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TeleOTIVA: Advanced AI-Powered Automated Screening System for Early Detection of Precancerous Lesions

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ABSTRACT

In 2023, the Indonesian Ministry of Health launched the Rencana Aksi Nasional (RAN) to enhance the detection and management of cervical cancer in Indonesia. One of the main pillars in this movement is the implementation of early screening for precancerous lesions aimed at identifying and treating these lesions before they develop into cervical cancer. This effort includes improving public access to healthcare services, providing education and awareness about the importance of early detection, and utilizing the latest technology in screening procedures. It is hoped that, through these targeted and effective interventions, the incidence of cervical cancer can be significantly reduced. This research aims to facilitate the early detection screening process for cervical precancerous lesions, particularly in difficult areas for medical experts to reach. This study also seeks to assist obstetricians and gynecologists in detecting precancerous lesions automatically, quickly, and accurately. By developing an advanced technology-based screening system, it is hoped that early detection of precancerous lesions can be carried out more efficiently, thereby increasing the chances of timely treatment and reducing the incidence of cervical cancer across various regions in Indonesia. This system is designed to provide reliable and user-friendly diagnostic support as it is developed on a mobile platform that can be accessed anytime and anywhere. This research developed a system for early screening called TeleOTIVA. The TeleOTIVA application system is an advanced platform that uses artificial intelligence (AI) based approaches to provide optimal services in early detection of precancerous lesions. This application is designed for mobile, allowing users to access and use its advanced features anytime and anywhere. With the integration of AI technology, TeleOTIVA can detect and analyze cervical precancerous lesions accurately and quickly to provide accurate and efficient screening results. The TeleOTIVA application system is capable of providing satisfactory detection results. The performance of the proposed model achieves accuracy, sensitivity, and specificity levels above 90%. With this high performance, TeleOTIVA ensures that the detection of precancerous lesions is carried out with high reliability and precision, instilling greater confidence in healthcare professionals and users during the screening and diagnosis process. The implementation of our application model offers numerous advantages over traditional methods. It significantly enhances efficiency by automating processes, reduces human error through rigorous error-checking mechanisms, and accelerates the processing of large datasets. These improvements streamline operations and ensure more reliable and rapid data analysis.

Keywords: *Screening, VIA, Telemedicine, Artificial Intelligence*

1. INTRODUCTION

The incidence of cervical cancer remains a significant health concern in Indonesia, consistently ranking among the top three cancers in the country [1]. Based on the International Agency for Research Cancer (IARC), it is estimated that there were

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408,661 new cases and 242,988 deaths in Indonesia. In addition, IARC estimates that there will be a 77% increase in cervical cancer cases by 2050 [2]. The high number of cervical cancer cases in Indonesia prompted the Indonesian Ministry of Health to create a Rencana Aksi Nyata (RAN) program to eliminate cervical cancer in Indonesia in 2023-2030 [3]. This comprehensive strategy includes four main pillars, one on service provision, particularly through screening initiatives. Early screening for cervical cancer aims to detect, remove, or treat precancerous lesions that could develop into cancer [4], [5]. Visual inspection with acetic acid (VIA) is one of the screening techniques used in Indonesia [6], [7]. However, accessibility to VIA and cytology screenings, which are currently covered, remains limited, reaching only about 9.3% of the targeted female population in 2020, with significant disparities observed across provinces [1].

One of the main reasons for the low national screening rates is the limited access to and coverage of health facilities [7], [8]. Many areas, especially those that are remote and far from health service centers, experience difficulties in providing routine screening. This is caused by a lack of skilled and experienced health personnel in carrying out screening. Apart from that, limited infrastructure and health facilities also worsen the situation, so that people in remote areas do not get the services they need. To address these issues, researchers have been developing an automatic cervical cancer lesion screening model using artificial intelligence and machine learning technologies to boost accuracy and efficiency in cancer detection [9-18].

Khaled, et al. [14] emphasize the significance of activation functions on the performance of a residual network (ResNet). They trained and tested their models on a dataset of colposcopy cervical images. The experimental results demonstrated that residual networks using leaky and parametric rectified linear unit (Leaky-ReLU and PReLU) activation functions achieved comparable accuracy, with 90.2% and 100% accuracy, respectively. Ling Yan, et al. [16] developed an advanced AI tool called HLDnet (HSIL+ Detection Network) to combine information from both types of cervicograms, ensuring high accuracy in detecting HSIL+ regions. HLDnet employs the Intersection over Union (IoU) decision algorithm to assess the overlap of lesion regions detected in both colposcopy images, reducing false positives and improving HSIL+ detection accuracy. They achieved an accuracy of 0.86 (sensitivity 0.82 and specificity 0.90) with the test data, surpassing the single-channel detection accuracy of 0.61 and 0.53 using only acetic acid cervicograms or Lugol's iodine, respectively. Patiyus [9] et al. proposed a mask-RCNN architecture to simultaneously segment, classify, and detect CA and AW lesions. They conducted experiments on 262 VIA+ cervicogram images and 222 VIA− cervicogram images. The model achieved an intersection over a union of approximately 63.60% for CA and 73.98% for AW lesions. The dice similarity coefficient was about 75.67% for CA and 80.49% for AW lesions. It also demonstrated strong performance in detecting cervical cancer precursor lesions, with a mean average precision of about 86.90% for CA and 100% for AW lesions, along with 100% sensitivity and 92% specificity. Our previous study in [12] employed the object detection approach using the combined You Only Look Once (YOLO) framework. Consequently, the model achieved an impressive

