

SEVIA

Smartphone Enhanced Visual Inspection with Acetic Acid

HOW A MOBILE HEALTH SOLUTION HAS LED TO A
POSSIBLE AI SOLUTION

DR.KAREN YEATES, DEPARTMENT OF MEDICINE

<https://vimeo.com/359683048>

SEVIA: an mHealth Solution



SEVIA Functionalities

- Clinical decision support and provider supervision
- Secure and compliant data storage
- Real-time M&E
- Built-in patient navigation
- Training & validation for AVE technology



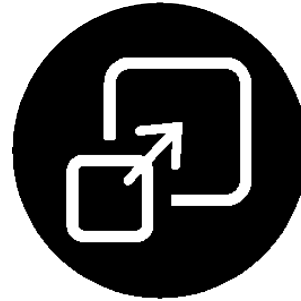
SEVIA System Advantages



**Internet
Optional**



**Less Expert
Dependent**



**Scalable &
Adaptable**

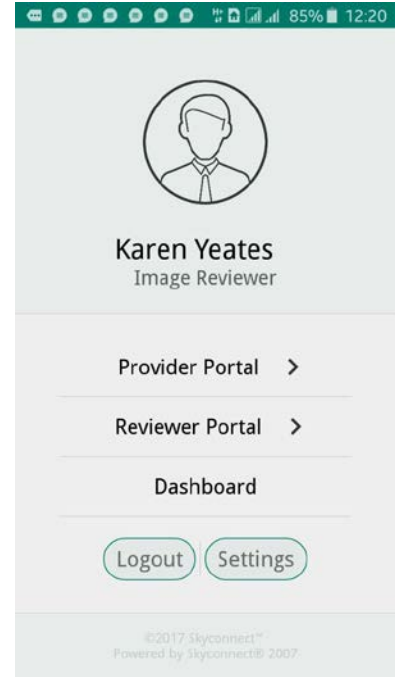
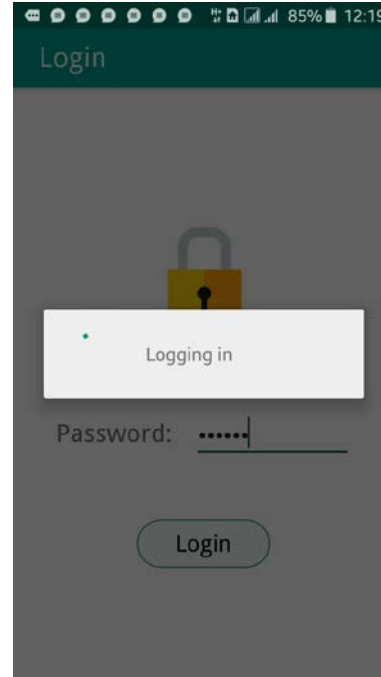
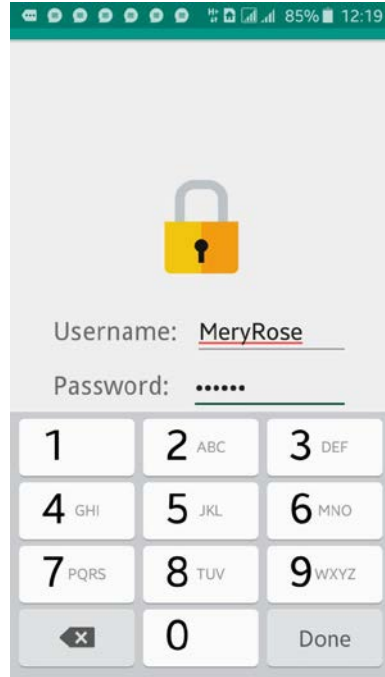
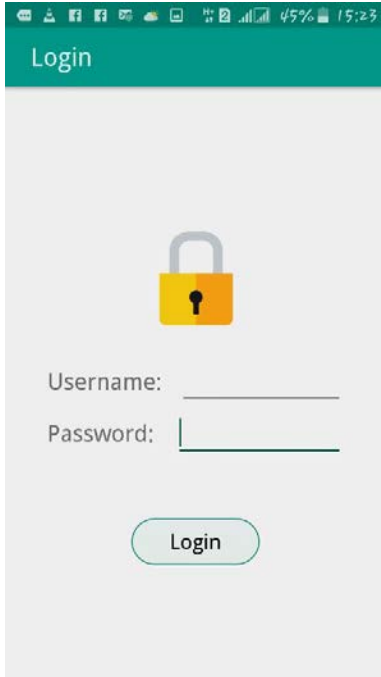


