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"DESIGN, DEVELOPMENT AND VALIDATION OF "E-MIDWIFE" MOBILE APPLICATION FOR NURSE-MIDWIVES IN THE MANAGEMENT OF OBSTETRIC COMPLICATIONS"

*Running Title: "E-MIDWIFE" mobile application for nurse-midwives

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Abstract

Background: Obstetric difficulties are health issues that arise throughout delivery. Nurse-midwives should have sufficient expertise and abilities to enhance the prompt identification and handling of these problems. **Objectives:** The primary objective of this research was to design and validate "E-Midwife" mobile

application for nurse-midwives on obstetric complications. **Methods:** This investigation was part of a randomized controlled study. A convenience sampling strategy was applied. The smartphone application "E-Midwife" was created in three stages. The mobile application was reviewed by 11 specialists in obstetrics and midwifery using the Content validity index. The second evaluation looked at how well the participants agreed on the app content. Finally, nurse midwives and nursing faculty (n=40) evaluated the app's efficacy, efficiency, satisfaction, learning ability, memorability, and cognitive load. **Results:** In the initial judgment, the content validity index varied between 0.89 and 1.0. Out of the twelve criteria reviewed, four were agreed upon by the experts. At the same time, four sections received 92% agreement with minor alterations such as content clarity, expansion, ease of use, and terminology. The other four aspects, namely the amount of content, reactivity, the appropriateness of contents, and graphic representation, required minor modifications. In second assessment, the mobile application's contents are rated as excellent, with a content validity value of 1.0. The app's overall satisfaction rating among 40 nurse midwives ranged from 32.5 (Satisfied) to 67.5% (Extremely satisfied). **Conclusion:** The "E-Midwife" smartphone app has been shown to be simple to use in clinical practice for early diagnosis and management of obstetric problems; nevertheless, conversations with other healthcare experts to make timely decisions based on their advice are encouraged.

Keywords: Android application, Android phones, E-Midwife, Information technology, nurse-midwives, nursing informatics

Introduction

Childbirth process encounters the most serious problems to the health of woman and her newborn if not managed properly. Approximately one in every 16 babies dies during childbirth. Worldwide, nearly 2,95,000 mothers die during her childbirth which is very high in underdeveloped and developing countries [1]. The main grounds for all this loss are being deficient in the quality of expertise care during childbirth [2][3]. Investments in skilled obstetric care can prevent an estimation of 1,13,000 maternal fatality, 5,31,000 intrauterine deaths and 1.325 million newborn baby deaths every year approximately [4]. Nurse-midwives were unable to provide skilled midwifery care due to restricted admittance to enduring learning and also deficient in receiving support from trained personnel [5]. The skill based educational trainings for nurse-midwives were considered ineffective when they are accomplished away from health care setting and are of short period [6]. The need for ready to use tool arises due to these reasons which helps them to refer continuously at their health care setting itself. The commonly accepted strategy to improve health care practices is the use of information technology in educating nurse-midwives [7]. Digital knowledge tools have propagated among health care personnel in India. But the proof of its effectiveness is negligible [8].

Educational interventions using technological advances have undergone severe transformations. It is indisputable that the introduction of information technology through sophisticated devices such as computers, laptops, notebooks, mobile phones, smart phones using internet has more benefits than traditional method of teaching [9]. Android is the most extensively used mobile operating System by the community currently [10]. Hence, we designed the mobile application for Android OS. Technological advancements favor

the improvement of obstetric care which accentuates its use in the care of mother and the fetus [9]. *M*obile applications in the health field is innovative and also easy method of delivering a concept [11]. A study reveals that a mobile device that hosts many mobile applications is used and referred by health care providers to 85% than books and magazines which is about 45% [12]. Hence, the importance of developing a mobile application for nurse-midwives for helping them to diagnose and immediately manage obstetric complications. The app can be easily accessed from any part of the country whether rural or urban areas [9]. However, choosing suitable mobile application found to be a big challenge for nurse-midwives[13]. List of Mobile apps that are available in market specifically for obstetric complications are normal labour and complication, doula labour coach, labour and delivery and abnormal labour[14–17]. All these apps have all the contents in static manner in which a user should download the app and read it when necessary. By addressing all the lacunae's in the above applications, "E-Midwife" mobile app was developed with dynamic features in it and also the user can directly visualize the videos of managing each complications with explanation.