mean average precision (mAP) of 99% for RoI cervix detection, with lesion segmentation attaining an mAP of 73% and an average intersection-over union score of 40%. Additionally, the model demonstrated an inference time of 10.4 ms, highlighting its efficiency in processing images and quickly generating results. In a subsequent study [19] we developed an explainable convolutional neural network named "CervicoXNet" for automated cervicogram interpretation to assist medical workers in decision-making. This model surpassed other deep learning models, achieving 99.22% accuracy, 100% sensitivity, and 98.28% specificity. To evaluate the model's robustness, colposcope images were used to validate its generalization ability, and the results remained strong with 98.11% accuracy, 98.33% sensitivity, and 98% specificity. CervicoXNet shows promise as an alternative early screening tool alongside VIA.

The Computer-Aided Diagnosis (CAD) method has been used in the diagnosis of cervical cancer [21-23] because it is able to overcome subjective interpretation problems and can be analyzed quickly and accurately. Previous research that developed cervical cancer lesion detection using mobile technology was still limited [24-25], so this research offers an innovative solution using a mobile application for cervical cancer lesion detection using the VIA method, in the future, it will be called TeleOTIVA. To our knowledge, this is the first mobile-based application to automatically detect cervical cancer lesions developed. By using the TeleOTIVA application, it is hoped that it can increase accessibility and speed of diagnosis, especially in areas that have limited health facilities.

2. MATERIAL AND METHODS

Study Design and Data Source

This research applies a cohort-AI study, a research approach that combines a cohort study design with artificial intelligence (AI) technology to analyze data and identify patterns or predictions that cannot be found through conventional methods. The main elements applied in this research include cervicogram data collection. This cervicogram dataset was collected from RSUP Dr. Mohammad Hoesin Palembang during VIA screening for women in 2023. A total of 1,500 subjects were screened for cervical pre-cancerous conditions using the VIA procedure. This dataset includes 1,450 normal cervicogram images and 50 images of cervical precancerous lesions, making it complex and challenging to analyze.

Furthermore, the TeleOTIVA system was developed using artificial intelligence (AI) methods, namely YOLO version 8 (YOLOv8). YOLOv8 is the backbone of TeleOTIVA for predicting and detecting cervical pre-cancerous lesions with high accuracy. This algorithm is able to identify and classify lesions in digital images of the cervix quickly and efficiently, thereby providing more reliable results for users [12], [19]. Additionally, the use of YOLOv8 allows the application to work in real-time, providing better clinical support and enabling early treatment of cervical pre-cancerous conditions. After this detection model achieves the desired performance, the next step is to develop it in the form of a mobile application. This mobile

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application is expected to increase accessibility and ease of use in detecting cervical pre-cancerous lesions, especially in areas that have limited health facilities.

Manual Screening Visual Inspection with Acetic Acid

One of the early screening methods for cervical cancer used in Indonesia is the visual inspection with acetic acid (VIA). VIA is a simple and effective approach, especially in areas with limited resources. This process involves the application of an acetic acid solution to the cervix to identify precancerous lesions based on changes in tissue color [26-28]. The advantage of this method is its relatively low cost, as well as ease of implementation, so it can be carried out in various health facilities without requiring complicated equipment. In addition, VIA can provide rapid results, allowing immediate follow-up for patients who are detected to be at risk. However, the weakness of this method is its dependence on the skills and experience of the health worker conducting the screening; the results obtained can vary depending on individual abilities, so false positives and false negatives often occur [28] .

Standards of care for cervical cancer screening and diagnosis vary between high- and low-resource areas. In high-resource countries, advanced technology and easy access to health services enable accurate and rapid routine screening. In contrast, in low-resource areas, limited medical facilities and trained health personnel mean that manual screening is often inadequate. Manual inspection, while important, can be very burdensome and error-prone [8], even for experienced experts. These errors can be caused by various factors, such as fatigue, high workload, and lack of adequate equipment. Therefore, TeleOTIVA can be an innovative solution that can increase accuracy and efficiency in cervical cancer screening, especially in areas with limited resources.

