HUAZHONG UNIVERSITY OF SCIENCE AND TECHNOLOGY

TSINGHUA MEDICINE

AI to Address Cervical Cancer Screening Challenges

- A Five-year Outcome Study Among 1.76 Million Women in China

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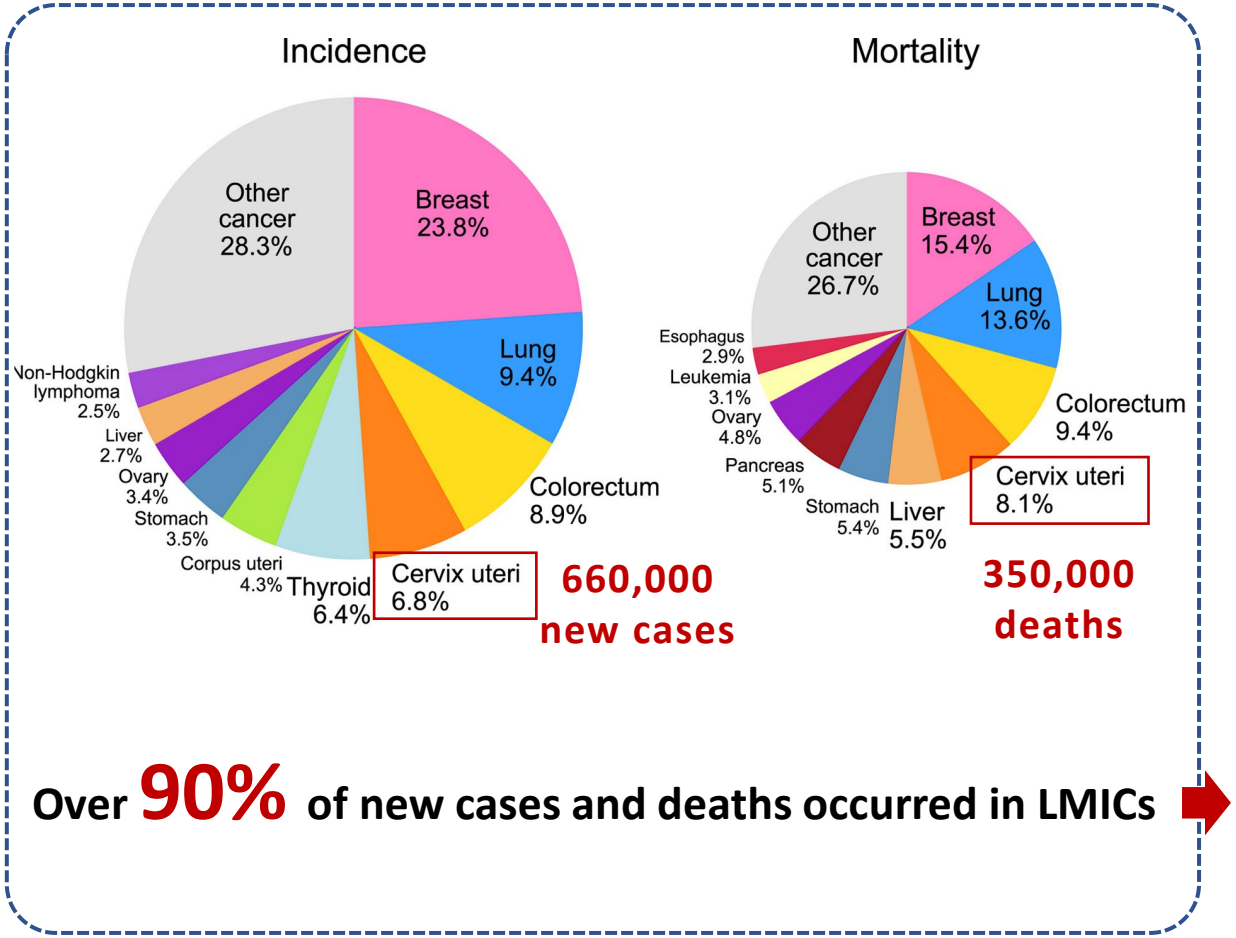
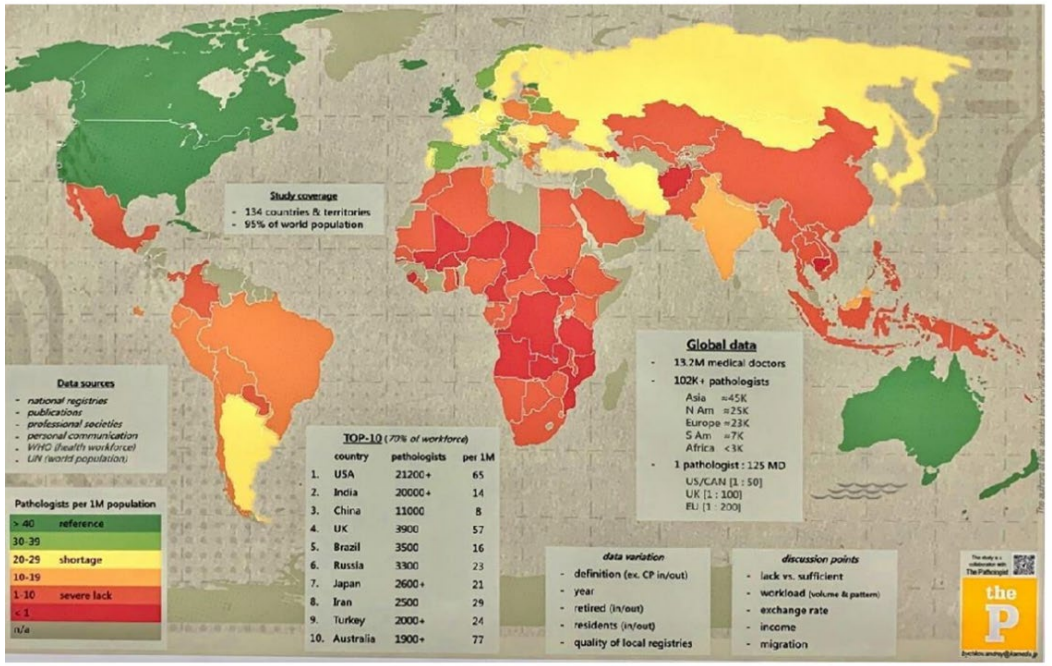
Global burden of cervical cancer

