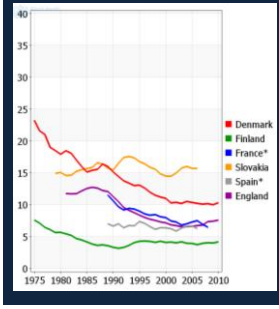
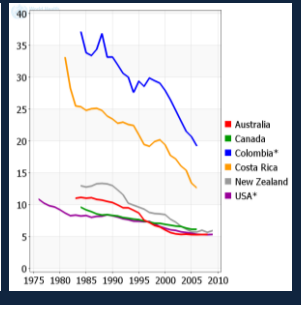
Professor Nimmi Ramanujam, Ph.D.
Director, Global Women's Health Technologies
Professor of Biomedical Engineering,
Global Health and Pharmacology, Duke University

Henrietta Lacks 1930-1951

Cervical Cancer Decline from 1975-2010
GLOBOCAN 2012 (IARC)



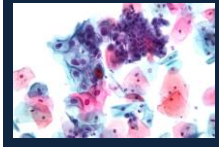


George Papanicolau 1883-1962

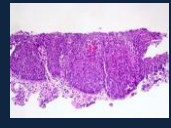
Hans Hinselmann
1884-1959

Reduction in Mortality attributed to early Screening and Diagnosis

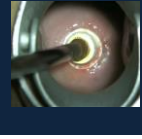
Screening



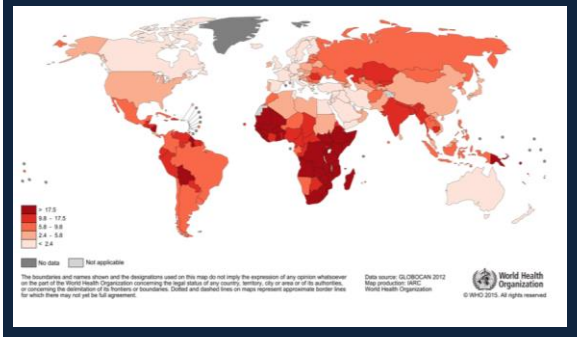
Diagnosis



Treatment



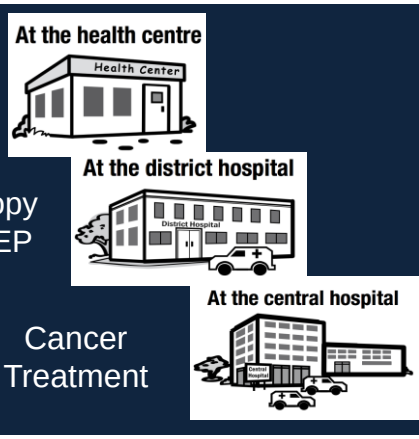
Cervical Cancer Mortality
Source: IARC (2012)



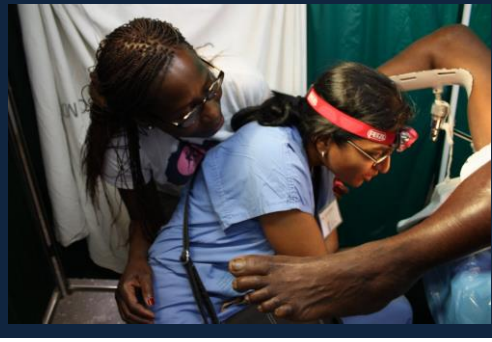
VIA/HPV

Colposcopy
Cryo/LEEP

Cancer
Treatment



Visual Inspection with Acetic Acid (VIA)