Proposed Screening using TeleOTIVA

TeleOTIVA is an innovative application developed to carry out early detection of cervical cancer lesions, aiming to increase accessibility and efficiency in women's health screening. By utilizing artificial intelligence technology, this application can analyze cervicogram images automatically and provide accurate results in a short time. TeleOTIVA is designed to help healthcare professionals identify precancerous lesions, allowing faster follow-up for patients who need it. Apart from that, this application also provides ease of use, so it can be accessed in various health facilities, especially in areas with limited resources. Thus, TeleOTIVA not only plays a role in early detection but also contributes to efforts to prevent and treat cervical cancer more effectively.

In general, the pipeline for using TeleOTIVA is shown in Figure 1. The TeleOTIVA application is used to take medical records in the form of images of the cervix by health workers when VIA screening is carried out. The images taken are pre-VIA and post-VIA. After the picture is taken the medical record and images are sent to

the server, after that the result is displayed in the application. Validation and treatment results are carried out with real-time assistance by oncology-gynecology sub-specialists.

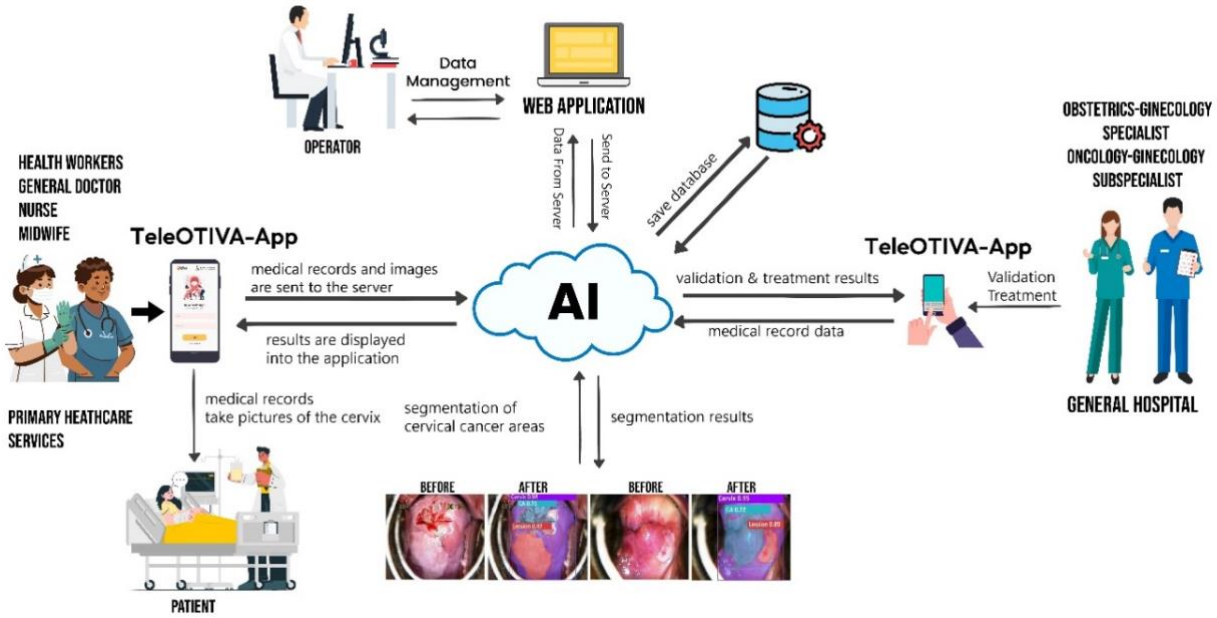

FIGURE 1. TeleOTIVA mobile pipeline flow used by health workers.

By using the TeleOTIVA application, problems related to cervical cancer screening in areas with limitations can be overcome effectively. This application is designed to increase the accessibility of healthcare services by providing a screening solution that is easy to operate and fast in analysis. By utilizing advanced technology, TeleOTIVA enables health workers in remote locations to perform accurate screening, even without the need for expensive equipment. It is hoped that this will encourage more women to undergo screening, thereby increasing screening rates nationally. In addition, this application also provides more consistent and reliable results, helping in the early identification of precancerous lesions. Thus, TeleOTIVA has the potential to become an invaluable tool in efforts to improve public health and reduce the incidence of cervical cancer throughout Indonesia.