Global cervical cancer statistics in women

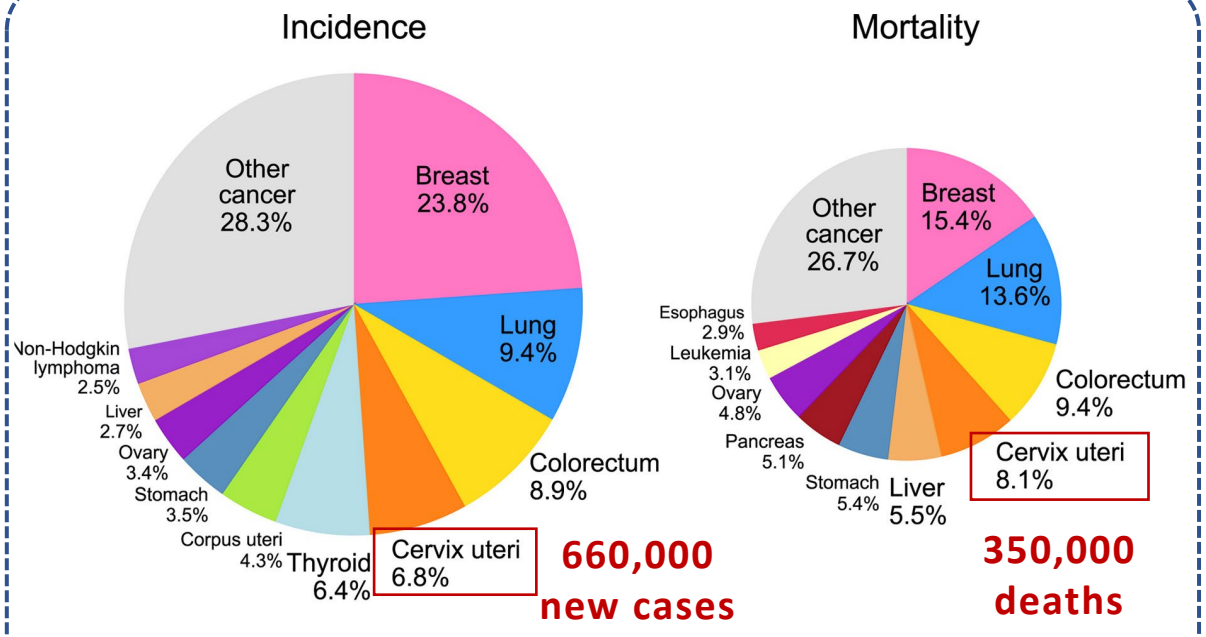




/ Andrey Bychkov MD, PhD, at the 2022 annual meeting of United States and Canadian Academy of Pathology (USCAP)

Global burden of cervical cancer & challenge in screening

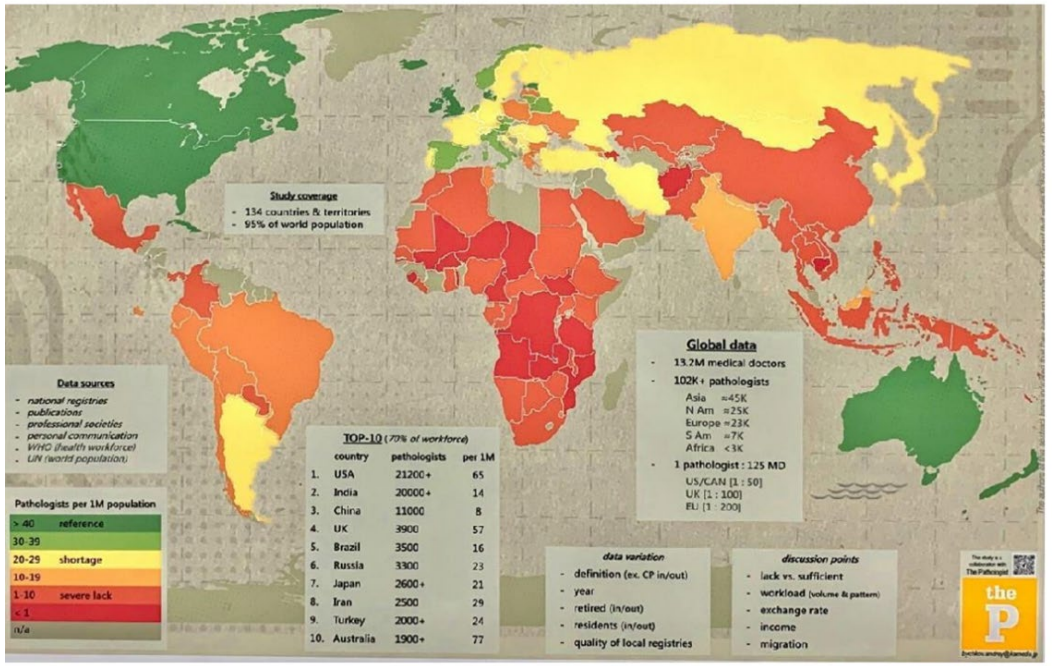
Global cervical cancer statistics in women



