

KARSA Mobile Application for Cervical Cancer Case Finding in Communities with Diverse Coverage

A'im Matun Nadhiroh¹, Fulatul Anifah², Annisa' Wigati Rozifa³

1. Lecturer of Midwifery Professional Education, Muhammadiyah University of Surabaya, Indonesia
2. Lecturer of Midwifery Undergraduate Program, Muhammadiyah University of Surabaya, Indonesia
3. Lecturer of Midwifery Professional Education, Muhammadiyah University of Surabaya, Indonesia

Corresponding author: Annisa' WigatiRozifa (email: annisa.wigati.rozifa@um-surabaya.ac.id)

Abstract:

Background: Cervical cancer poses significant health challenges, especially in developing regions with delayed diagnosis and limited early detection. This study assessed the effectiveness of the KarS-A mobile application in enhancing early detection among women of reproductive age.

Methods: Using a mixed-methods approach, the KarS-A app was developed and evaluated over eight months. The app integrates education, risk assessment, and navigation to health facilities, with pre-test and post-test analysis of knowledge, attitudes, and behavior.

Results: Among 500 participants, the app improved cervical cancer knowledge by 85% and increased screening rates, with 80% of high-risk users completing recommended checks. It also reduced stigma and improved access in rural areas.

Conclusion: The KarS-A app effectively supports early detection and enhances cervical cancer prevention efforts, with the potential for broader implementation in national health programs.

Keywords: cervical cancer, early detection, mobile app, health education

Introduction:

Cervical cancer is the second most common malignancy in female genital organs and often occurs in reproductive age (15-44 years). Globally, around 570,000 women were reported to have been diagnosed with cervical cancer in 2018, and around 311,000 died from the disease (Ferlay et al., 2015). In developed countries, around 87% of cervical cancers occur (Saslow et al., 2012). As many as 80-90% of cervical cancer cases occur in women who rarely or never undergo cervical cancer screening, and another 10%-20% of cervical cancer cases occur in women who have been screened but have not received adequate follow-up care (KEMENKES, 2018).

In Indonesia, cervical cancer is the second highest incidence of cancer in women, with around 23.4 per 100,000 women diagnosed with cervical cancer and a mortality rate of 13.9 per 100,000 population. Given the long course of cervical cancer, the cure rate for cervical cancer is almost 100% if found at an early stage. Still, not many WUS do early detection of cervical cancer for various reasons such as feeling no complaints, being embarrassed by the examination procedure, and WUS's ignorance about cervical cancer, and also early detection of cervical cancer. Most cases of cervical cancer come to health services at an advanced stage.

The leading cause of cervical cancer is human papillomavirus (HPV) infection. Delayed diagnosis in developing countries is the leading cause of cervical cancer death (KEMENKES, 2015). The risk factors for cervical cancer include sexual activity at a young age, having sex with multiple partners, smoking, having many children, low socioeconomic status, use of birth control pills (with negative or positive HPV), sexually transmitted diseases, and immune disorders (Bray et al., 2018). Other risk factors are smoking, obesity, lack of exercise, and immunomodulation caused by infection or drugs. These factors indirectly help HPV trigger infection or modulate immune function to increase susceptibility to cervical cancer (KEMENKES, n.d.). Cervical cancer treatment strategies are highly dependent on the stage of diagnosis and include surgery, chemotherapy, radiotherapy, or combination therapy. In addition, immunotherapy has shown an effective response in controlling cervical cancer.

Cervical cancer screening is the most effective way to reduce cervical cancer cases. The incidence of invasive cervical cancer has decreased in several developing countries, mainly due to early detection efforts (Tambunan, 2020), either through VIA (Visual Inspection with Acetic Acid) or Pap smear.