Features of TeleOTIVA

The TeleOTIVA application is equipped with various advanced features designed to increase effectiveness and efficiency in early detection of cervical cancer lesions: automatic detection, telemedicine system, and notification system. The automatic detection feature utilizes artificial intelligence technology to analyze cervicogram images automatically. This feature is able to identify precancerous lesions with high accuracy, thereby reducing the workload of medical personnel and minimizing the possibility of human error. The Telemedicine System is the feature that allows further consultation and validation of lesion prediction results remotely between health workers and obstetricians-gynecologists specialists and oncology-gynecology

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subspecialists. Through this system, screening results can be sent and evaluated by specialists in different locations, thereby speeding up the diagnosis process and enabling faster follow-up. This is very useful, especially for patients in remote areas who have limited access to complete health facilities. Last, the notification system is designed to provide notification to specialist doctors if there are screening results that need validation and need to provide follow-up recommendations. With this notification system, health workers in the area can be helped to validate the screening results that have been taken.

The TeleOTIVA application interface, as shown in Figure 2, features a simple yet functional design, including various menus, patient data input pages, and prediction results performed by the system. Each element in this interface is designed to make it easy for users to navigate, so they can quickly access the various features and services provided. Users can easily enter patient data, view medical prediction results, and interact with healthcare professionals through this application. Designed to optimize user experience, the TeleOTIVA application ensures that telemedicine services can be accessed quickly and efficiently, providing a reliable and convenient solution for users.

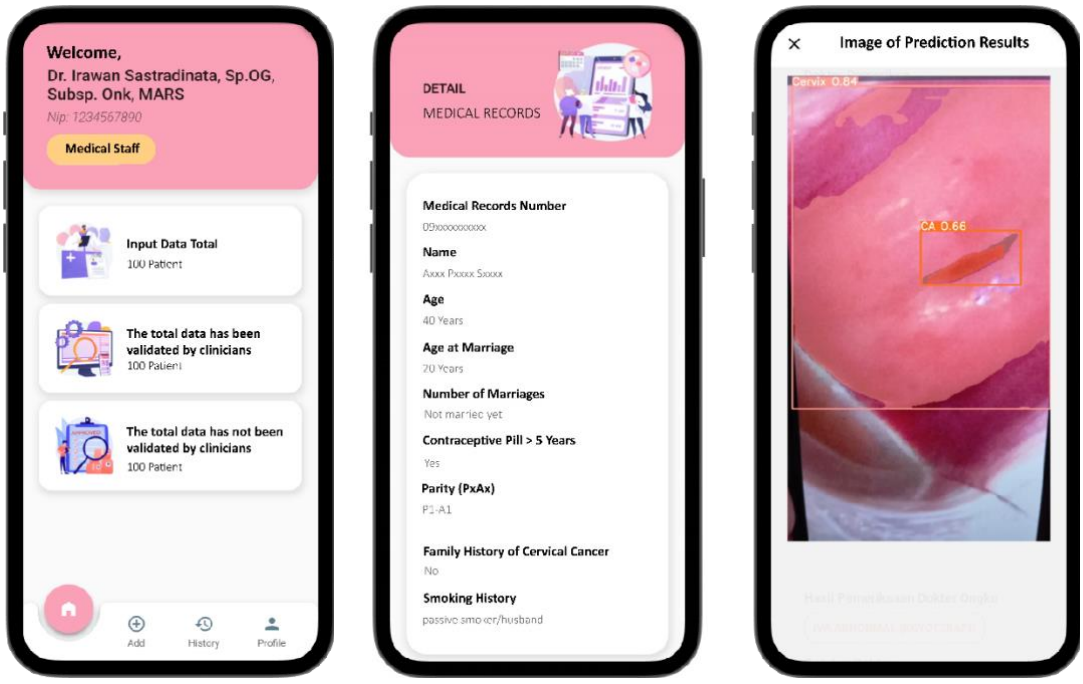

FIGURE 2. TeleOTIVA mobile application preview.

Overall, the combination of advanced features offered by TeleOTIVA makes it a highly effective tool in improving the quality and coverage of cervical cancer screening, especially in resource-limited areas. TeleOTIVA provides automatic and fast analysis with high accuracy through artificial intelligence technology and is also designed to be easy to use by healthcare workers of all skill levels.

Ethics Statement

The development and use of TeleOTIVA with AI for cervical precancer detection raise important ethical issues that require careful consideration [29]. This study was approved by the Health Research Ethics Committee of Central General Hospital Dr. Mohammad Hoesin Palembang, Indonesia, under ethical certificate No. DP.04.03/D.XVIII.6.1.1/ETIK/95/2023. The procedures followed the principles of the Declaration of Helsinki and the International Ethical Guidelines for Biomedical Research Involving Human Subjects [30]. Participants provided written informed consent to participate in the study, and all research subjects were given detailed information about the examination procedures and the study's objectives.