"E-Midwife" mobile application is digital health learning tool which was designed and developed by researchers in India centering on South Asian perspective. "E-Midwife" mobile application was intended to emphasize the expert abilities of nurse-midwives in managing obstetric complications using E-learning platform using instructional videos, management strategies, drugs, images and tools to guide nurse-midwives. The main purpose of this mobile application is to access appropriate information about obstetric complications from their personal place at a convenient time. The android users can freely download the app Google Play Store. The objective of this research was to design, develop and validate "E-Midwife" mobile application on obstetric complications for nurse-midwives.

Materials and Methods

This study described the method of renovation of old printed learning material into digitized stuff through thorough exploration in design, research and practice. This inquiry was a part of a randomized controlled trial which involved the use of mobile application as a component of the intervention. This study sticks on to the CONSORT principles and its checklist. The research was accomplished in Puducherry, India. Written consent was obtained from all participants. Contextualized instructional design is used to develop "E-Midwife" app. The steps involved in this are proposal planning, development and application of specific didactic situations. **(Figure 1)**

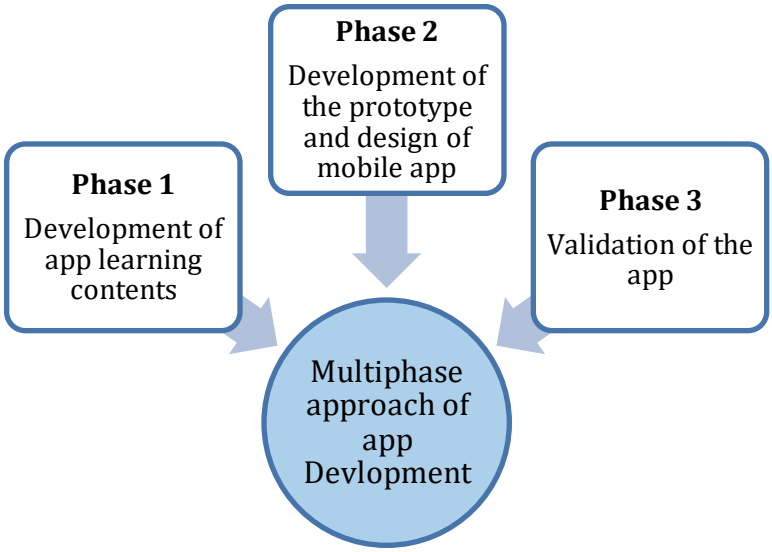

Figure 1: Multiphase Approach of the "E-Midwife" mobile application development

Multiphase approach was adopted in this app development. It involves 3 phases. The first phase encompassed the development of mobile application contents and the need for its development. The mobile application was evaluated by 11 experts in the field of obstetrics and midwifery using the Delphi method and Content validity index. Second phase corresponded to the development of the prototype and design of the mobile application which was defined based on the integrative literature review of various mobile apps available in midwifery and obstetric complications. This phase explained the construction of the application, where elaborate flowchart, structured database and software were developed. Final phase involved the steps of application efficiency tests.

Phase 1 – Development of mobile app learning contents

An integrative literature review was carried out before developing the app contents. Identification of the theme, selection of research question, defining inclusion and exclusion criteria of the research, assessment of studies and synthesis of knowledge was carried out. The mobile application for diagnosis and immediate management of obstetric complications was defined as the theme with the guiding question: what are the ways to diagnose and manage obstetric complications?

The contents was developed based on integrated management of pregnancy, labour and childbirth module [18]. Instructional content consisted of the core signs and symptoms, diagnosis and management of the obstetric complications. This app was developed to educate the nurse-midwives. The researcher reviewed maternal health nursing and midwifery textbooks and several journals to input updated information about obstetric complications[19][20][18][21][22] [23][24][25][26]. After thorough substantiation of the hospital and ward standard operating procedures, the diagnosis and management of obstetric complications part were distributed across the static and dynamic contents of the app.