National procedure guidelines recommend monitoring infection through Visual Inspection with Acetic Acid (VIA) for women at average risk aged 20-65 years or married women at least every year for 3 years (Fauza et al., 2018). VIA is a cervical cancer screening examination through direct observation of the cervix after the application of 3-5% acetic acid. This type of screening is considered cheaper than the Papanicolaou (Pap) smear test. However, only around

2.45% of Indonesian women undergo the VIA screening test, which is still far from Indonesia's target of around 50% in 2019. Many factors influence women's involvement in cervical cancer screening, including education, behavior, access to information, and husband's support (Juwitasari et al., 2021; Kashyap et al., 2019). Knowledge of risk factors plays a vital role because cervical cancer can be identified earlier. Identification of high-risk populations and early screening have been proven effective in the early recognition of cervical cancer. There needs to be an effort to prevent and detect cervical cancer early, which can be done through socialization and education, socialization, and counseling in the community. The efforts to increase knowledge and awareness and change attitudes in cervical cancer screening must be carried out continuously. One strategy that can be used in cervical cancer prevention is to provide ongoing health education. Health workers play an essential role in providing information and advice on cervical cancer prevention through screening programs and encouraging women to access and utilize available health services. Based on this phenomenon, health education to increase knowledge, attitudes, and motivation of WUS about cervical cancer, including cervical cancer risk factors (Uchendu et al., 2021) must continue to be provided. This study used a tool to assess oneself (self-assessment) related to cervical cancer risk factors, namely KarS-A (A'im Score Card). KarS-A is a tool created based on a meta-analysis of several journals of cervical precancerous lesions and cervical cancer of as many as 15,342 women with details of the number of cases as many as 6,986 women and the number of controls as many as 8,356 women from Indonesia and other countries and to determine the cut-off point has been tested on patients at the One-Roof Oncology Clinic (POSA) of Dr. Sutomo Hospital Surabaya. Thus, our study aims to answer the question: Can the A'im Score Card (KarS-A) trigger WUS behavior to detect cervical cancer early by conducting IVA examinations?

Methods

For more than 8 months, a KARSA Mobile Application was developed for smartphones running the Android operating system. The first version was available as an application link that can be installed on a mobile device and then developed in the Play Store. The name KARSA, which means A'im Score Card, highlights the concept of self-assessment related to cervical cancer risk factors. All KARSA content is written in Indonesian and English, with simple and easy-to-understand language, and is aimed at the target population of all women of childbearing age with smartphones from several regions in East Java with diverse early detection coverage.

Skema Desain

This study uses a mixed methods approach to ensure the development and implementation of the KarS-A application as a patient navigation tool in the early detection of cervical cancer. This study is the development and validation of the application using the true experimental pre-test and post-test design method; this phase includes the development of the KarS-A application based on trials on women of childbearing age (WUS) in various regions. The parameters measured include knowledge, motivation, and attitudes before and after using the application.

The KarS-A application design scheme consists of five modules integrated to ensure the application's functionality runs effectively in helping early detection of cervical cancer. The five modules include user modules, education, risk checking, patient navigation, data management, and reports.

This application has a user module to provide user access for registration, login, and personal data management. The main components are registration and login, done by inputting WhatsApp numbers, name, age, and email. The profile has a personal data management feature, such as name, contact, address, and password updates.

The Education Module aims to increase the knowledge of Women of Childbearing Age (WUS) about cervical cancer and the importance of early detection. The main components of the News and Articles education module contain informative content about risk factors, IVA/Pap smear procedures, and cervical cancer prevention. In addition, this module is equipped with an educational video in the form of a short video explaining the importance of cervical cancer screening.

The Risk Check Module aims to provide a self-assessment tool based on a risk score to detect the possibility of cervical cancer. The main components of this module are a digital questionnaire and examination results. The digital questionnaire contains questions related to risk factors (age, number of pregnancies, history of sexual intercourse, etc.). Automatic scores that are categorized include Low Risk (<11) and High Risk (≥ 11). Next, the Examination Results, which are Recommendations according to the score, will appear. Low Risk to undergo annual Screening, and High Risk to undergo IVA/Pap smear examination immediately.

The Patient Navigation Module functions to help users access the nearest health facilities for further examination. The main components in this module include Digital Map Integration, which directs users to health facilities based on their location, and Google Maps-based navigation guidance. An automatic digital referral system that provides facility recommendations with contact information and service schedules. Reminder Notifications to remind you of the following examination or screening schedule.

Data Management and Report Module. This module provides a platform for admins and health workers to

monitor the results of the checks and follow-ups. On the Admin Dashboard, the task is to monitor the results of users' checks. In addition, statistical reports on application usage and risk scores are also available. The design of this application has several advantages, namely user-friendliness, a simple interface to improve WUS accessibility, integration because there is a combination of education, risk checking, and health service navigation in one application, and high security through user privacy maintained through data encryption and secure authentication. And real-time data analysis that supports the planning and evaluation of public health programs.

