{1, 2, 3, \ldots, K\}$ (sub-topics).
- *Initial evaluation tests:* in order to determine the general women's knowledge about SRH, our platform conducts an initial evaluation using a test that has several questions related to each educational category. The test is represented by the following structure: $\vec{T} = \{q_1, q_2, q_3, \ldots, q_M\}$.
- *Knowledge thresholds:* is a set of values that determine the minimum knowledge that must have a women in each category. This values are defined by experts (doctors and teachers) as follows: $\vec{\Theta} = \{\theta_1, \theta_2, \theta_3, \ldots, \theta_L\}$.

Using the information structures depicted above, the expert system performs the operation described in Equations 1 and 2.

$$\vec{C} = \vec{EC} \times \vec{LT}$$
$$LT_i = \{\phi(EC_i, \theta_i), \forall i = 1, 2, \ldots, L\} \quad (1)$$

With this first equation, the expert system can suggest which educational contents ($\vec{C}$) will be assigned to a specific deaf woman (user), according to her knowledge about SRH.

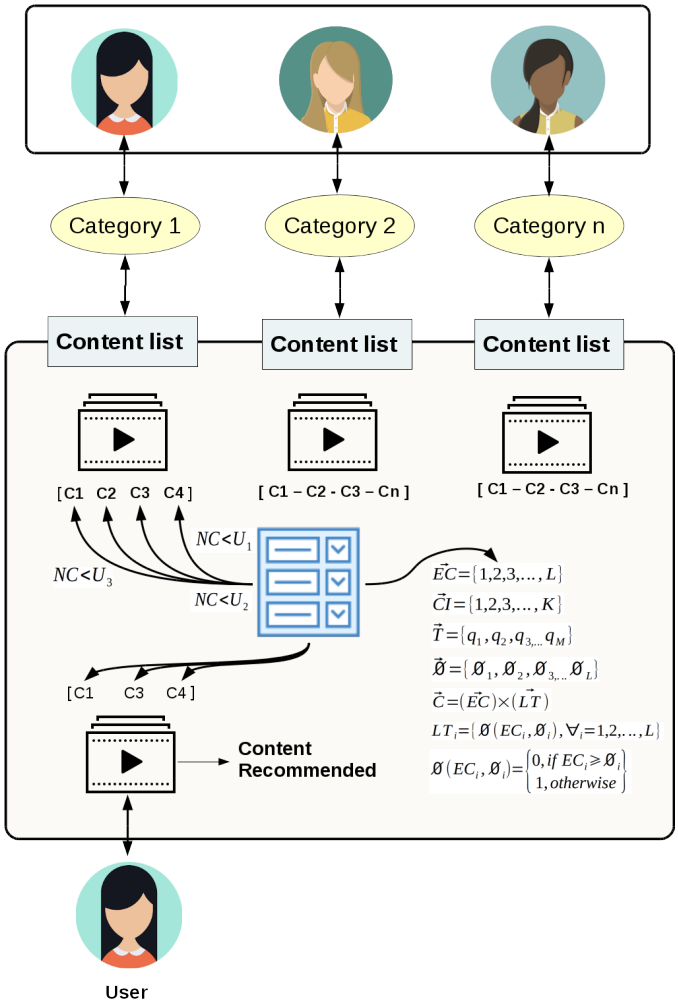
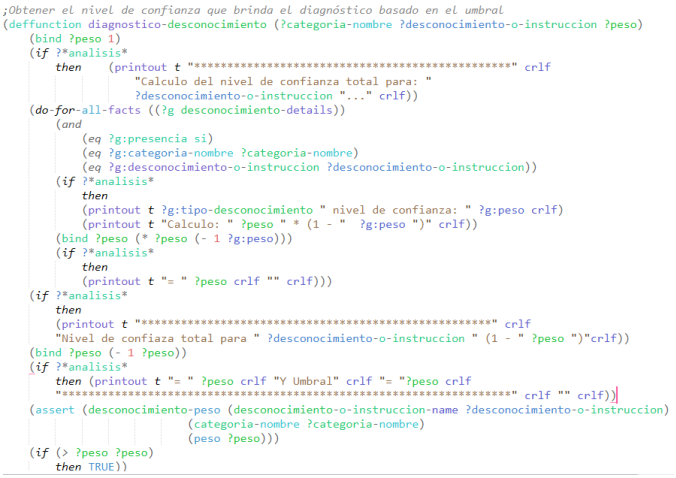


Fig. 2. The schematic diagram of the internal structure and equations used to build the expert system.

$$\phi(EC_i, \theta_i) = \begin{cases} 0, if & EC_i \geq \theta_i \\ 1, & otherwise \end{cases} \quad (2)$$

On the other hand, it is essential to note that the system uses the Equation 2 to determine if a woman has the minimum knowledge required on a specific SHR topic. This knowledge is determined using the threshold θ_i defined by a team of doctors and deaf women that have substantial experience in SHR.