The contents were reviewed by two administrators of nursing and midwifery field and four nursing faculties specialized in midwifery. It was verified by three nurse-midwives and two obstetricians working in Labour room. It can be in accord that for validation and review process, the least acceptable expert number is two,

though most of the suggestions recommend minimum of six experts [27]. Considering the recommendations, 11 experts reviewed the mobile application contents. The contents of the app was validated by two assessments using Delphi Technique [28][29]. Participants were invited with a letter consisting of personal introduction by the researcher, research topic clarification and the importance of contribution of the health care provider in this research. Invitation was given using email or in person along with the mobile application evaluation questionnaire along with the informed consent form. In the first assessment, the experts suggested few corrections in the clarity of the contents, expansion, improvement in vocabulary and adapting user-friendly design. Among 12 criterions suggested for content development, 8 were accepted with minor changes and 4 needed moderate corrections in it. In the second assessment, all these corrections were incorporated to make the app user-friendly.

Phase 2 - Development of the prototype & Design of Mobile app

The development of the app included the application tool selection, navigation structure definition and configuration planning. A tailored mobile application was build for the android platform. App development involved generating the contents of the app, incorporating management criteria's which are evidence based, and need-accommodating communication techniques into design aspects and confer with software developers to build up the app. Based on this, the involved content pathways were identified and sketched. Then with the help of software designer and with tools such as ADOBE PHOTOSHOP and Android studio 3.0 interface with major functionalities were designed. Continuous follow up and interaction between the peer leaders and end users was maintained via regular meetings, virtual work spaces, file sharing platforms, emails and messages. During design process, digital prototypes were used. **(Table 1)**

Constant and Vibrant "E-Midwife" app features

Content of the App	Features of the app
Constant	Information on how to diagnose the obstetric complications and its immediate management
	Information on how to overcome anticipated barriers to normal childbirth
	Information on normal labour and its management
	Information on Partograph
Vibrant	Request to rate the feelings following app usage and its contents
	Short videos to sort out the doubts easily

The mobile app was compatible with android phones. This app contains text, graphic based images, videos and points that will be easy to ready by the nurse-midwives. We hired an app developer to develop the application model based on the approved content. Primary testing was done to identify preliminary malfunctions such as delayed opening of images, inoperable buttons and minimizing image screen. The errors which were sorted out during primary testing are frozen pages, frozen images, display error, spelling errors, and syntax error.

Designing of application involved planning and organization of didactic contents, definitions, writing of steps involved, selection of media and interface layout. Texts involved in topics and figures were interlinked using hypertexts. The application asks for username and password. The nurse-midwives should unlock the app using password provided by the researcher. Contents covered in mobile app were divided into 14 topics: normal labour, partograph, eclampsia, fetal distress, preterm labour, unsatisfactory progress in labour, prolonged labour, cord prolapse, shoulder dystocia, postpartum hemorrhage, retained placenta, perineal tear, emergency caesarean section preparation, and drugs used by midwives.

Phase 3 – Validation of mobile app

Secondary testing was done to identify malfunctions and to obtain their feedback with a group of participants (N=40). The participants were nurse-midwives and nursing faculties from two tertiary health care institutions and two nursing colleges in Puducherry and Chennai. The contents and its progress were discussed with 2 administrators of nursing field, 4 nursing faculties from obstetric nursing, 4 nurse-midwives, and 1 obstetrician. It consists of an intentional process of mapping, developing and relating definite informative circumstances. This was used after being validated by subject experts who was undergone by participants who handled the mobile application for assessing its usability, performance, utility, compatibility, information, aesthetics, and overall app quality of the mobile application. Opinions from arbitrators were obtained who are having specific knowledge in certain areas. Questionnaires were used to analyze and judge the contents of the app by the experts. We expect 50 to 100% agreement among the arbitrators. Brazilian Association of Technical Standards and International Organization for Standardization/ International Electro technical Commission (ISO/IEC) 25062:2011 norms were followed in the choice of number of arbitrators for validation of the instrument. It recommends a minimum of 8 samples for validation process [30]. Participants were selected using convenience sampling. The inclusion criteria was graduation in nursing, working in any health care or teaching institution and those who using android phones. Exclusion criteria were those not pursued the set up time limit for filling the questionnaire.