**Cost effective
< \$1 USD per woman**



SEVIA for Health Provider Training

Mobile Application Interface



Provider Portal

Provider Portal

CCS Client Data Capture →

Saved Cases to be Submitted →

Reviewer Responses →

Mismatched Assessments logs →

Client Data

Phone number

Visit date: Choose date

Client names

First initial

Middle initial

Last initial

Phone No: _____

Age: _____

Client Data

Has patient received PITC?:
 Yes No

HIV Status:
 Positive
 Negative
 Unknown

CCS Facility: _____


Client number: _____

CTC number: _____

Visit Status: _____

Client Data

Capture at least one (1) photo



Provider Assessment

VIA neg

VIA+ for cryotherapy

VIA+ for LEEP

Suspect Cancer

Refer

Via not completed due to cervicitis

Via not completed due to

Screening, Image Generation, Diagnosis & Submission



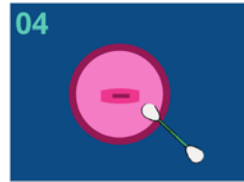
01 Prepare for screening procedure with double gloves, speculum, headlamp or torch and smartphone.



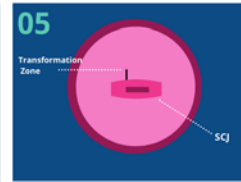
02 Perform the speculum exam and keep the speculum in place to perform SEVIA examination/test.



03 Adjust the light source. The best view is achieved with light shining down from a headlamp or from the side with a torch held by an assistant.



04 Use cotton swab to clean the cervix with saline and remove discharge, blood or mucus.



05 Confirm that you can see the entire transformation zone, and identify the SCJ and the area around it.



06 Apply acetic acid to the cervix and wait 1-2 minutes to allow changes to develop.



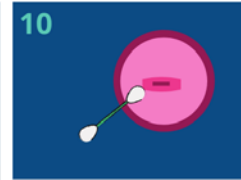
07 Inspect the SCJ carefully. Look for any raised and thickened white plaques or acetowhite epithelium.



08 Remove and dispose of one pair of gloves to prevent contamination.



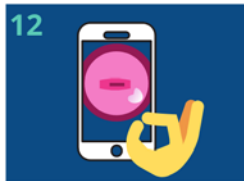
09 Using the SEVIA app, take 3 good quality images of the whole cervix. If the whole cervix is not visible, take 3 good quality images that together show all quadrants of the cervix.



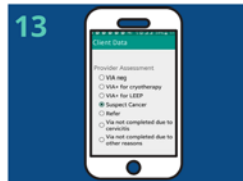
10 Use a fresh cotton swab to remove any remaining acetic acid from the cervix and vagina.



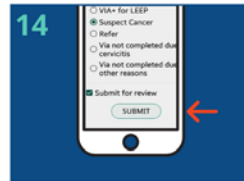
11 Gently close and remove the speculum, placing it in a decontamination solution.



12 To make your diagnosis: review images on the smart phone, using your fingers to zoom in and out.



13 Enter your diagnosis and treatment plan into the SEVIA app.



14 Press submit in the SEVIA app to submit the client case information (including cervical images) to the assigned reviewer.