Over 90% of new cases and deaths occurred in LMICs

Challenge in cervical cancer screening worldwide

- **Shortage** of specialized workforce (pathologists)
- **Inaccessible** pathology services
- **Time consuming** screening process
- **High cost** of screening



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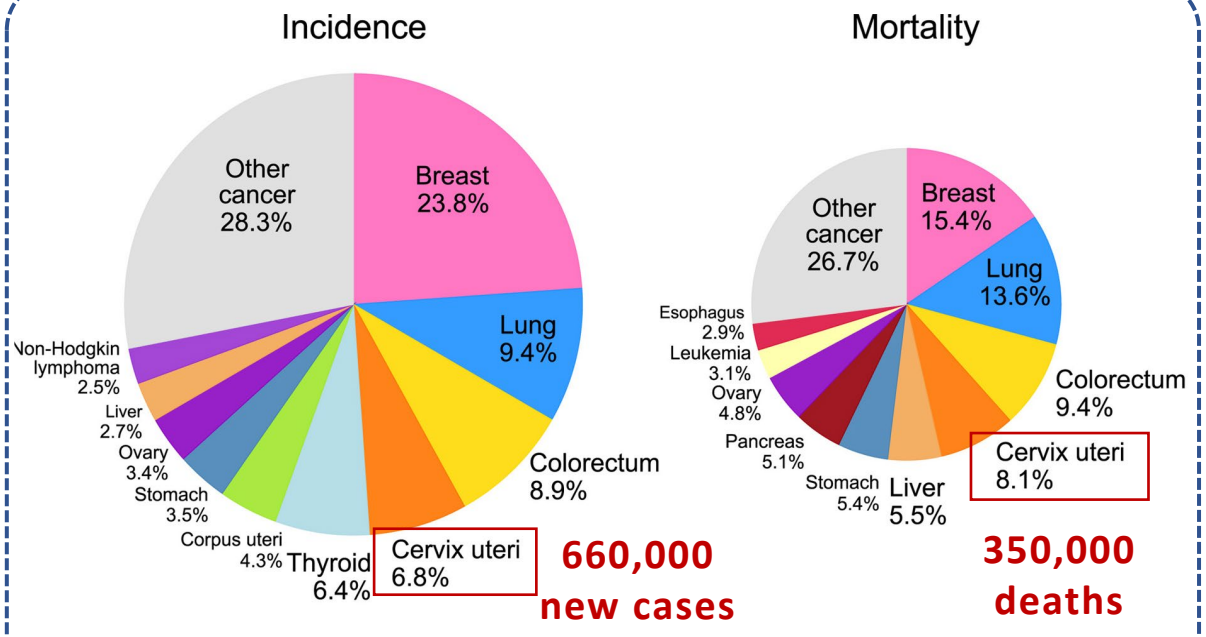
Cervical cancer burden & targeted screening rate in China

Cervical cancer burden in China



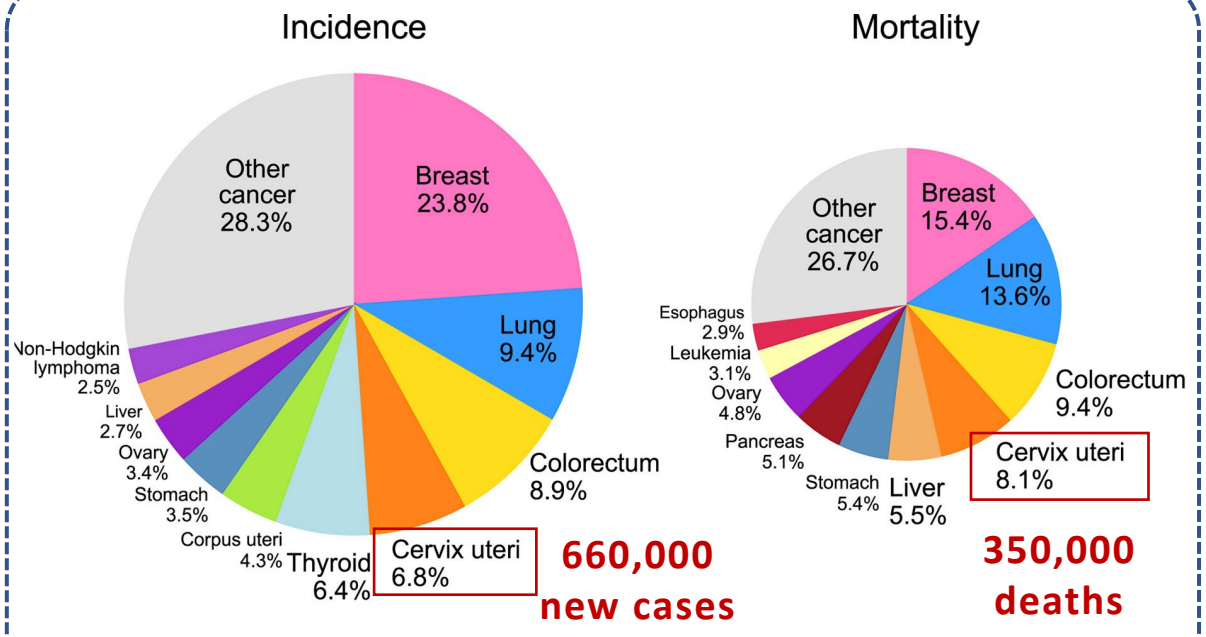
In 2022, China has 16% new cases and 23% deaths from cervical cancer of the world