Questionnaire was sent to all cross-reviewers with the downloadable link of UI version of app. Questionnaire was divided into two parts: demographic data of the participants and twelve questions to assess for quality of mobile app contents. The answers were scored using 5-point Likert scale. Every item was rated on a scale of 1 to 5. Rating of 1 considered as least desirable (E.g. not at all likely, very difficult, not at all satisfied, not at all effective, cluttered, or strongly disagree) and rating of 5 being most desirable (E.g. Very likely, very easy, extremely satisfied, extremely effective, organized, very likely, and very satisfied). We also asked for subjective criticism from users for the questions like “Valuable comments to improve the app” and “suggest interested topics to add into app”. Responses marked with score of 4 or 5 were considered suitable whereas scores of 1 to 3 were reassessed. Suggestions given by the participants were scrutinized, modified and altered.

The expertise of the participants included midwifery, obstetrics, nursing administration, obstetric nursing and health informatics. The results received from above groups incorporate evaluations and activities for

designing and developing a functional prototype. Requirements for the design were identified from literature review and possible needed activities from secondary documents. Statistical analysis was performed based on the Content Validity Index, which was considered adequate for values equal to or greater than 0.80 (80% agreement among participants).

Overall, the reviewers observed that the mobile app was easy to use and professional. Implications were prepared to improve some information like using bullet points instead of paragraphs, increasing image size and also font size of few topics. Resolutions about modifications of the mobile app were considered by its practicability and charges estimated in implementing the modifications. For instance, one nurse-midwife suggested simplifying the contents of perineal tear. Another nurse-midwife suggested adding visual representation of plotting partograph. All feasible suggestions were implemented. Some suggested adding on more topics on obstetrics which included normal scenario in the app. This was not practicable due to time restrictions. Feasible suggestions were resolved next to with reported malfunctions, proceeding to the focal evaluation. The final app was uploaded in GOOGLE PLAY STORE. Construction of provisions for downloading the app on the internet and its installation on a mobile phone which would be freely available in the play store was made. Once all the above issues were addressed successfully, the final version of the mobile application was updated in GOOGLE PLAY STORE.

Ethical considerations

Institutional Research Committee approval (IRC202104 dated 01.07.2021) obtained from study setting (IGMC & RI, Puducherry) and Institutional Ethical Committee approval obtained (322/IEC/32/PP-2/2021dated 03.08.2021). Written consent to participate in this study was obtained from all the participants. Personal identity of the participants was not disclosed at any stage. Prior permission and consent was obtained from institution and participants to take images and videos needed for mobile app.

Results

The application was developed and its contents were validated by a panel of 11 experts. After modifications to the suggestions given by the arbitrators, the application was resent for reassessment. Then the necessary corrections were made and uploaded in Google Play Store.

The home screen of the app asks for username and password for registration purpose. For users who already registered, they need to enter their name to access the information. The following screen lists the various clinical features of the obstetric complications which link it to the actual diagnosis, then its definition and immediate management. The evaluators suggested changing the following patterns of the content: Pictorial representation of the complications and inclusion of videos for the necessary topics.

Table showed the application contents assessed in the first assessment cycle from 1 to 5 rating. In the first evaluation, the content validity index scores are 0.89 to 1.0. Four out of twelve areas of the criterion were completely agreed 100% by the experts. Other four areas had 92% agreement with few minor corrections like clarity of the contents, expansion, easy to use and vocabulary. Remaining four areas like volume of the

contents, reactivity, suitability of the contents and graphic representation needs moderate corrections. Based on the suggestions given by the arbitrators, the mobile app was revised and given for second assessment. Content validity index varied from 0.89 to 1.0 in the first assessment and in reassessment it was 1.0. E-Midwife mobile application was validated by experienced health professionals in the field of obstetrics and midwifery showing 100% concordance of the mobile contents between the participants in the subsequent assessment.