3. RESULT

Prediction results of the backbone TeleOTIVA use the Yolov8 show very significant results. The performance metrics measured in this study show that the sensitivity and accuracy obtained exceed 90%. These figures show that Yolov8 8 is able to detect cervical cancer lesions with a very high level of accuracy, making it a very reliable tool in the screening process. The high sensitivity means that the app can identify almost all cases of precancerous lesions, thereby reducing the risk of cases going undetected. In addition, the high level of accuracy shows that Yolov8 can differentiate well between cancerous lesions and normal tissue, reducing the possibility of misdiagnosis. This success also shows that the integration of artificial intelligence in health applications can have a significant positive impact on efforts to prevent and treat critical illnesses.

Table 1 shows the performance metrics generated by the backbone model in the TeleOTIVA application. In the table, there are various important metrics such as accuracy, sensitivity, specificity, and positive and negative predictive values that are used to evaluate the model performance. The results shown in this table illustrate how effective the backbone model is in detecting cervical cancer lesions. For example, the high accuracy rate indicates that the model is able to correctly identify lesions in the majority of cases. High sensitivity indicates the model's ability to detect precancerous lesions, while high specificity indicates the model's effectiveness in identifying healthy tissue. Consistent positive and negative predictive values also indicate the reliability of the model in providing accurate results. With these impressive performance metrics, Table 1 confirms that the backbone model in the TeleOTIVA application is a very reliable and effective tool for use in cervical cancer screening, which can help medical personnel provide more precise and faster diagnoses, especially in areas with low resources. limited.

Table 1. The performance of the TeleOTIVA backbone model.

Metric	Screening Dataset Result (%)
Accuracy	90.78
Sensitivity	91.67
Specificity	90.96

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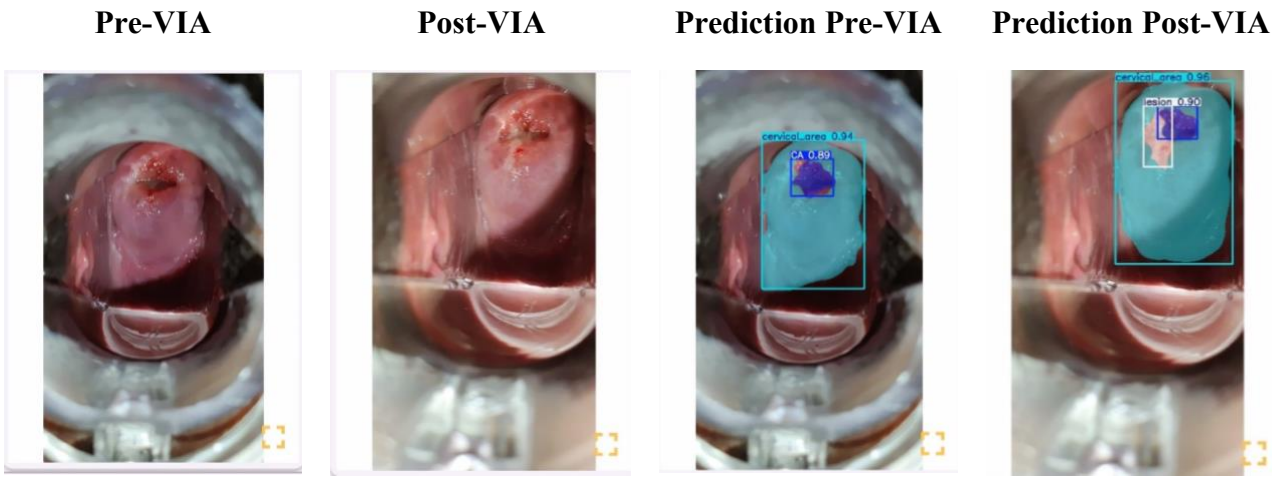
Figure 3 shows the prediction results for cervical cancer lesions produced by the TeleOTIVA application. In the image, it is clear how this application is able to detect and mark areas suspected of being precancerous lesions using artificial intelligence technology. These prediction results not only provide visualizations that are easy for medical personnel to understand but also confirm TeleOTIVA's ability to carry out accurate and fast analysis. Thus, this image is concrete evidence that TeleOTIVA can be relied on as a diagnostic aid in cervical cancer screening. Additionally, the prediction results displayed in this figure also help increase medical professionals' confidence in the use of AI technology in daily clinical practice. Figure 3 illustrates the great potential of TeleOTIVA in improving the early detection of cervical cancer lesions, which could ultimately contribute to reducing the incidence and mortality of this disease.