Cervical cancer screening program in China

- **Initiated Rural Cervical Cancer Screening Program (NCCSP) in 2009 but by 2019 coverage rate was only 30%**
- **Started a 2023-2030 National Action Plan for Accelerating the Elimination of Cervical Cancer**
- **Aim: Cervical cancer screening rate increase to 50% by 2025 and 70% by 2030 among women aged 35-64 years old**

AI to Address Cervical Cancer Screening Challenges

Global burden of cervical cancer



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Cervical cancer screening program in China

- **Initiated Rural Cervical Cancer Screening Program (NCCSP) in 2009 but by 2019 coverage rate was only 30%**
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Huge population

Low screening rate

Shortage of pathology

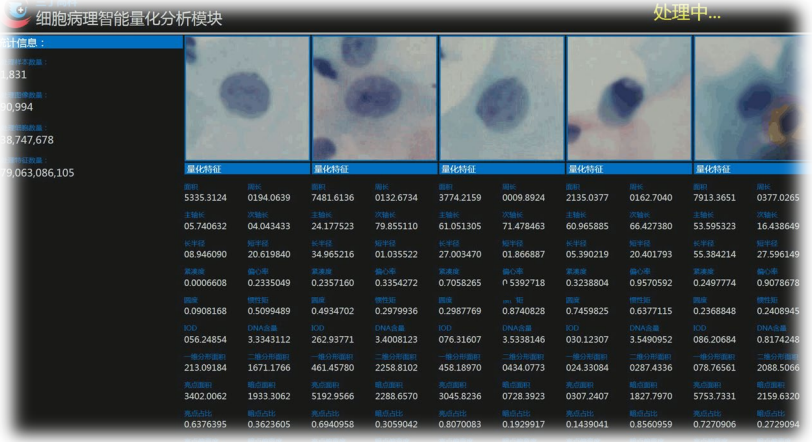
High cost

AI-assisted Cell Pathology System provides opportunity to address these challenges

AI Cell Pathology System

AI Foundation Model

Cyto Brain 宫颈癌模型



Digital Data Processing & Cloud Diagnosis Platform

人工智能云诊断平台

Robots for Slide Preparation & Scanning

制片 染色 扫描仪

AI Cell Pathology System for Cervical Cancer Screening

1. Registration and Sample Collection



Screening registration → Simpling → Samples storing

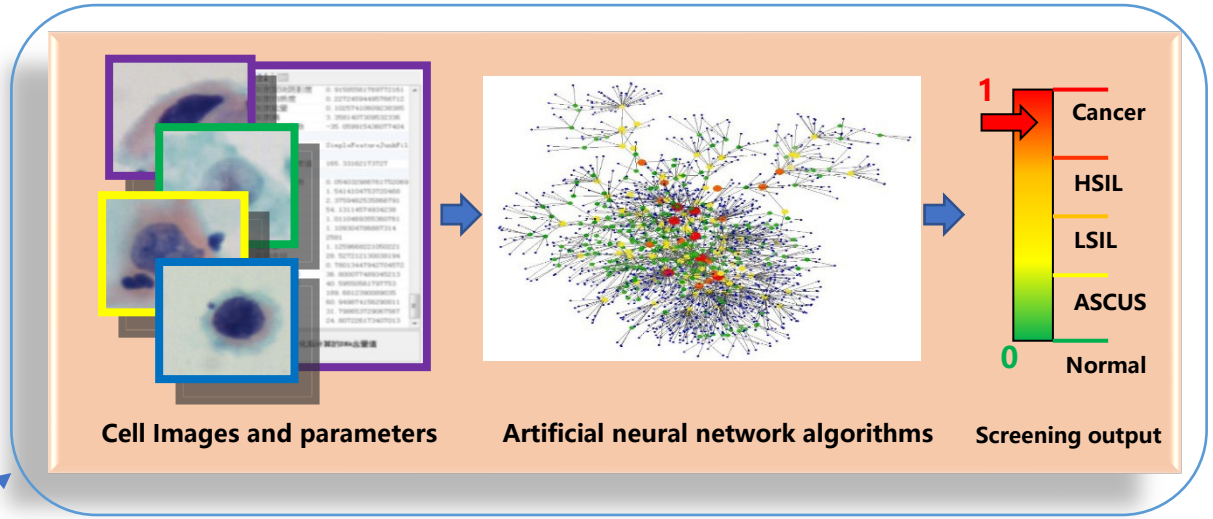
Health workers in local health centres, or maternal and child health hospitals

2. AI-assisted cytology screening



Prepare and stain slides → Scan slides and upload → AI-based diagnosis

Slide preparation technicians and diagnostic health workers in central laboratory



3. Reviewing and reporting

All abnormal cytology (positive) cases

+

10% normal cytology (negative) cases

Review and reports confirmation by pathologists → Received reports online

Cytopathologists in central laboratory

Referral and treatment for positive cases

Research Setting, Objective

Setting

A 3-year (2018-2020) cervical cancer screening program among 1.2 million women in rural Hubei Province, China, where cervical cancer incidence and mortality are relatively high compared with other regions.