Challenge
Quality Control and Teleconnectivity

Mobile Screening in Tamil Nadu, India

Challenge
Health Worker Shortage

Majengo Clinic, Moshi Tanzania

Primary care Provider
Pap, HPV and Colposcopy
In One Visit

Specialist
Provide consultation on
Images and guide biopsy

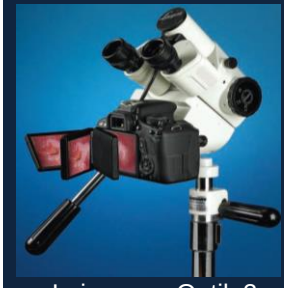
No cancers lost to follow up

No unnecessary referrals and biopsies

Low capital investment

Reimagining the Colposcope

Colposcopy/Cervicography

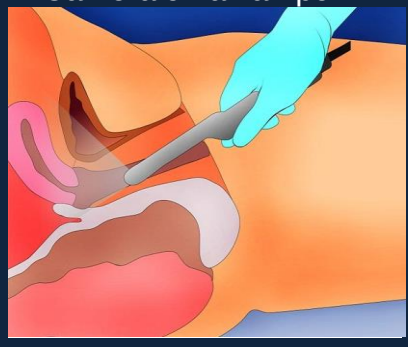


Leisegang Optik 2
@ 3.75, 7.5, and 15 X
US$ 20,000 and >150 lbs

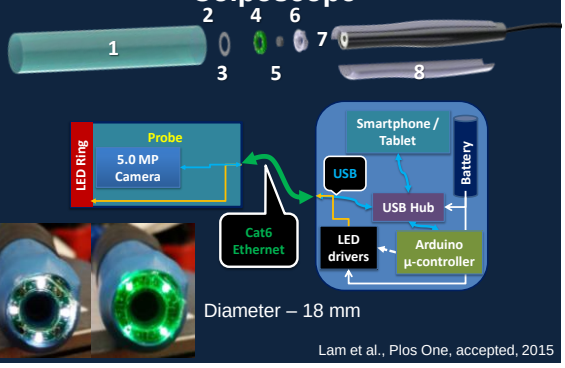
Canon SX50HS
@ 2.75X
US$ 500 and 1.5 lbs

Portable Colposcopes

Can we put the Light Source and Camera on a Tampon?



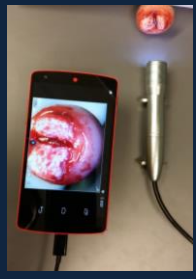
POC*ke*T (Point Of Care Tampon) Colposcope