15 Reviewer will receive and review client case information and cervical images in real time.

SEVIA Process Video:

<https://vimeo.com/383647015>

Cervical Image Review Process



1. HEALTHCARE PROVIDER CONDUCTS SEVIA EXAM

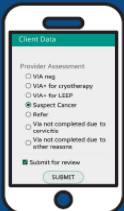

The healthcare provider conducts a speculum exam, and using SEVIA, takes 3 good quality images of the cervix. The provider then selects a diagnosis and treatment plan, which is submitted with the images through the SEVIA Provider Portal.

Provider Assessment

- VIA neg
- VIA for cryotherapy
- VIA for LEEP
- Suspect Cancer
- Refer

2. IMAGE REVIEWER RECEIVES CERVICAL IMAGES IN REAL-TIME

The assigned Image Reviewer receives a notification from SEVIA. The reviewer is blinded to the provider's diagnosis and treatment plan, but can assess the de-identified cervical images in real-time.



3. IMAGE REVIEWER SUBMITS DIAGNOSIS AND TREATMENT PLAN

After assessing the cervical images, the reviewer selects a diagnosis and submits his/her response through SEVIA.

Provider Assessment

- VIA neg
- VIA for cryotherapy
- VIA for LEEP
- Suspect Cancer
- Refer
- Via not completed due to inexperience
- Via not completed due to other reasons

Submit for review


SUBMIT

4. SEVIA DETERMINES PROVIDER CONCORDANCE



SEVIA compares diagnoses and treatment plan from the provider and reviewer and notifies both parties whether an agreement was made. If both parties agree, the client can continue down the care pathway.

VIA neg	null	null	VIA neg
VIA for LEEP		Referred for LEEP treatment	VIA neg
VIA neg		No treatment required	VIA neg



5. PROVIDER/REVIEWER DISCORDANCE

If the provider and reviewer diagnoses and treatment plans do not agree, SEVIA will prompt them to connect via phone call or message through the app. Both parties will discuss client case information (providing clinical mentorship to healthcare provider) before the client proceeds with further treatment.

VIA neg	null	null	VIA neg
VIA for LEEP		Referred for LEEP treatment	VIA neg
VIA neg		No treatment required	VIA neg

6. PROVIDER MONITORING & QUALITY ASSURANCE

SEVIA can track provider submissions over time, and can monitor agreement rates at the provider level, facility level, and system level.



Provider Graduation & Quality Assurance

A screenshot of a mobile application interface. At the top, there is a status bar with various icons and a battery level of 68%. Below the status bar is a circular profile icon of a person. Underneath the icon, the name "Catherine Anthony" is displayed with a graduation cap icon, followed by "Kasulu District Hospital". A menu is visible with three items: "Provider Portal" with a right-pointing chevron, "Reviewer Portal" with a right-pointing chevron, and "Dashboard". At the bottom of the menu are two buttons: "Logout" and "Settings". At the very bottom, there is a footer with the text "©2017 Skyconnect™ Powered by Skyconnect® 2007".

A screenshot of a mobile application interface titled "User Profile". The name "Catherine Anthony" is prominently displayed. Below the name, there is a phone icon followed by the number "0623050385" and a person icon followed by the word "Provider". A horizontal line separates this information from a statistics section. The statistics section has two columns: "Submissions" with the value "305" and "Accuracy" with the value "95.7%". Another horizontal line separates this from a "Facilities, 1" section. Below this, there is a vertical bar followed by the text "Kasulu District Hospital, Kasulu, Kigoma, Tanzania". At the bottom, there is a line of text: "Last activity: 2017-02-11 20:21:32".

A screenshot of a mobile application interface titled "Client Data". It features a "Provider Assessment" section with several radio button options: "VIA neg", "VIA+ for cryotherapy", "VIA+ for LEEP", "Suspect Cancer" (which is selected), "Refer", "Via not completed due to cervicitis", and "Via not completed due to other reasons". Below this list is a checked checkbox labeled "Submit for review". At the bottom of the screen is a large button labeled "SUBMIT".