Content Development

The content of the KarS-A application was developed based on a systematic approach to meet the needs of women of childbearing age (WUS) in understanding and preventing cervical cancer. This development includes identifying user needs, developing main modules, and validating content. Identifying User Needs using in-depth interviews and Focus Group Discussions (FGD) with WUS, health workers, and experts. This activity aims to identify obstacles to early detection of cervical cancer, such as lack of knowledge, embarrassment, and limited access to health facilities. The next stage is developing the main modules, which include education modules, risk checks, and navigation.

The Education Module contains articles and videos on risk factors for cervical cancer, the importance of early detection through IVA/Pap smears, and prevention through a healthy lifestyle. The education module is presented in a simple and easy-to-understand format. The Risk Check Module contains a questionnaire based on risk factors (e.g., age, pregnancy history, sexual behavior) and produces a risk score (low/high) with follow-up guidance. The Navigation Module contains Information on the nearest health facility, a Guide to making an appointment for an IVA/Pap smear examination, and a Notification of the following examination schedule. The content validation process involves medical and technology experts to assess the accuracy of the information and ease of use. Content is revised based on feedback until it is deemed ready for implementation.

Implementation

This program is designed to facilitate WUS access to early detection services through the KarS-A application through the stages of socialization, technology implementation, and monitoring and evaluation. The Socialization Stage aims to increase awareness of the benefits of the KarS-A application. Socialization is carried out on WUS in Surabaya, Jombang, Kediri, Pasuruan, and Pamekasan through direct counseling by health workers using promotional materials such as brochures, posters, and videos on social media. The Android application and Website can be implemented via mobile devices to facilitate use and are integrated with a digital map for navigation to the nearest health facility. Health workers have special access to monitor the examination results and provide follow-up to patient needs. Monitoring and evaluation are carried out by collecting application usage data and user satisfaction surveys. The Success Indicator of the KARSA Application is an increase in early detections through IVA/Pap smears and a decrease in cases of advanced cervical cancer.

Patient Navigation Program

The patient navigation program ensures that high-risk WUS receive appropriate follow-up. The patient navigation program includes in-app navigation features, personal guidance, collaboration with health facilities, and assistance from health workers. In the in-app navigation feature, a list of digital maps displays the location of the nearest health facility based on the user's GPS. Follow-up recommendations include low-risk classification for routine annual screening and high-risk for further examination at a health facility. Personal Guidance guides making appointments with health facilities and automatic reminders for the following examination schedule. At the Collaboration with Health Facilities point, partner health facilities are trained to receive data from the application and provide services according to the results of the risk check, as well as an online referral system for patients who require further examination. Health workers are navigators who ensure that WUS carries out the application's recommendations.

Privacy and Data Handling

Security User data is encrypted on a server meeting ISO 27001 standards. User authentication uses a combination of WhatsApp numbers and OTP. Access to personal data is limited only to researchers or health workers related to user permission so that confidentiality is guaranteed and no user data is shared with third parties without consent. Users can delete or change their data through this application's "Profile" feature for data management. Data backup is done automatically every week to prevent data loss.

Statistical Analysis

Descriptive statistics will be used to analyze sociodemographic data and the distribution of risk score of application users. This study uses a Paired t-test to compare knowledge, motivation, and attitudes before and after using the application. ANOVA is used to analyze the variation of results in test groups with different demographic characteristics. The chi-square test tests the relationship between risk scores and early detection actions. In addition, this study uses Logistic Regression to identify the main predictors that influence early detection behavior. Data were analyzed using SPSS software.

Results

This study evaluated the effectiveness of the KarS-A Mobile Application in supporting cervical cancer case findings in communities with diverse demographic and geographic coverage. The results showed that this application was practical in improving knowledge, behavior, and access of WUS (Women of Reproductive Age) to early detection services for cervical cancer.

1. Respondent Characteristics

In this study, the number of respondents was 500 WUS from urban and rural areas in Surabaya, Jombang, Kediri, Pasuruan, and Pamekasan. The average age was 30.8 years ($SD \pm 5.4$). The respondents' education level was 65% and had secondary education (high school/equivalent). The majority of respondents were housewives (62%), with the rest working in the informal sector (25%) or formal (13%). Previous screening history: 20% of respondents had undergone IVA or Pap smear examinations, while 80% had never been screened.