Objective

To evaluate the 5-year impact of this AICPS-based cervical cancer screening program (2018-2023)

Research Setting, Objective

Setting

A 3-year (2018-2020) cervical cancer screening program among 1.2 million women in rural Hubei Province, China, where cervical cancer incidence and mortality are relatively high compared with other regions.

Objective

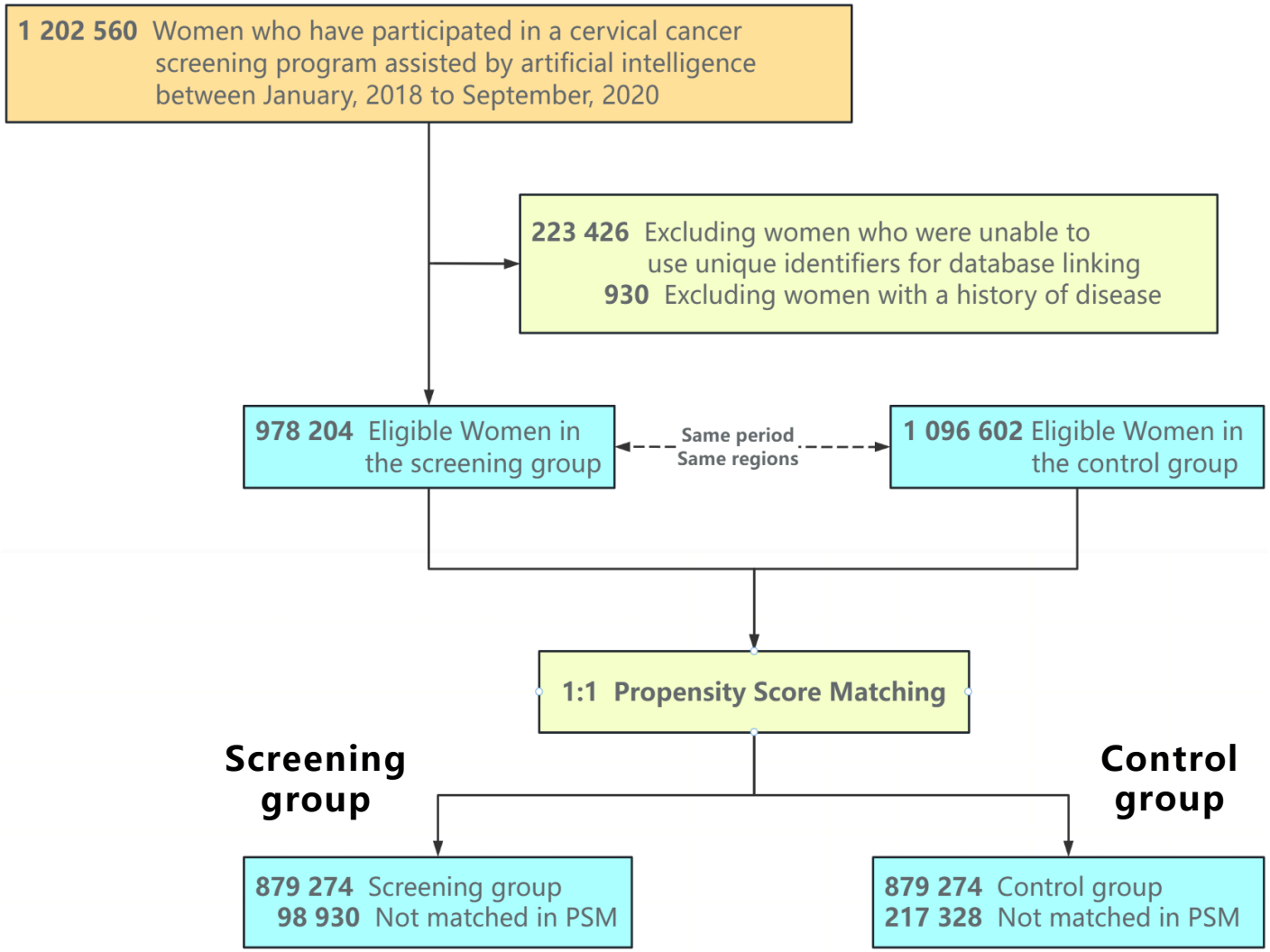
To evaluate the 5-yr impact of AI Cell Pathology System-based cervical cancer screening program by 2023

Research Questions

1. How the AI Cell Pathology System perform in a large-scale community-based cervical cancer screening setting?
2. Would women participating in this screening program have lower cervical cancer incidence and mortality, comparing to those not in the screening program?
3. What are the impact on cervical cancer related healthcare utilization?