4. DISCUSSION

The TeleOTIVA application has partnered with RSUP Dr. Mohammad Hoesin Palembang in developing advanced devices for cervical cancer screening. This partnership aims to leverage medical expertise and cutting-edge technology to create effective and efficient solutions for detecting pre-cancerous lesions. With this collaboration, RSUP Dr. Mohammad Hoesin provides invaluable clinical data and practical insights, while TeleOTIVA integrates artificial intelligence technology to improve detection accuracy and speed. This collaboration not only strengthens the scientific and clinical validity of the TeleOTIVA application but also ensures that the device developed meets medical needs and standards. Through this partnership, it is hoped that TeleOTIVA can become a reliable and widely used tool in national screening programs so that it can help reduce the incidence of cervical cancer and improve women's health throughout Indonesia.



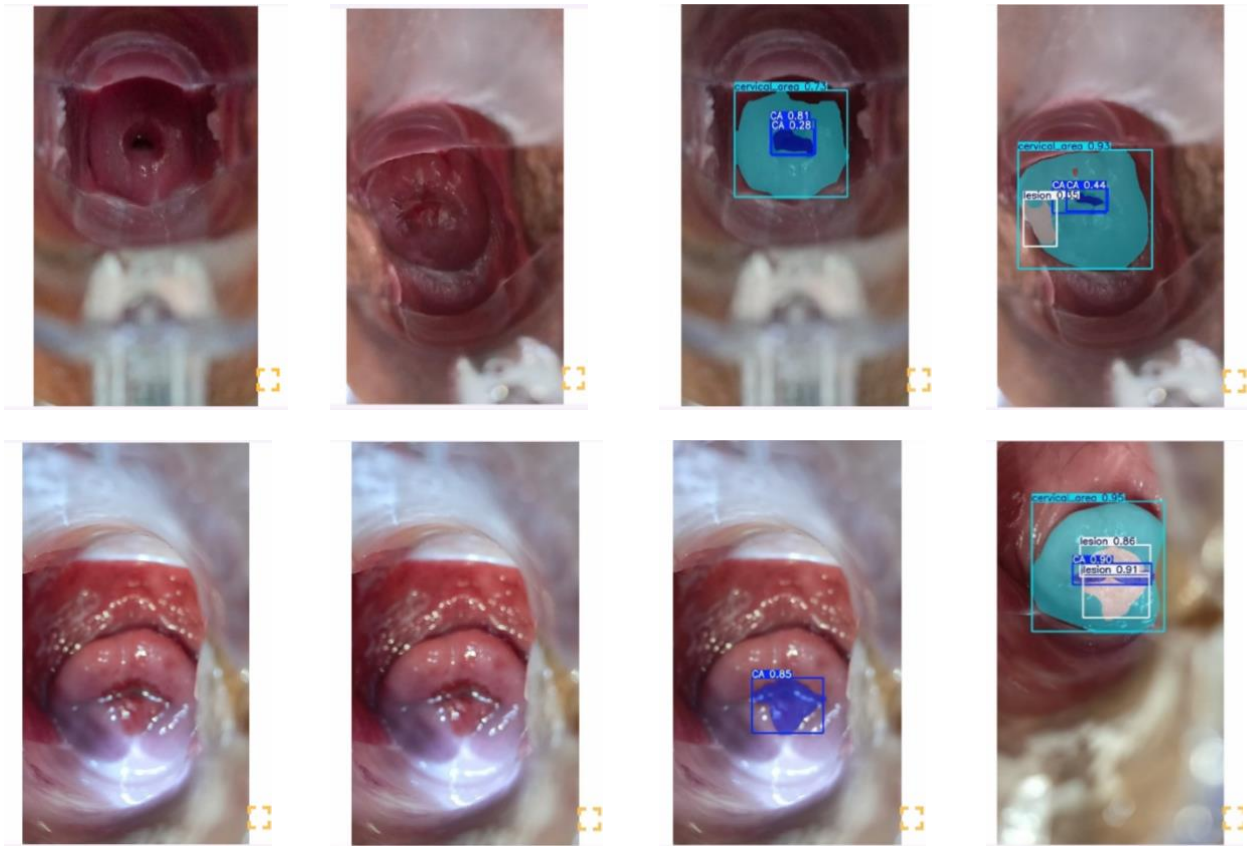


FIGURE 3 Prediction Result of cervicogram using TeleOTIVA. Consists of normal and abnormal images (predicted pre-cancerous cervical lesions)

The TeleOTIVA system is designed to help health workers in remote areas carry out cervical cancer screening more effectively and efficiently. Through the artificial intelligence technology integrated in this application, health workers can analyze cervicogram images quickly and accurately, identifying precancerous lesions more easily. TeleOTIVA not only provides a practical and easy-to-use tool but also provides a step-by-step guide that helps medical personnel in carrying out screening procedures. With this capability, TeleOTIVA enables broader and timely early detection, reducing the gap in healthcare between urban and rural areas. In addition, this system also supports the training and skills improvement of local health workers, strengthening their capabilities in facing public health challenges. With improved accessibility, the app allows more women in remote areas to get regular screening without having to travel long distances to larger health facilities. In addition, TeleOTIVA is able to reduce the workload of medical personnel by automating the process of identifying precancerous lesions, so they can focus on more critical medical procedures. TeleOTIVA implementation also has the potential to reduce health operational costs by reducing the need for expensive equipment and intensive training. With all these advantages, TeleOTIVA not only contributes to increasing early detection of cervical cancer but also supports efforts to prevent and treat the disease more efficiently throughout Indonesia. In this way, TeleOTIVA contributes significantly to improving the quality and coverage of cervical cancer

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screening throughout the region, supporting better disease prevention and control efforts at the national level.