SEVIA in Tanzania

SEVIA in Tanzania 2016-2019: Provider Training

- First group of providers trained: **July 20, 2016**
- SEVIA providers were incentivized to provide mini-campaigns and on the job screening to reach a target 200 women screened per month per site from date of training until **December 15, 2016**
- Number of providers trained: **120**
- Number of image reviewers trained on the platform: **34**
- Number of sites: **61**
- Number of clients screened through to present: 35,000

SEVIA in Tanzania 2016-2018: Screening Results

- Overall VIA Positivity rate: **6.9%**
 - VIA Positive and received/referred for Cryotherapy: **4.6%**
 - VIA Positive and received/referred for LEEP: **0.9%**
 - VIA Positive and referred and Suspect Cancer: **1.4%**
- HIV Positive Clients: **21.6%**
- HIV VIA Positivity rate: **8.9%**
 - VIA Positive and received/referred for Cryotherapy: **5.4%**
 - VIA Positive and received/referred for LEEP: **2.2%**
 - VIA Positive and Referred and Suspect: Cancer **1.1%**

SEVIA in Tanzania: Where are we now?



50+

Health Facilities



130+

Health Providers



10,000+

Women Screened



100,000+

Labeled Images



SEVIA in national
CECAP program

Requires Implementation Research

- Demonstrate feasibility, acceptability, and usability of the SEVIA platform (App) to improve training and quality of health provider skills in visual assessment of the cervix
- Demonstrate that the navigation ‘tools’ within the platform can improve tracking and follow-up of women who have received cervical cancer screening, especially those who require follow-up and further treatment
- Demonstrate functions of the SEVIA platform to systematically capture, track and report process, programmatic and clinical data in real-time where needed to support country HMIS
- Demonstrate sustainability to be transferred and supported to the health system in a robust and cost-effective manner to allow for ongoing use for scaling and customization for health system needs