(Table 2)

Table 2: Assessment of mobile application contents using Likert Scale & Content Validity Index

Questions	Rating					Content Validity Index	
	1	2	3	4	5	First assessment	Second Assessment
Suitability of contents	0	0	0	4 (36)	7 (64)	0.89	1.0
Clarity of contents	0	0	0	3(27)	8(73)	0.92	1.0
Simplicity of contents	0	0	0	1(9)	10 (91)	1.0	1.0
Content updation	0	0	0	2(18)	9(82)	1.0	1.0
Volume of the contents	0	0	0	4 (36)	7 (64)	0.89	1.0
Reactivity of the contents	0	0	0	4 (36)	7 (64)	0.89	1.0
Expansion of the contents	0	0	0	3(27)	8(73)	0.92	1.0
Understandability	0	0	0	0	11(100)	1.0	1.0
Graphic representation	0	0	1(9)	1(9)	9(82)	0.89	1.0
Sequence of the contents	0	0	0	2(18)	9(82)	1.0	1.0
Easy usability of the contents	0	0	0	3(27)	8(73)	0.92	1.0
Vocabulary	0	0	0	3(27)	8(73)	0.92	1.0
Average						0.94	1.0

In the last phase, after developing UI version of app interface, "E-Midwife" was given to nurse-midwives and nursing faculties (n=40) for assessing the effectiveness, efficiency, satisfaction, learning ability, memorability and cognitive load. Overall rating of the app ranges from satisfied (32.5%) to extremely satisfied (67.5%). The participants describes that the mobile app was easy to use (62.5%) and professional (32.5%). The evaluators suggested adding following criteria in the application content like inclusion of more videos, newborn resuscitation procedures, and detailed description of magnesium sulphate injection administration separately and Rearrangement of obstetric complications list from labour to childbirth.

(Table 3)

Table 3: Subjective assessment and App quality assessment results of the app

Item	*Experts (N=40)*			
	Mean	*SD*	*Min Score*	*Max Score*

Subjective Quality				
Overall star rating	4.63	0.38	4.25	5.00
Recommending app to others	4.56	0.45	4.11	5.00
App Experience	4.31	0.45	3.86	4.75
Perceived Impact				
Increase knowledge	4.17	0.84	3.33	5.00
Increase awareness	4.00	1.00	3.00	5.00
Increase motivation	3.83	0.50	3.33	4.33
Improvement of app	4.00	1.00	3.00	5.00
App quality				
Keeping app in phone	4.13	0.88	3.25	5.00
Downloading app	3.88	0.88	3.00	4.75
Contents	4.63	0.38	4.25	5.00
Effectiveness	4.00	0.75	3.25	4.75
Organization	4.50	0.5	4.00	5.00
Usefulness	4.13	0.63	3.50	4.75