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Conflict of Interest

The authors declare that there is no conflict of interest

Ethics approval and consent to participate

All methods were conducted according to relevant guidelines and regulations. All experimental protocols were approved by General Hospital Muhammad Hoesin, Indonesia. Informed consent was obtained from all subjects and/or their legal guardians.

REFERENCE

[1] Kemenkes, "Rencana Aksi Nasional Eliminasi Kanker Leher Rahim di Indonesia tahun 2023-2030." Accessed: Jul. 16, 2024. [Online]. Available: https://kemkes.go.id/id/national-cervical-cancer-elimination-plan-for-indonesia-2023-2030

[2] International Agency for Research on Cancer, "Indonesia - Global Cancer Observatory 2022.," 2022.

[3] Kemenkes, "Rencana Aksi Nasional Eliminasi Kanker Leher Rahim di Indonesia Tahun 2023-2030," https://kemkes.go.id/id/national-cervical-cancer-elimination-plan-for-indonesia-2023-2030.

[4] U. R. Poli, P. D. Bidinger, and S. Gowrishankar, "Visual inspection with acetic acid (via) screening program: 7 years experience in early detection of cervical cancer and pre-cancers in rural South India," *Indian Journal of Community Medicine*, vol. 40, no. 3, pp. 203–207, Jul. 2015, doi: 10.4103/0970-0218.158873.

[5] C. N. Bui *et al.*, "Effect of Pap smear screening on cervical cancer stage at diagnosis: results from the Korean National Cancer Screening Program," *J Gynecol Oncol*, vol. 32, no. 5, p. e81, Sep. 2021, doi: 10.3802/jgo.2021.32.e81.

[6] S. L. Silkensen, M. Schiffman, V. Sahasrabuddhe, and J. S. Flanigan, "Is It Time to Move Beyond Visual Inspection With Acetic Acid for Cervical Cancer Screening?" [Online]. Available: www.ghspjournal.org

[7] L. Nuranna *et al.*, "Cervical cancer prevention program in Jakarta, Indonesia: See and Treat model in developing country," *J Gynecol Oncol*, vol. 23, no. 3, pp. 147–152, Jun. 2012, doi: 10.3802/jgo.2012.23.3.147.

[8] R. M. Islam, B. Billah, M. N. Hossain, and J. Oldroyd, "Barriers to cervical cancer and breast cancer screening uptake in low-income and middle-income countries: A systematic review," Jul. 01, 2017, *Asian Pacific Organization for Cancer Prevention*. doi: 10.22034/APJCP.2017.18.7.1751.

[9] P. Agustiansyah *et al.*, "Automated Precancerous Lesion Screening Using an Instance Segmentation Technique for Improving Accuracy," *Sensors*, vol. 22, no. 15, Aug. 2022, doi: 10.3390/s22155489.

[10] Y. R. Park, Y. J. Kim, W. Ju, K. Nam, S. Kim, and K. G. Kim, "Comparison of machine and deep learning for the classification of cervical cancer based on cervicography images," *Sci Rep*, vol. 11, no. 1, Dec. 2021, doi: 10.1038/s41598-021-95748-3.

[11] C. Yuan *et al.*, "The application of deep learning based diagnostic system to cervical squamous intraepithelial lesions recognition in colposcopy images," *Sci Rep*, vol. 10, no. 1, Dec. 2020, doi: 10.1038/s41598-020-68252-3.

[12] S. Nurmaini *et al.*, "Real-time mobile AI-assisted cervicography interpretation system," *Inform Med Unlocked*, vol. 42, Jan. 2023, doi: 10.1016/j.imu.2023.101360.

[13] M. Sato *et al.*, "Application of deep learning to the classification of images from colposcopy," *Oncol Lett*, vol. 15, no. 3, pp. 3518–3523, Mar. 2018, doi: 10.3892/ol.2018.7762.

[14] K. M. A. Adweb, N. Cavus, and B. Sekeroglu, "Cervical Cancer Diagnosis Using Very Deep Networks over Different Activation Functions," *IEEE Access*, vol. 9, pp. 46612–46625, 2021, doi: 10.1109/ACCESS.2021.3067195.