2. Increased Knowledge and Screening Behavior

After using the KarS-A application for 6 months, there was a significant increase in knowledge and early detection behavior. Regarding knowledge about Cervical Cancer, before using the application, 40% of respondents knew that HPV was the leading cause of cervical cancer. After using the application, there was an increase of 85%. Knowledge about the importance of HPV vaccination and early detection through IVA/Pap smear also increased by 45%. Regarding Screening Behavior, of the 340 respondents with a low-risk score (<11), 50% continued the IVA examination voluntarily. Of the 160 respondents with a high-risk score (≥ 11), 80% performed further examinations according to the application's recommendations.

3. Effectiveness of Case Finding

The KarS-A application successfully identified high-risk WUS using a digital risk factor questionnaire. The results of the case finding are as follows: the number of WUS with High Risk: 160 out of 500 respondents (32%). In addition, based on the results of the IVA/Pap Smear Examination, of the 160 WUS with high risk, 20% (32 people) were found to have positive or abnormal IVA results. In addition, this group referred 10% (16 people) for further examinations, such as colposcopy or biopsy.

4. Improving Access to Health Services

At the Health Facility Navigation point, 85% of respondents felt helped by the navigation feature to find the nearest health facility. Respondents in rural areas reported increased access to cervical cancer screening services, which were previously difficult to reach. The reminder notification feature helped 70% of respondents comply with the re-screening or follow-up schedule according to the application's recommendations.

5. Reducing Misunderstandings

The KarS-A application is effective in reducing myths and misunderstandings about cervical cancer. Previously, 55% of respondents believed that cervical cancer only occurs in women who have physical complaints. After education through the application, this figure decreased to 15%. In addition, at the IVA and Pap Smear Stigma points, after using the application, 30% more respondents felt comfortable undergoing the examination compared to before the intervention.

6. User Satisfaction

A user satisfaction survey showed that 90% of respondents felt the application was easy to use, 85% of respondents considered the information presented in the application relevant and valuable, and 80% of respondents suggested the development of additional features, such as online consultation with a doctor or health care provider.

7. Statistical Analysis

The Paired t-test results showed a significant increase ($p < 0.001$) in the knowledge score and early detection motivation after using the application. The Chi-square test showed a significant relationship ($p < 0.001$) between high-risk scores and early detection actions. Logistic Regression showed that the main predictors of early detection behavior were High-risk score ($OR = 3.5$; 95% CI: 2.1–5.6) and education level ($OR = 1.8$; 95% CI: 1.2–2.8).

8. Main Findings

Regarding Case finding, KarS-A effectively identified high-risk WUS groups, allowing early detection in 20% of high-risk users with positive IVA results. The KarS-A application increases knowledge and reduces social barriers that have prevented early detection of cervical cancer. The KarS-A application has easy access by helping to bridge the geographical gap in access to health services, especially in rural communities.

Discussion

This study discusses the role of the KarS-A (Kartu Skor A'im) application as an innovative tool to support cervical cancer case finding in communities with diverse demographic and geographic backgrounds. The results showed that the KarS-A application significantly increased cervical cancer case finding through a technology-based approach. This is to previous studies on the effectiveness of applications in case finding and early detection of cervical cancer (Aprina et al., 2024; Bhatt et al., 2018; Jasmawati et al., 2023; Kazemi et al., 2022; Mungo et al., 2021).

Using a digital questionnaire, karS-A can accurately classify WUS based on cervical cancer risk. The findings showed that 32% of users were in the high-risk category, most previously unaware of their danger. Of the 160 high-risk users, 20% showed positive or abnormal IVA results, which have the potential to prevent progression to advanced cervical cancer if followed up early. As many as 80% of high-risk users continued to follow-up examinations after using the application. This confirms that this application is effective in encouraging early detection actions.

This application has reached communities with diverse characteristics in urban and rural areas. In urban areas, users are more receptive to technology and have adequate internet access. This supports the application's rapid implementation success. Despite technological infrastructure challenges in Rural Areas, the app still provides benefits through its straightforward approach and focus on risk education (Chen et al., 2019; Reddick et al., 2020; Sepasgozar et al., 2019; Van Hoof et al., 2018). The navigation feature to find the nearest health facility has been proven to help 85% of rural users.