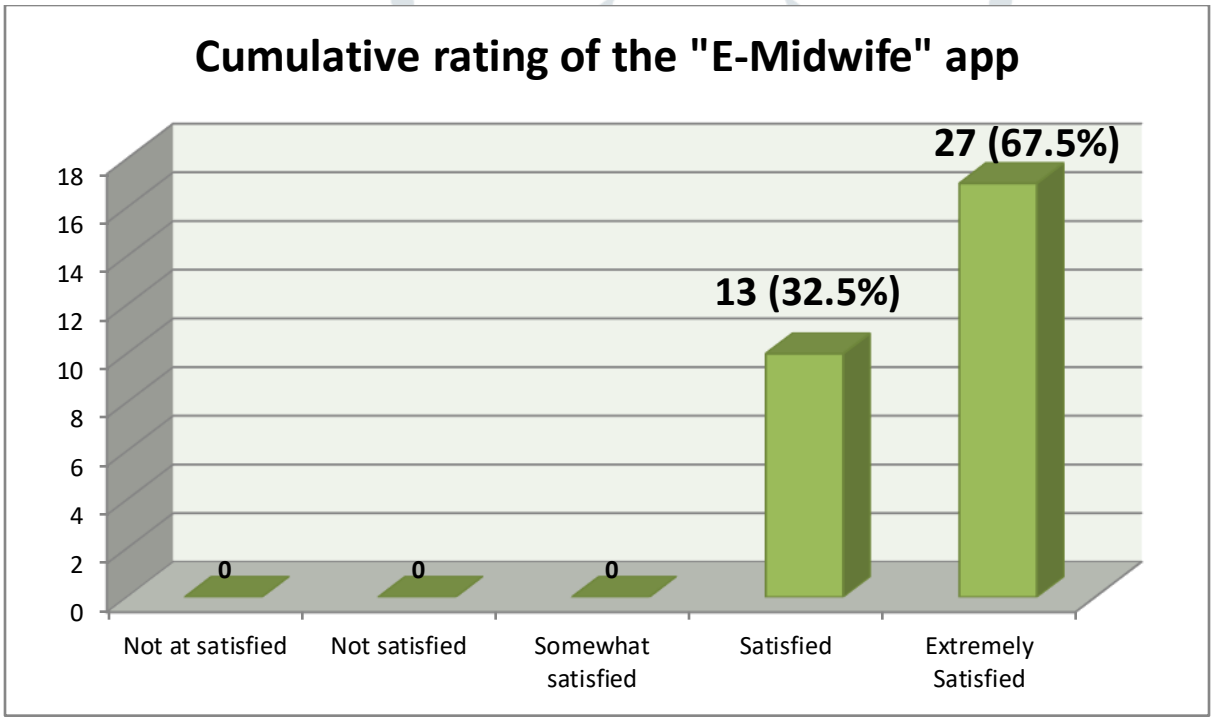

Figure 3: Cumulative rating of the "E-Midwife" mobile application

Figure 4 and 5)