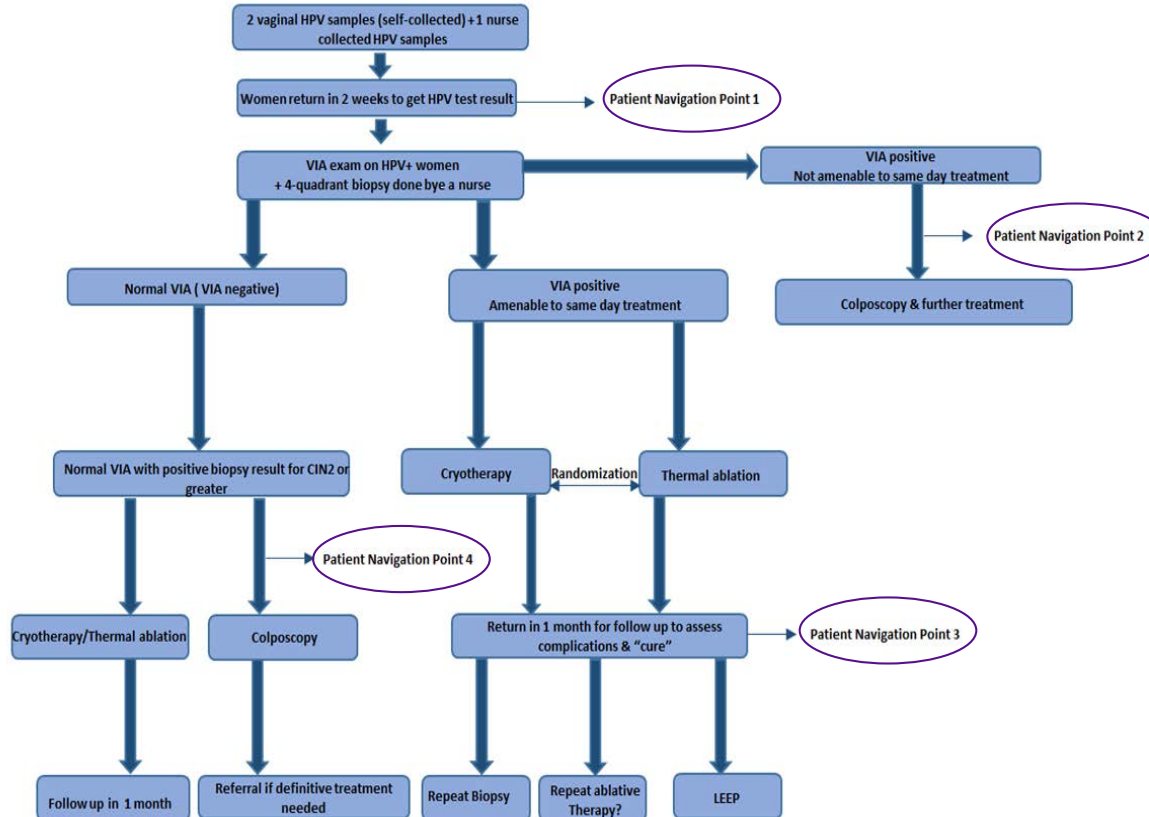


SEVIA Patient Navigation tools

Automated Patient Navigation

- **Patient navigation tools** have been designed for SEVIA platform.
- Navigation facilitates the cervical cancer screening process and can **reduce loss to follow-up** for women undergoing HPV screening to complete the care pathway.
- Women in the program will be asked to provide their mobile number (with consent to be contacted via SMS/voice call).
- SEVIA platform will **automatically initiate SMS messages** and/or voice messages (or both, per participant preference) with reminders to return at specific points in the care pathway.

Patient Navigation Throughout Care Pathway



Automated Visual Evaluation of the Cervix

- Has the potential to reduce health provider error and eliminate the need for resource intensive training of health providers to perform high quality visual inspection of the cervix to screen for pre-cancerous lesions
- Has to be low-cost and scalable in any setting
- Requires robust efficacy trials and WHO pre-qualification
- In combination with HPV testing has the ability to provide a solution for elimination of cervical cancer deaths if screening with AVE is introduced along with widespread HPV vaccination of 9-13 year old girls in LMICs