Although the results show the application's success, several challenges remain: technological barriers, social stigma, and limited health infrastructure. Rural areas with limited internet access and low smartphone ownership are major obstacles (Forenbacher et al., 2019; Graves et al., 2021; Misaki et al., 2018; Onitsuka et al., 2018). There is still resistance to VIA or Pap smear examinations among women of childbearing age, mainly due to embarrassment or lack of family support (Corkum et al., 2019a; Fitriani et al., 2024a; Haloho et al., 2022; Hutagalung & Manik, 2021; Komalawati & Martha, 2023; Nurjanah et al., 2022a). The application has helped reduce stigma. However, additional efforts are still needed, such as collaboration with community leaders (Corkum et al., 2019b; Fitriani et al., 2024b; Nurjanah et al., 2022b). In addition, some communities face the constraint of limited health facilities providing early detection services.

The KarS-A application significantly reduces myths and misunderstandings among women of childbearing age. Previously, many women believed that cervical cancer only attacks women with symptoms or complaints. This misunderstanding was decreased from 55% to 15% through application-based education. In addition, there was an increase in Understanding among Women of Childbearing Age (WUS).

Education about the role of HPV as the leading cause of cervical cancer and the importance of vaccination succeeded in increasing understanding by 45% compared to before the intervention.

The KarS-A application improves early detection and strengthens the community health system. This is applied through integration with Health Services and Data for Policy integration with Health Services and Data for Policy. Digital referral features and health facility navigation help accelerate user access to appropriate health services. This can improve the effectiveness of national early detection programs (Abermety et al., 2022; Sheikh et al., 2021). User data collected through the application provides essential insights for evidence-based health planning, such as resource allocation for HPV screening and vaccination services.

KarS-A has excellent potential to be further developed so that its benefits are more optimal by adding online consultation features, expanding to remote areas, and partnering with local organizations. This feature can help users who need further support after receiving screening results (Haleem et al., 2021; Ignatowicz et al., 2019). The development of SMS or USSD-based applications can be a solution to reach users in areas with technological limitations. Collaboration with local governments, community organizations, and health institutions can increase application adoption.

The KarS-A application has proven effective in supporting cervical cancer case finding in communities with diverse coverage. The success of this application lies in its ability to increase awareness, identify risks, and encourage early detection actions. Although challenges such as technological barriers and social stigma remain, further application development and cross-sector collaboration can help expand the benefits of KarS-A in the future. This innovation is a strategic step to support the national program in handling cervical cancer, especially in areas with limited access to health services.

Conclusion

This study shows that the KarS-A Mobile Application effectively supports cervical cancer case finding in communities with diverse coverage. This application helps identify high-risk women of childbearing age, increases knowledge about cervical cancer, and encourages early detection behavior. KarS-A also expands access to health services through navigation features, makes it easier for users to find the nearest health facility, and reduces stigma and misunderstandings about cervical cancer. This application can potentially strengthen the national cervical cancer early detection program with further development, such as adding online consultation features and expanding coverage areas.

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KarS-A System Flowchart

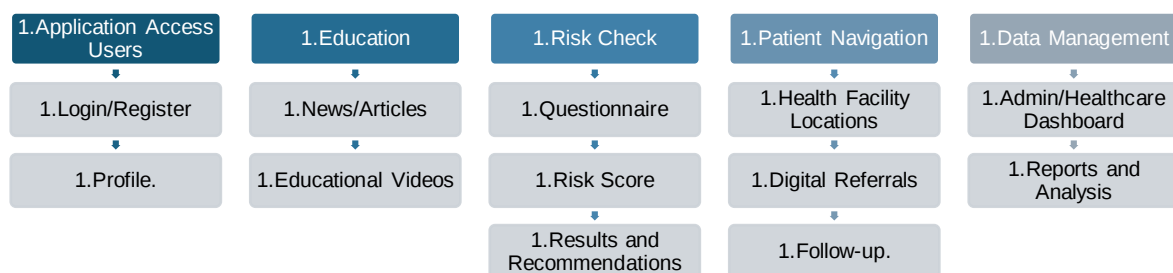


Fig. 1 The KarS-A system comprises Application Access Users, Education, Risk Check, Patient Navigation, and Data Management. The integration of all these points is expected to increase the knowledge of women of childbearing age and motivation to carry out early detection of cervical cancer.