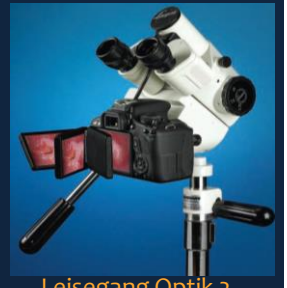
Diameter – 18 mm

Lam et al., Plos One, accepted, 2015

Colposcopy/Cervicography



POCkeT Colposcope
US$ 500
7 - 27 µm resolution



Leisegang Optik 2
US$ 20,000
5 - 35 µm resolution

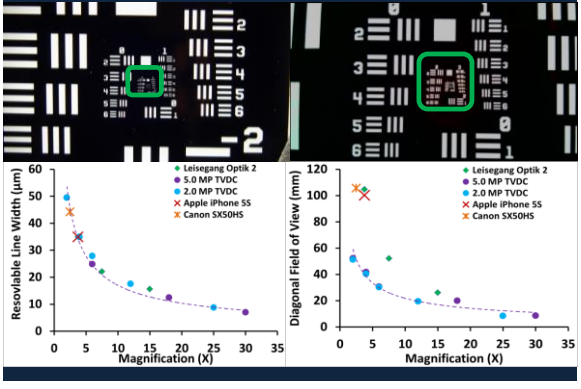
Illumination Characteristics

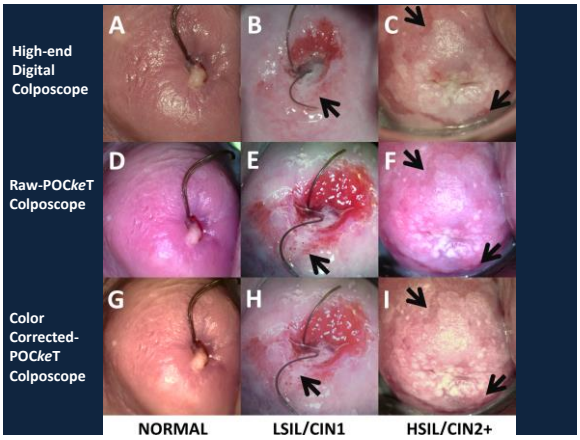
System	Illumination type	Electrical Power (W)	Optical Power (mW)	Irradiance (mW/cm²)
Leisegang Optik	White LED 5000k	18	79.3	183.9
	SP Red Filter	18	32.1	77.3
POCketT Colposcope	White LED 5000k	2.4	1.07	2.36
	Green LEDs	1.2	0.36	0.95

Detector Characteristics

System	Detector Type	Resolution (MP)	Diagnnal FOV
Leisegang Optik	18 MP CMOS	35 µm	30 mm
POCketT Colposcope	5 MP CMOS	35 µm	52 mm

Resolution – 35 µm or 14 lp/mm





Concordance between the Leisegang Optik and the POC*ke*T Colposcope

Clinical Study Protocol (DUMC)

Speculum Placement + Vinegar (5% Acetic Acid)

↓

Leisegang Optik 2

↓

POC*ke*T Colposcope

35 Image Pairs

↓

Standard of Care Biopsy

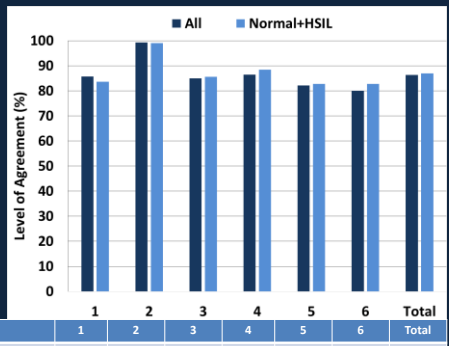
↓

Blinded Image Interpretation – Ob./Gyn.
(3 Duke & 3 International)

→ Reid Index
Lesion Margin, Color, Vessels

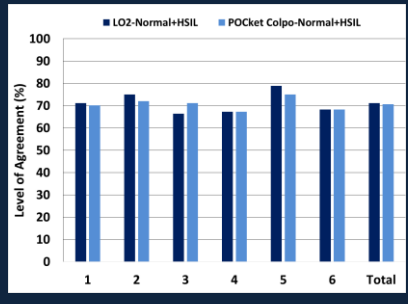
Physician Readers

Concordance Testing across 6 Physicians



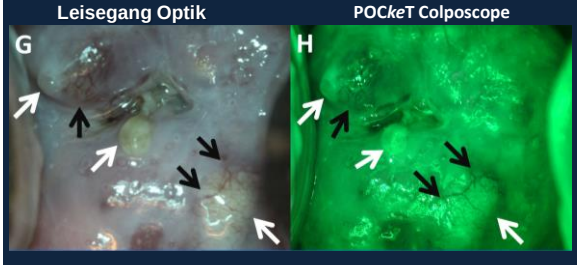
Clinician #	1	2	3	4	5	6	Total
All (*kappa*)	0.4444	0.971	0.4913	0.5019	0.4380	0.5360	0.6256
Normal+HSIL (*kappa*)	0.3739	0.9592	0.5455	0.6139	0.3777	0.6014	0.6319