First Deep Learning Algorithm



JNCI J Natl Cancer Inst (2019) 111(9): djy225

doi: 10.1093/jnci/djy225

First published online January 10, 2019

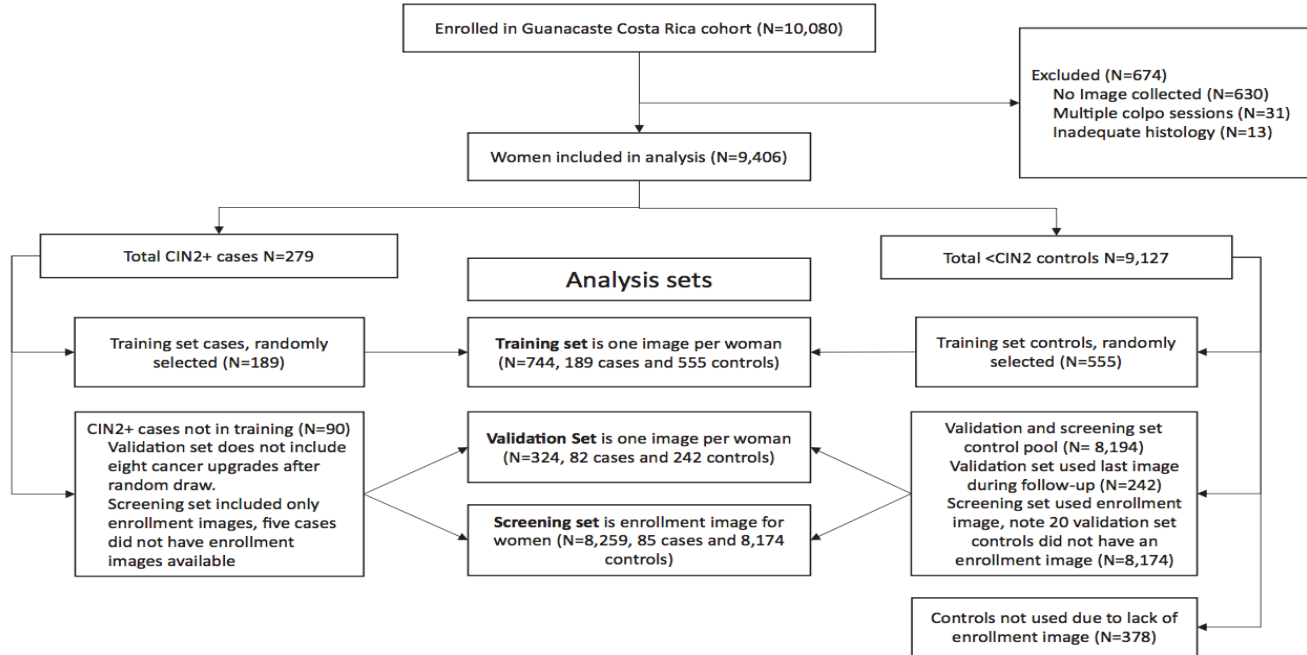
Article

ARTICLE

An Observational Study of Deep Learning and Automated Evaluation of Cervical Images for Cancer Screening

Liming Hu, David Bell, Sameer Antani, Zhiyun Xue, Kai Yu, Matthew P. Horning, Noni Gachuhi, Benjamin Wilson, Mayoore S. Jaiswal, Brian Befano, L. Rodney Long, Rolando Herrero, Mark H. Einstein, Robert D. Burk, Maria Demarco, Julia C. Gage, Ana Cecilia Rodriguez, Nicolas Wentzensen, Mark Schiffman

Training and Validation for AVE



AVE Detection Algorithm

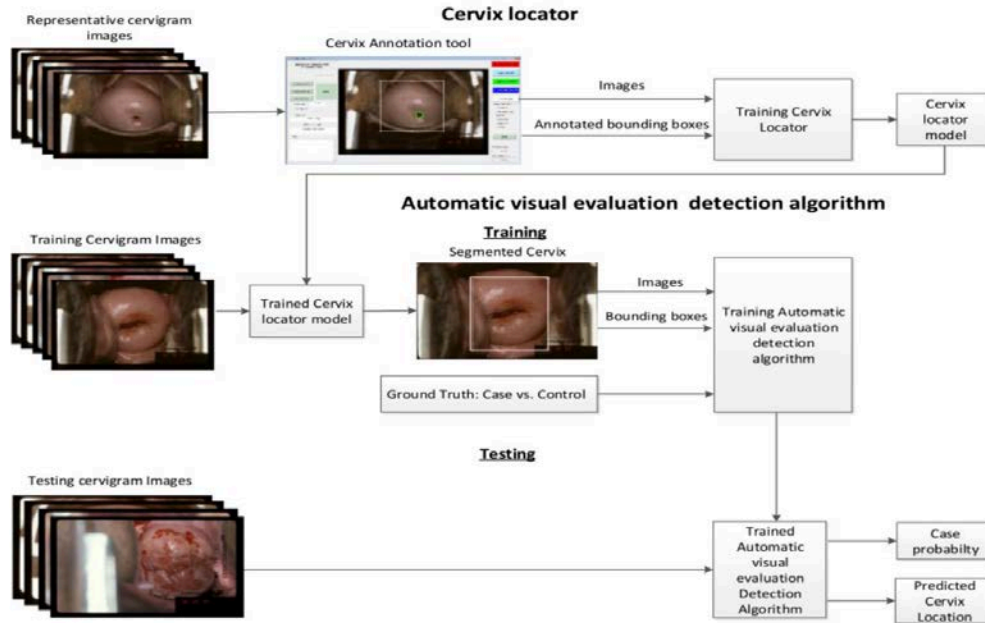
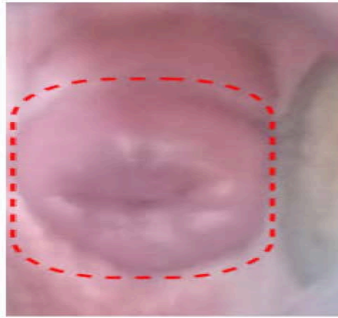


Figure 2. The system architecture of the automated visual evaluation algorithm. Two models are trained: a cervix locator (top), and the automated visual evaluation detection algorithm (bottom). The final validation algorithm incorporated both cervix locator and automated visual evaluation.