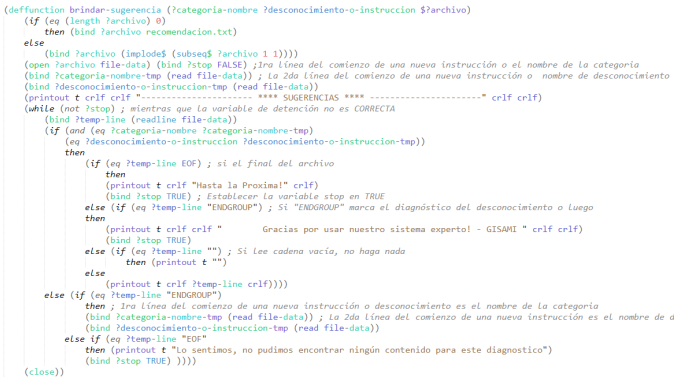
Currently, our expert system contains 58 rules programmed on the based on the equations above mentioned. Figure 3 depicts an example of one rule used to determine the knowledge thresholds of the platform's users. These thresholds represent the name with which describes the suggestion provided by the system to learn a specific SRH topic (category) that currently is unknown by a woman. For example, with this rule, it is possible determining the knowledge level of deaf women in the sub-topics of each category.



```
;Obtener el nivel de confianza que brinda el diagnóstico basado en el umbral
(deffunction diagnostico-desconocimiento (?categoria-nombre ?desconocimiento-o-instruccion ?peso)
    (bind ?peso 1)
    (if ?*analisis*
        then    (printout t "*********************************************" crlf
                    "Calculo del nivel de confianza total para: "
                    ?desconocimiento-o-instruccion "..." crlf))
    (do-for-all-facts ((?g desconocimiento-details))
        (and
            (eq ?g:presencia si)
            (eq ?g:categoria-nombre ?categoria-nombre)
            (eq ?g:desconocimiento-o-instruccion ?desconocimiento-o-instruccion))
        (if ?*analisis*
            then
            (printout t ?g:tipo-desconocimiento " nivel de confianza: " ?g:peso crlf)
            (printout t "Calculo: " ?peso " * (1 - "  ?g:peso ")" crlf))
        (bind ?peso (* ?peso (- 1 ?g:peso)))
        (if ?*analisis*
            then
            (printout t "= " ?peso crlf "" crlf)))
    (if ?*analisis*
        then
        (printout t "*********************************************" crlf
        "Nivel de confiaza total para " ?desconocimiento-o-instruccion " (1 - " ?peso ")"crlf))
    (bind ?peso (- 1 ?peso))
    (if ?*analisis*
        then (printout t "= " ?peso crlf "Y Umbral" crlf "= "?peso crlf
        "*************************************************************" crlf "" crlf))
    (assert (desconocimiento-peso (desconocimiento-o-instruccion-name ?desconocimiento-o-instruccion)
                                  (categoria-nombre ?categoria-nombre)
                                  (peso ?peso)))
    (if (> ?peso ?peso)
        then TRUE))
```

Fig. 3. An example of a rule used to determine the knowledge level that has a deaf woman in a specific sub-topic.