A Target Trial Emulation Study Among 1·76 Million Women in China

Study Population



Outcome measures

A. Screening performance

Screening sensitivity & specificity

B. Outcomes

1. **High-grade cervical intraepithelial neoplasia (CIN2-CIN3) incidence**
2. **Cervical cancer incidence**
3. **Cervical cancer mortality**

C. Healthcare utilization

1. **Multiple hospitalizations rate**
2. **Hospitalizations from the emergency department rate**
3. **Hospitalization costs**
4. **Length of hospital stays**

n.

Screening performance of the AICPS

- **Performance of the AICPS for detecting cervical intraepithelial neoplasia of grade 2 or worse (CIN2+) in the three-year cervical cancer screening program：**
- **93.5 % Sensitivity； 94.5 % Specificity.**

Screening results	Clinical diagnosis		Sensitivity, % (95% CI)	Specificity, % (95% CI)
	CIN2+, n	Not CIN2+, n		
Positive, n	2,043	46,658	93.46 (92.32, 94.44)	94.53 (94.48, 94.58)
Negative, n	143	806,301		

n.

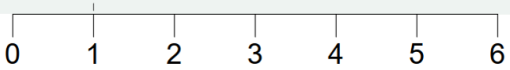
Baseline characteristics before & after propensity score matching

Characteristics	Before 1:1 PSM [a]			After 1:1 PSM [a]		
	Screening group (n=978204)	Control group (n=1096602)	Absolute SMD	Screening group (n=879274)	Control group (n=879274)	Absolute SMD
Age, mean (SD), years	47.96 (8.92)	47.92 (8.94)	0.004	48.11 (8.90)	47.98 (8.81)	0.015
Ethnicity, n (%)						
Han	893916 (91.38)	1008430 (91.96)	0.021	796606 (90.6)	808933 (92.0)	0.050
Minority	84288 (8.62)	88172 (8.04)		82668 (9.4)	70341 (8.0)	
Education level, n (%)						
Primary school and below	292379 (29.89)	240482 (21.93)	0.335	247523 (28.2)	235486 (26.8)	0.031
Junior High School	598924 (61.23)	637049 (58.09)		545290 (62.0)	555189 (63.1)	
High School or Technical School	73397 (7.50)	154507 (14.09)		72957 (8.3)	74261 (8.4)	
College and above	13504 (1.38)	64564 (5.89)		13504 (1.5)	14338 (1.6)	
Residential district, n (%)						
Rural	887265 (90.70)	841158 (76.71)	0.386	796606 (90.6)	788577 (89.7)	0.001
Urban	90939 (9.30)	255444 (23.29)		90939 (10.3)	90697 (10.3)	
Marital status, n (%)						
Married	940347 (96.13)	1033379 (94.23)	0.154	842221 (95.8)	841227 (95.7)	0.064
Divorced	9948 (1.02)	23968 (2.19)		9844 (1.1)	14401 (1.6)	
Widowed	21533 (2.20)	17848 (1.63)		20838 (2.4)	15591 (1.8)	
Unmarried	6376 (0.65)	21407 (1.95)		6371 (0.7)	8055 (0.9)	
Occupations, n (%)						
Farmers	884768 (90.45)	845663 (77.12)	0.373	786006 (89.4)	777832 (88.5)	0.034
Laborers	19812 (2.03)	54036 (4.93)		19796 (2.3)	20433 (2.3)	
Government officials	13210 (1.35)	50819 (4.63)		13207 (1.5)	14120 (1.6)	
Small business	5233 (0.53)	10361 (0.94)		5228 (0.6)	4868 (0.6)	
Others	55181 (5.64)	135723 (12.38)		55037 (6.3)	62021 (7.1)	
Number of children, n (%)						
None	4504 (0.46)	18570 (1.69)	0.286	4504 (0.5)	6241 (0.7)	0.055
One	240781 (24.61)	394704 (35.99)		240642 (27.4)	243182 (27.7)	
Two	573164 (58.59)	539581 (49.20)		510366 (58.0)	492289 (56.0)	
Three or more	159755 (16.33)	143747 (13.11)		123762 (14.1)	137562 (15.6)	

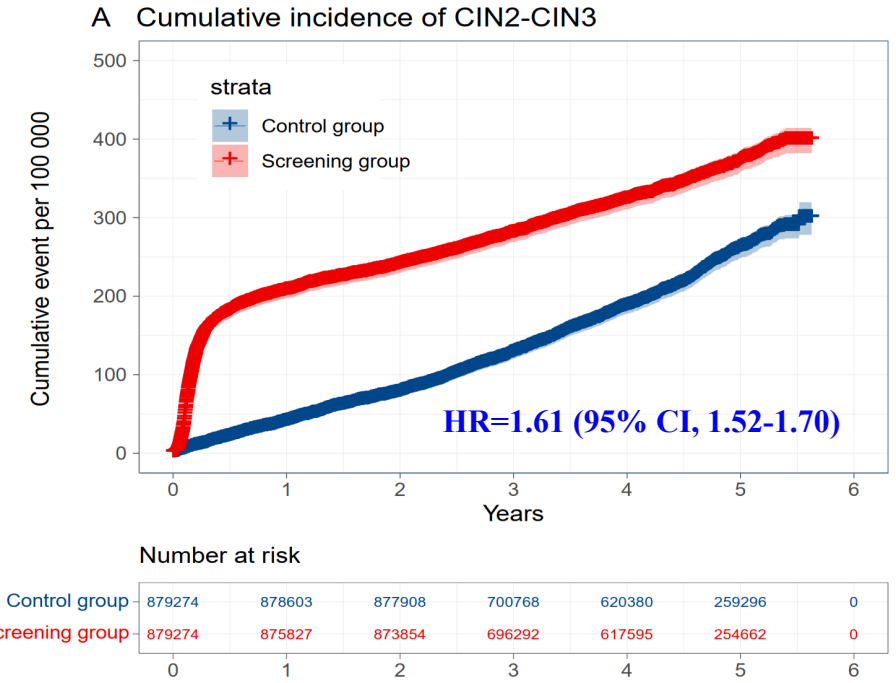
Outcome 1: Precancerous lesions CIN2-CIN3