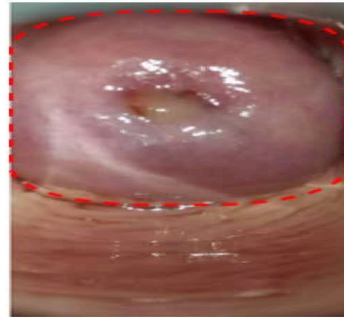
Automated Visual Evaluation of the Cervix

- The challenges of implementing AVE technology in LMICs include limited internet access and the high cost of obtaining digital colposcopy images.
- To show that it is technically feasible, we need to answer two core questions:
- 1) Can a mobile phone camera capture high quality cervix images in primary care settings when used by health workers with minimal training?
- Can the algorithm provide feedback to the health workers in real time to help capture high quality images?
- 2) Can an AVE algorithm running on a mobile platform accurately detect precancerous lesions in a reasonable time with onboard computing resources (i.e. without resorting to cloud computing)?

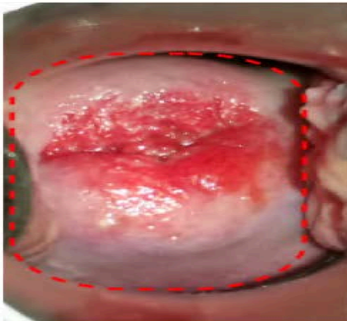
Image quality on a simple Android smartphone is important



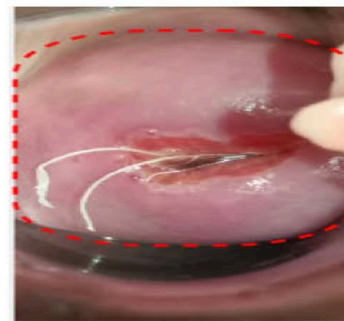
(a)



(b)



(c)



(d)

IV. CONCLUSION

We demonstrated two key aspects required for smartphone-based cervical precancerous screening for LMIC settings: (1) the ability of a detection algorithm to run quickly on the limited computing resources of a smartphone and (2) a quality assessment algorithm that can quickly determine whether a smartphone image contains an in-focus cervix. Ongoing work involves collecting the data necessary to fully train a detection algorithm on smartphone images. With the advancement of better and faster deep learning based general object detection methods, i.e. EfficientDet [14], and RefinedDetLite [15], and continuous improvement of smartphone hardware and software, we will continue investigating better and faster methods for VIA image acquisition and cervical precancerous lesion detection.

Gates Foundation and Unitaid have funded the next steps

- Scale up across Tanzania within the national health system and introduction of the program in Kenya within a new mobile health 'exchange' program to provide UHC to low-income earners
- Introduction of SEVIA and patient navigation tools to Cote D'Ivoire, Burkina Faso, Guatemala and the Philippines
- Our consortium will collaborate with NIH-NCI to feed cervical images, HPV DNA test results, HIV status and histopathology slide images to the team at NLM and Gates Intellectual Ventures
- Further validation of the AVE algorithm will take place in Tanzania starting in March
- Efficacy trials will be needed

Acknowledgements

- Dr. Ophira Ginsburg, NYU Langone and NYU Center for Population Health
- Dr. Mark Schiffman
- Global Good/Intellectual Ventures
- Gates-Grand Challenges Africa
- Grand Challenges Canada
- NIH-NCI and the Cervical Cancer Moonshot
- My awesome team!!



QUESTIONS?