On the other hand, the rules defined in Figure 4 have the aim of determining the recommendations for the calculated threshold. In this line, the system identifies two blocks: the category and its contents. For example, if the threshold obtained by a user in the "pregnancy sub-topic" is lower than the minimum threshold allowed, the expert system will include this sub-topic in the "learning plan".



```
(deffunction brindar-sugerencia (?categoria-nombre ?desconocimiento-o-instruccion $?archivo)
    (if (eq (length ?archivo) 0)
        then (bind ?archivo recomendacion.txt)
    else
        (bind ?archivo (implode$ (subseq$ ?archivo 1 1))))
    (open ?archivo file-data) (bind ?stop FALSE) ;Ira línea del comienzo de una nueva instrucción o el nombre de la categoria
    (bind ?categoria-nombre-tmp (read file-data)) ; La 2da línea del comienzo de una nueva instrucción o  nombre de desconocimiento
    (bind ?desconocimiento-o-instruccion-tmp (read file-data))
    (printout t crlf crlf "---------------------- **** SUGERENCIAS **** ----------------------" crlf crlf)
    (while (not ?stop) ; mientras que la variable de detención no es CORRECTA
        (bind ?temp-line (readline file-data))
        (if (and (eq ?categoria-nombre ?categoria-nombre-tmp)
                 (eq ?desconocimiento-o-instruccion ?desconocimiento-o-instruccion-tmp))
            then
                (if (eq ?temp-line EOF) ; si el final del archivo
                    then
                    (printout t crlf "Hasta la Proxima!" crlf)
                    (bind ?stop TRUE) ; Establecer la variable stop en TRUE
                else (if (eq ?temp-line "ENDGROUP") ; Si "ENDGROUP" marca el diagnóstico del desconocimiento o luego
                then
                    (printout t crlf crlf "       Gracias por usar nuestro sistema experto! - GISAMI " crlf crlf)
                    (bind ?stop TRUE)
                else (if (eq ?temp-line "") ; Si Lee cadena vacía, no haga nada
                      then (printout t "")
                else
                    (printout t crlf ?temp-line crlf))))
        else (if (eq ?temp-line "ENDGROUP")
                then ; Ira línea del comienzo de una nueva instrucción o desconocimiento es el nombre de la categoria
                (bind ?categoria-nombre-tmp (read file-data)) ; La 2da línea del comienzo de una nueva instrucción es el nombre de a
                (bind ?desconocimiento-o-instruccion-tmp (read file-data))
            else (if (eq ?temp-line "EOF"
                then (printout t "Lo sentimos, no pudimos encontrar ningún contenido para este diagnostico")
                (bind ?stop TRUE) ))))
    (close))
```

Fig. 4. An example of a rule used to suggest which sub-topic of a specific category must be learning by a deaf woman.

IV. Experiments and Results

With the aim of determining the appropriate parameters to evaluate the proposed expert system, we worked with 3 (deaf) human experts of the Federation of the Deaf of Azuay. It is important to mention that the three experts are representatives of the Federation with wide experience in educational topics and SRH rights defense. Below we provide a detailed description of each parameter:

- **Ability and motivation (attractiveness, interest):** determines if the platform incorporates characteristics of interest and that allow to develop motivation to learn content about SRH.
- **Suitability for the user, contents and activities:** allows to determine if the platform provides content that is understandable, adapts to the user needs and that encourages the development of learning activities.
- **Applicative/creative approach:** it analyzes if the platform is applicative to promote knowledge about SRH in the Ecuadorian Sign Language and determines if the proposal as well as the content development methodology are creative.
- **Tutoring, evaluation questions and reinforcement:** feature that allows to determine if the platform adapts resources or interactive evaluations that help the content development.
- **Teaching resources, activities:** parameter that allows to evaluate if the platform activities support the development of knowledge about SRH.
- **Promotion of the self-learning initiative:** parameter that determines if a self-education environment is generated in SRH subjects through virtual platforms in comparison to bibliographic or digital resources which are not adapted to the Ecuadorian Sign Language.
- **Team work:** determines if the environment allows a cooperative work environment and content broadcasting within a group of virtual agents.

Table II shows the results obtained during the evaluation of the platform (including the expert system). As we can see, it is necessary for improving some aspects such as the creative approach, teaching resources, and the self-learning support. However, the category related to the expert system (tutoring) has reached the maximum score over a 1-10 scale.

TABLE II
Scores reached by the complete platform according to the three human experts.

Parameter	Assessment			Average
	Expert I	Expert II	Expert III	
Creative Approach	6	8	7	7
Tutoring	10	10	10	10
Teaching Resource	5	5	5	5
Self-Learning	5	5	5	5
Team Work	9	8	10	9
Attractiveness	10	10	10	10
Suitability	10	10	10	10

Finally, Figure 5 presents graphically the overall scores reached by the platform. As it can be seen, it is necessary to improve only three parameters.

V. Conclusion

The lack of educational plans for students with hearing disabilities within institutions makes the importance of Sexual and Reproductive Health (SRH) invisible, negatively influencing the development of sexually transmitted infections (STIs) including HIV, increasing the number of pregnancies in adolescents, in certain cases with complications during the gestation stage of deaf women.