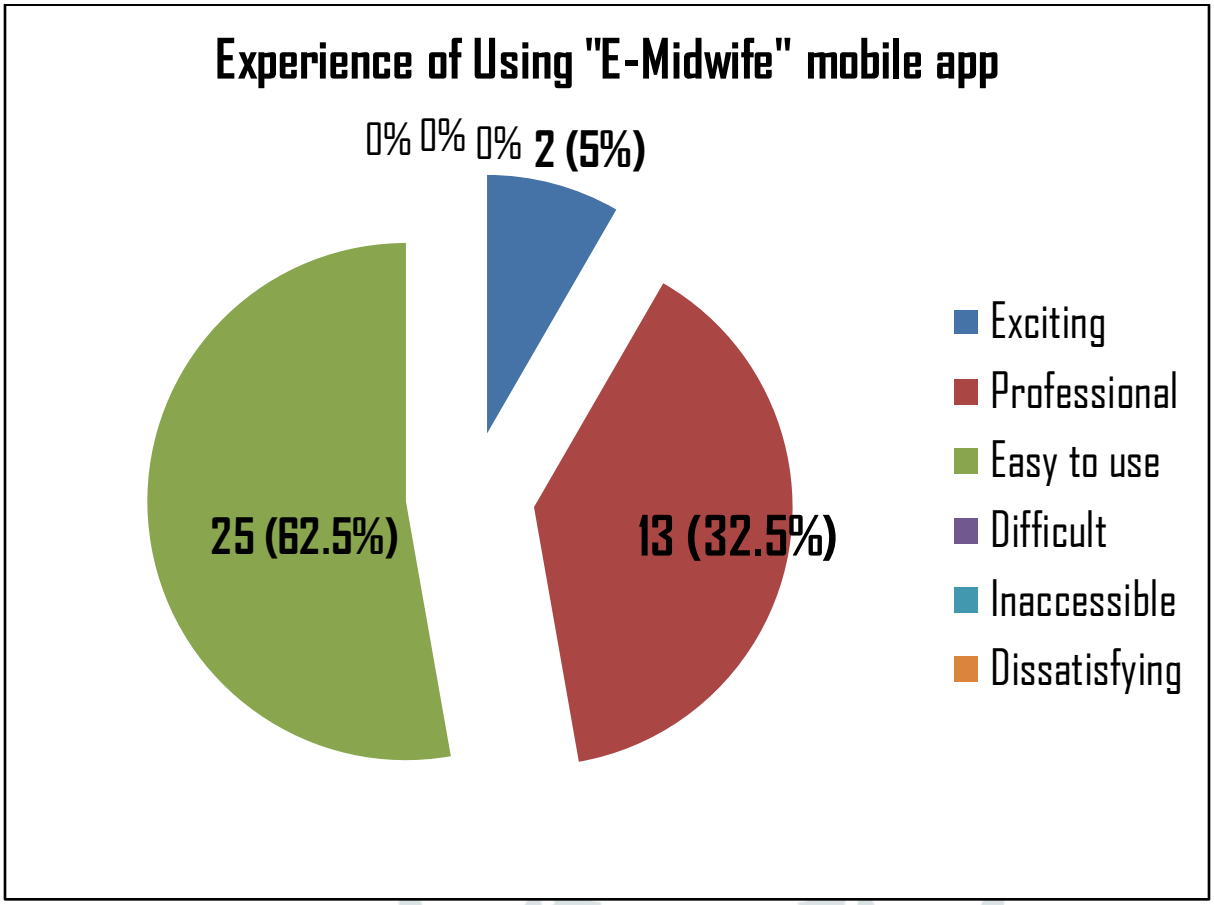

Figure 4 – Best Experience of participants using this mobile app

Discussion

Modern evidence recommends that mobile apps may be used to communicate health care teaching to nurse-midwives and also can used as a self-reference guide[31]. This evidence helps in the construction of a mobile application which helps the nurse-midwives to make a clinical decision during health assessment, early diagnosis, and proper identification of complications and promotion of health of the fetus. In this study, we compared various midwifery apps in android platforms with the concept of comprehending content, utility, design and rating characteristics. This assessment helped to design and refine "E-Midwife" mobile application for the better functioning of the app. There are only 12 apps in android platform on midwifery education in Google Play Store. However, most of these apps required subscription to use and download many features of the app. In many apps, there are no video illustrations for explaining the contents.

"E-Midwife" mobile application was assessed by health experts with experience in that field. The content was propelled back for reassessment for obtaining 100% consensus among arbitrators after inculcating the corrections. In some studies, it was stated that the Delphi technique helps to obtain an extensive, absolute and enhancing approach in correcting faults and also in incarcerating initiatives and knowledge [32][28]. This method helps to improve the functions of the application by incorporating the field specific experts' opinions and suggestions. Experts' suggestions contribute to the better functioning of the app and also help the nurse-midwives to choose the most suitable method of management for each complication in one touch.

In this study, content evaluation was done by subjective assessment of the experts' view on the developed content to establish whether this tool investigates all elements and domains relevant to the perception or constructs of the study. In the first assessment, it was 94% agreement among the experts whereas during second phase of assessment, it was 100% among all the experts. This value indicates the application contents are excellent. Hence, the agreements between two assessments were found to be valid and reliable. The contents evaluated on content, functioning, design and illustrative domains by the subject experts considered that mobile app was found to be valid. The overall content validation index ranges from 0.89 to 1.0 in the first assessment and in reassessment it was 1.0. Evaluating the accuracy of the contents is important for the proposed technologies to meet its defined objectives. Other important characteristics to be considered while preparing an mobile application for its attraction of learning by downloader are design, organization, quantity of information given, type of information, font size, screen background, color between each screens[33]. E-Midwife mobile application items achieved estimation of those recommended in the literature in the aspects of reviewers' expectation. Mobile technology in health education process can be used from everywhere, anytime and everybody which favors quick access to standard instructions, recommendations, principles and protocols in single tap[34]. This mobile app "E-Midwife" supposed significant relevance in terms of health teaching and learning. This app provides quick access to early identification signs, diagnosis and immediate management of obstetric complications in simple phrases for the better understanding of the concepts. This app provides easy access to the users at no cost with easy downloadable capacity and installation. The development of this app incorporated WHO recommendations in the management of obstetric complications. It is understood that the design and validation of studies on mobile application for android phones to control obstetric complications, such as the present study, at hands itself act as a health teaching tool in India to identify the core symptoms at the earliest, thereby recognizing the obstetric complications which helps for the immediate management and reducing the mortality and morbidity.

Conclusion

"E-Midwife" mobile application was validated by health care providers with experience in obstetrics and midwifery which showed 100% consensus among the experts in the second phase of assessment. This application helps to improve the evidence based practice of nurse-midwives in managing obstetric complications. Mobile application is an effective teaching learning method that can be used by nurse-midwives, caregivers and also students. The strength of this study is its design and innovative approach used to sort out the problem identified and encouraging its wider usage. Limitations of this study are testing of app with higher population and usage of app in very critical emergency situations. In future, the researchers should consider testing the app with wider population and test the effectiveness with grass root level workers in the midwifery field.

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Conflict of interests

The authors report no conflicts of interest.

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