Comparison of Physician Reading to Gold Standard Pathology

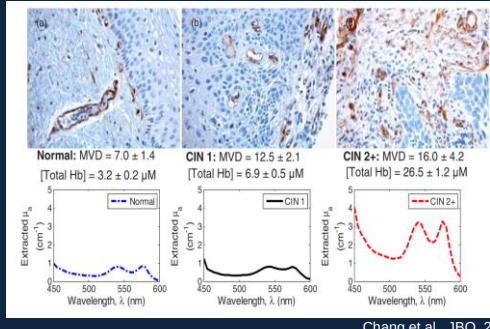


Improving Specificity

Imaging Blood Vessels with a Green Filter

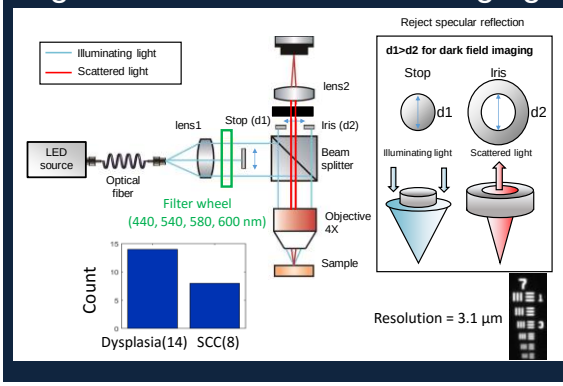


Can we use Neovascularization to Detect CIN 2+?

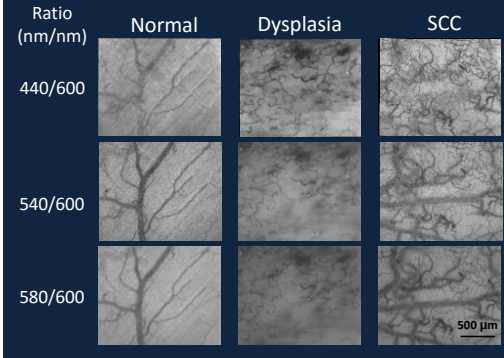


Chang et al., JBO, 2009

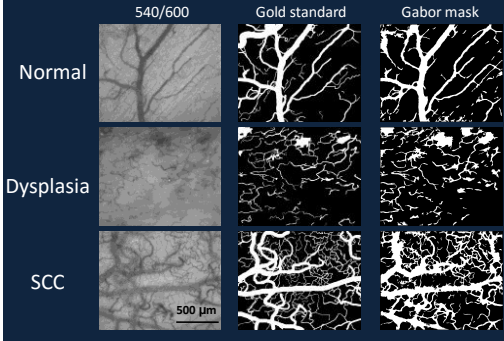
High Resolution Vascular Imaging



High-Resolution Vascular Imaging

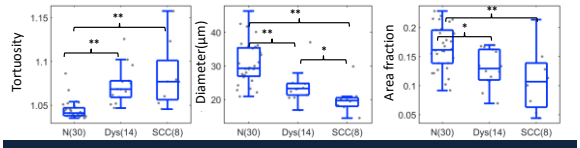


High-Resolution Vascular Imaging

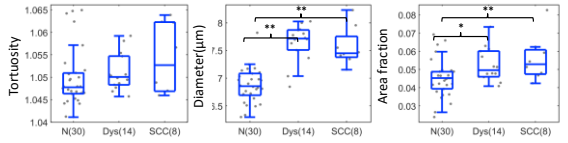


Diagnostic Vessel Characteristics

Large vessels



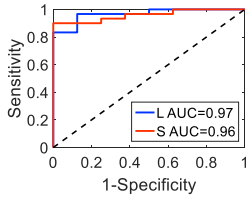
Small vessels



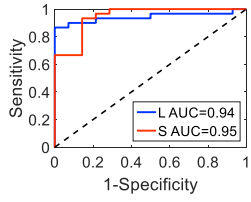
* : p<0.05 ** : p<0.01

Classification results

Normal vs. SCC



Normal vs. Dysplasia



Features used: tortuosity, diameter, area fraction

Summary

- Rethinking the implementation of the traditional colposcope to a tampon configuration enables low cost innovation with comparable performance
- Vascular contrast decoupled from scattering is enhanced in severe dysplasia
- Multi wavelength dark field microscopy unravels vessel contrast at different depths in precancerous lesions

Collaborators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Funding

- NIH R21 Quick Trials – 2012-2015
- NIH RO1 2015-2020
- NIH R01 Quick Trials 2015-2018
- NIH STTR Phase II grant 2014-2016
- Duke School of Medicine Grant 2014-2015
- DGHI – PRATT seed grant 2014-2015