For these reasons, in this paper, we presented a proposal for an educational platform on SRH for deaf women. WIth

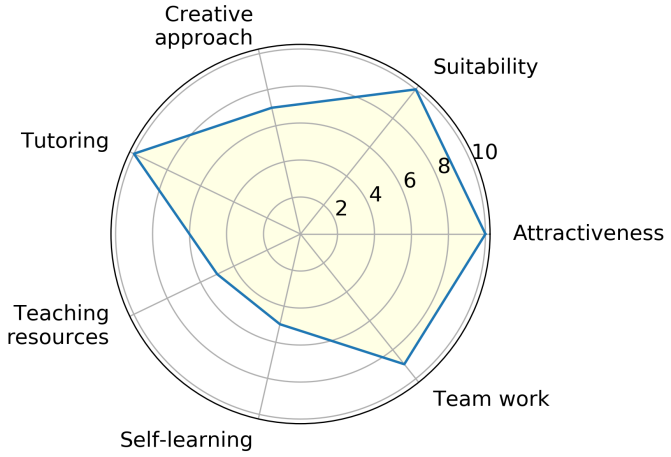


Fig. 5. Overall scores reached by the platform according to criteria of the three human experts.

the aim of suggesting "learning plans," the platform uses two essential elements: the women's profile and knowledge level that they have on SRH.

The platform provides a social network based environment for the women. This functionality allows users are sharing ideas, thoughts and feeling with their peers.

In this line, it is important mentioning the lack of educational plans for students with hearing disabilities within institutions makes the importance of Sexual and Reproductive Health (SRH) invisible, negatively influencing the development of sexually transmitted infections (STIs) including HIV, increasing the number of pregnancies in adolescents, in certain cases with complications during the gestation stage of deaf women.

As lines of future work we propose the following ones:

- To develop a module to generate study groups according to users preferences and needs automatically.
- To design and develop serious games for the youngest platform users.

ACKNOWLEDGMENT

This work has been funded by the "Sistemas Inteligentes de Soporte a la Educación (v5)" research project, the Cátedra UNESCO "Tecnologías de apoyo para la Inclusión Educativa" initiative, and the Research Group on Artificial Intelligence and Assistive Technologies (GI-IATa) of the Universidad Politécnica Salesiana, Campus Cuenca.

REFERENCES

[1] P. A. Sánchez, "Las escuelas son para todos," *Siglo cero*, vol. 27, no. 2, pp. 25–34, 1996.

[2] O. Pérez de la Fuente, "Las personas sordas como minoría cultural y lingüística," 2016.

[3] M. I. Rey, "El cuerpo en la construcción de la identidad de los sordos," *Papeles de trabajo-Centro de Estudios Interdisciplinarios en Etnolingüística y Antropología Socio-Cultural*, no. 16, pp. 0–0, 2008.

[4] A. R. Richman, M. C. Webb, J. Brinkley, and R. J. Martin, "Sexual behaviour and interest in using a sexual health mobile app to help improve and manage college students' sexual health," *Sex Education*, vol. 14, no. 3, pp. 310–322, 2014.

[5] L. Spigel and R. Amador, "Minipilotaje de Proyecto Chat Salud en la comunidad de Los Robles, Jinotega en Febrero 2014," 2014.

[6] K. Chau, A. Traoré Seck, V. Chandra-Mouli, and J. Svanemyr, "Scaling up sexuality education in senegal: integrating family life education into the national curriculum," *Sex Education*, vol. 16, no. 5, pp. 503–519, 2016.

[7] N. B. Ippoliti and K. LEngle, "Meet us on the phone: mobile phone programs for adolescent sexual and reproductive health in low-to-middle income countries," *Reproductive health*, vol. 14, no. 1, p. 11, 2017.

[8] E. R. Mangone, S. Agarwal, K. LEngle, C. Lasway, T. Zan, H. Van Beijma, J. Orkis, and R. Karam, "Sustainable cost models for mhealth at scale: modeling program data from m4rh tanzania," *PloS one*, vol. 11, no. 1, p. e0148011, 2016.

[9] E. Eckersberger, E. Pearson, K. Andersen, A. Hossain, K. Footman, K. K. Biswas, S. Nuremowla, and K. Reiss, "Developing mhealth messages to promote postmenstrual regulation contraceptive use in bangladesh: Participatory interview study," *JMIR mHealth and uHealth*, vol. 5, no. 12, 2017.

[10] N. Sukar and N. L. M. Shuib, "An expert system framework for infertility in women using web-based application," *International Journal of Information Systems and Engineering (online)*, vol. 2, no. 1, 2014.

[11] S. S. A. Naser and M. I. Alhabbash, "Male infertility expert system diagnoses and treatment," *American Journal of Innovative Research and Applied Sciences*, vol. 2, no. 4, 2016.

[12] A. T. Owoseni, I. O. Ogundahunsi, and S. Ayeni, "A mobile-based fuzzy system for diagnosing syphilis (sexually transmitted disease)," 2015.

[13] S. E. de Medicina Familiar y Comunitaria *et al.*, "Itinerario 1. Potenciando la capacidad de resolución del médico de familia [XXXIII Congreso semFYC]," *Atención Primaria*, vol. 45, no. Esp. Congreso_2, pp. 2–15, 2013.