- Compared to the control group, the screening group detected significantly more CIN2-CIN3 cases **(HR, 5.16; 95%CI, 4.60 to 5.79)** in the screening year.
- During the 2-5 years post-screening period, the screening group experienced a significantly **23% lower risk of CIN2-CIN3.**

Follow-up Year	Screening	Control	CIN2-CIN3 incidence	HR (95% CI)
1st (screening year)	1819 (47.99)	352 (9.33)		5.16 (4.60 to 5.79)
2nd	290 (7.69)	328 (8.66)		0.89 (0.76 to 1.04)
3rd	339 (9.00)	428 (11.30)		0.79 (0.69 to 0.92)
4th-5th	538 (16.51)	760 (23.16)		0.71 (0.64 to 0.79)
Overall (2nd-5th)	1167 (30.96)	1516 (40.00)		0.77 (0.72 to 0.84)



Association between screening program and high-grade cervical intraepithelial neoplasia (CIN2-CIN3) incidence in each follow-up year. The number and rate (per 100 000 person-years) of incidence were reported.



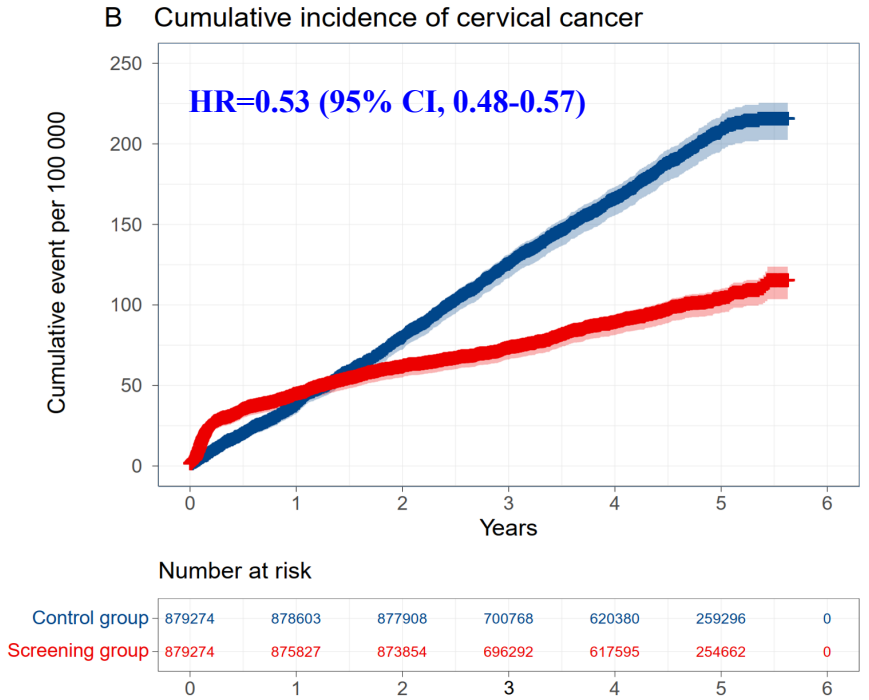
Cumulative probability curves for high-grade cervical intraepithelial neoplasia (CIN2-CIN3) events in the screening and control group

Outcome 2: Cervical cancer incidence

- Compared to the control group, the screening group detected significantly more cervical cancer cases **(HR=1.18; 95% CI: 1.01 to 1.37)** in the screening year.
- During the 2-5 years post-screening period, the screening group experienced a significantly **65% lower risk of cervical cancer incidence.**

Follow-up Year	Screening	Control	Cervical cancer incidence	HR (95% CI)
1st (screening year)	380 (10.03)	322 (8.54)		1.18 (1.01 to 1.37)
2nd	148 (3.93)	365 (9.63)		0.41 (0.33 to 0.49)
3rd	97 (2.58)	391 (10.32)		0.25 (0.20 to 0.31)
4th-5th	186 (5.71)	470 (14.32)		0.40 (0.33 to 0.47)
Overall (2nd-5th)	431 (11.43)	1226 (32.35)		0.35 (0.31 to 0.39)

Association between screening program and cervical cancer incidence in each follow-up year. The number and rate (per 100 000 person-years) of incidence were reported.