[15] M. Kalbhor, S. Shinde, P. Wajire, and H. Jude, "CerviCell-detector: An object detection approach for identifying the cancerous cells in pap smear images of cervical cancer," *Heliyon*, vol. 9, no. 11, Nov. 2023, doi: 10.1016/j.heliyon.2023.e22324.

[16] L. Yan *et al.*, "HLDnet: Novel deep learning based Artificial Intelligence tool fuses acetic acid and Lugol's iodine cervicograms for accurate pre-cancer screening," *Biomed Signal Process Control*, vol. 71, Jan. 2022, doi: 10.1016/j.bspc.2021.103163.

[17] J.-S. Dessureault and D. Massicotte, "Feature selection or extraction decision process for clustering using PCA and FRSD," Nov. 2021, [Online]. Available: http://arxiv.org/abs/2111.10492

[18] M. Kyrgiou *et al.*, "Cervical screening: ESGO-EFC position paper of the European Society of Gynaecologic Oncology (ESGO) and the European Federation of Colposcopy (EFC)," Aug. 18, 2020, *Springer Nature*. doi: 10.1038/s41416-020-0920-9.

[19] S. Nurmaini *et al.*, "CervicoXNet: an automated cervicogram interpretation network," *Med Biol Eng Comput*, no. 9/2023, 2023.

[20] L. Liu *et al.*, "Computer-aided diagnostic system based on deep learning for classifying colposcopy images," *Ann Transl Med*, vol. 9, no. 13, pp. 1045–1045, Jul. 2021, doi: 10.21037/atm-21-885.

[21] E. R. Putri, P. Prajitno, and D. S. Soejoko, "Computer-aided diagnosis (cad) ct images for abnormal cervix using region-based snake model and support vector machine (SVM)," in *Journal of Physics: Conference Series*, Institute of Physics Publishing, Oct. 2018. doi: 10.1088/1742-6596/1097/1/012007.

[22] E. Jin, J. A. Noble, and M. Gomes, "A Review of Computer-Aided Diagnostic Algorithms for Cervical Neoplasia and an Assessment of Their Applicability to Female Genital Schistosomiasis," *Mayo Clinic Proceedings: Digital Health*, vol. 1, no. 3, pp. 247–257, Sep. 2023, doi: 10.1016/j.mcpdig.2023.04.007.

ISSN: 2252-4274 (Print)
ISSN: 2252-5459 (Online)

[23] V. Mosiichuk, A. Sampaio, P. Viana, T. Oliveira, and L. Rosado, "Improving Mobile-Based Cervical Cytology Screening: A Deep Learning Nucleus-Based Approach for Lesion Detection," *Applied Sciences (Switzerland)*, vol. 13, no. 17, Sep. 2023, doi: 10.3390/app13179850.

[24] D. Champin, M. C. Ramírez-Soto, and J. Vargas-Herrera, "Use of smartphones for the detection of uterine cervical cancer: A systematic review," Dec. 01, 2021, *MDPI*. doi: 10.3390/cancers13236047.

[25] R. B. Hassan, E. Armawan, and I. F. D. Arya, "Visual Inspection Test with Acetic Acid for Cervical Cancer Screening: Willingness and Acceptability among Reproductive Age and Married Women," *Althea Medical Journal*, vol. 5, no. 2, pp. 98–104, Jun. 2018, doi: 10.15850/amj.v5n2.1419.

[26] S. Wang *et al.*, "Cervical Cancer Screening via Visual Inspection with Acetic Acid and Lugol Iodine for Triage of HPV-Positive Women," *JAMA Netw Open*, vol. 7, no. 3, p. E244090, Mar. 2024, doi: 10.1001/jamanetworkopen.2024.4090.

[27] T. W. Utami *et al.*, "Visual Inspection of Acetic Acid (VIA) as a Promising Standard for Cervical Cancer Screening Inspeksi Visual dengan Asam Asetat (IVA) sebagai Standar Metode Skrining Kanker Serviks yang Menjanjikan," 2014.

[28] L. Hu *et al.*, "Deep learning-based image evaluation for cervical precancer screening with a smartphone targeting low resource settings - Engineering approach," *42nd Annual International Conference of the IEEE Engineering in Medicine \& Biology Society (EMBC)*, pp. 1944–1949, 2020.

[29] A. J. Andreotta, N. Kirkham, and M. Rizzi, "AI, big data, and the future of consent," *AI Soc*, vol. 37, no. 4, pp. 1715–1728, Dec. 2022, doi: 10.1007/s00146-021-01262-5.

[30] D. Zion, L. Gillam, and B. Loff, "The Declaration of Helsinki, CIOMS and the ethics of research on vulnerable populations," 2000. doi: 10.1038/76174.