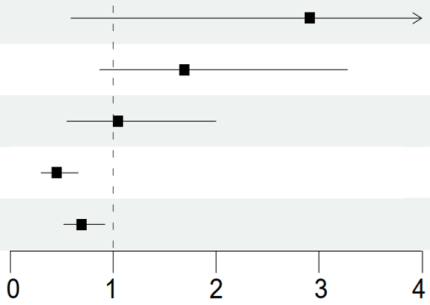


Cumulative probability curves for cervical cancer events in the screening and control group

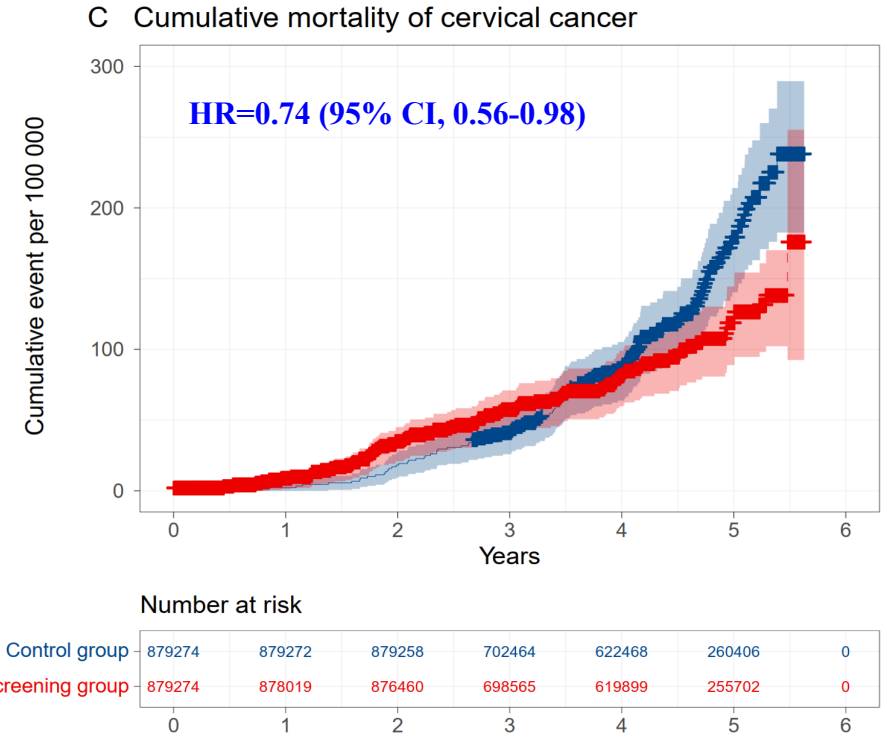
Outcome 3: Cervical cancer mortality

- **During post-screening years 4-5, the screening group experienced a significantly 55% lower risk of cervical cancer mortality.**

Follow-up Year	Screening	Control	Cervical cancer mortality	HR (95% CI)
1st (screening year)	6 (0.16)	2 (0.05)		2.91 (0.59 to 14.40)
2nd	23 (0.61)	14 (0.47)		1.69 (0.87 to 3.28)
3rd	19 (0.50)	18 (0.47)		1.05 (0.55 to 2.00)
4th-5th	36 (2.57)	80 (3.46)		0.45 (0.30 to 0.66)
Overall (2nd-5th)	78 (2.06)	112 (3.21)		0.69 (0.52 to 0.92)



Association between screening program and cervical cancer mortality in each follow-up year. The number and rate (per 100 000 person-years) of mortality were reported.



Cumulative probability curves for cervical cancer death events in the screening and control group

Outcome 4: Healthcare Utilization

The AI Cell Pathology System-based cervical cancer screening program screening had significantly

1. **Shortened length of hospital stays related to CIN2-CIN3 or cervical cancer treatment (median 11 days vs 13 days, P < 0.001);**
2. **Lowered hospitalization costs (median $1882 vs $2818; P < 0.001);**
3. **Lowered rate of multiple hospitalizations (27.34% vs 39.88%; P < 0.001);**
4. **Lowered rate of hospitalizations from the emergency department (6.82% vs 9.13%; P < 0.001).**

Conclusions

In this study of 1.76 million rural women in China, we provided the following real-world evidence that the organized cervical cancer screening program assisted by AI Cell Pathology System can:

1. Significantly improve early detection and diagnosis of the disease;
2. Significantly reduce subsequent incidence and mortality of cervical cancer;
3. Significantly reduce cancer-related healthcare utilization.

Acknowledgement & Contact Information

- The AI Cell Pathology System was created and operated by the Wuhan Landing Intelligence Medical Co. Ltd. (Landing Med) China
- We thank the 1.76 million women participants from Hubei Province, China, who contributed their data to this study

- Contact information:
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  - Dr. Xiaoxv Yin, School of Public Health, Tongji Medical College, Huazhong University of Science and Technology, E-mail: yxx@hust.edu.cn

This study was awarded as the 1st price

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2021-2024, Professor, Institute of Hospital Management, Tsinghua Shenzhen Graduate School
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Research:
Cancer biomarkers and etiology, prevention, screening, treatment and prognosis, with personalized and systematic approach, with over ten million US dollars NIH funding & more than 250 publications.

Current focus:
1. AI and women's and children's health, health literacy, new screening & treatment tools and its implementation;
2. AI and cancer biomarkers, screening, treatment, post-treatment management and prognosis;
3. Development of physician scientist in academic health systems;