

# The NCI Center for Global Health's Affordable Cancer Technologies Program

Translational Research in Global Oncology

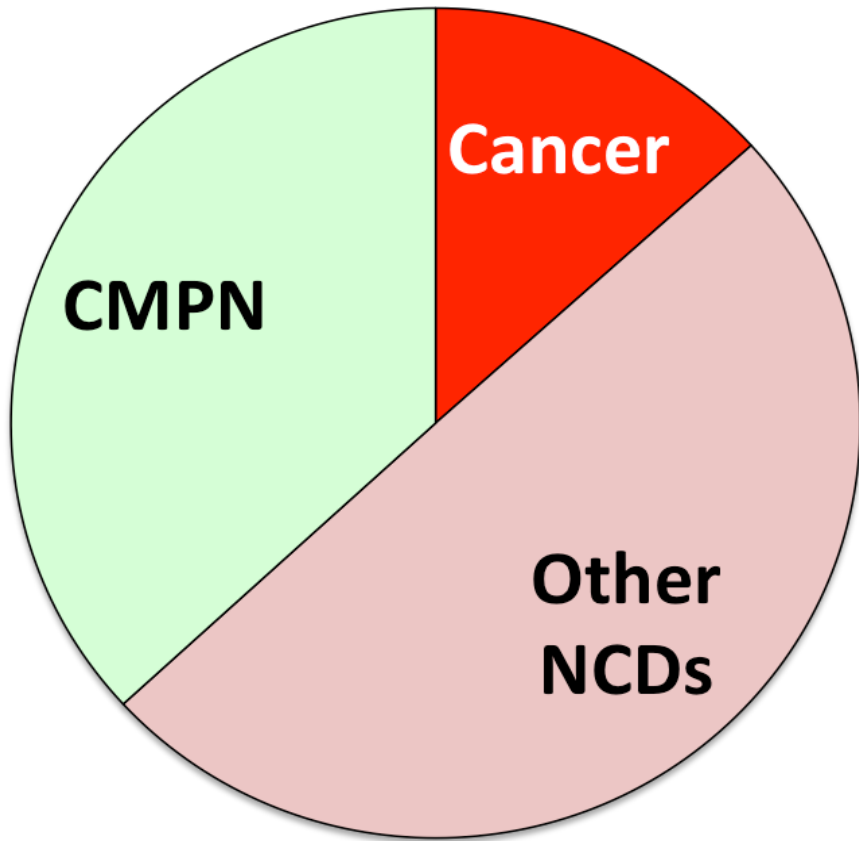
Informational Webinar for PAR-18-801 & PAR-18-802

*July 24, 2018*



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*Lead, Global Health Technology*  
*Center for Global Health*

# Worldwide Deaths by Cause of Death



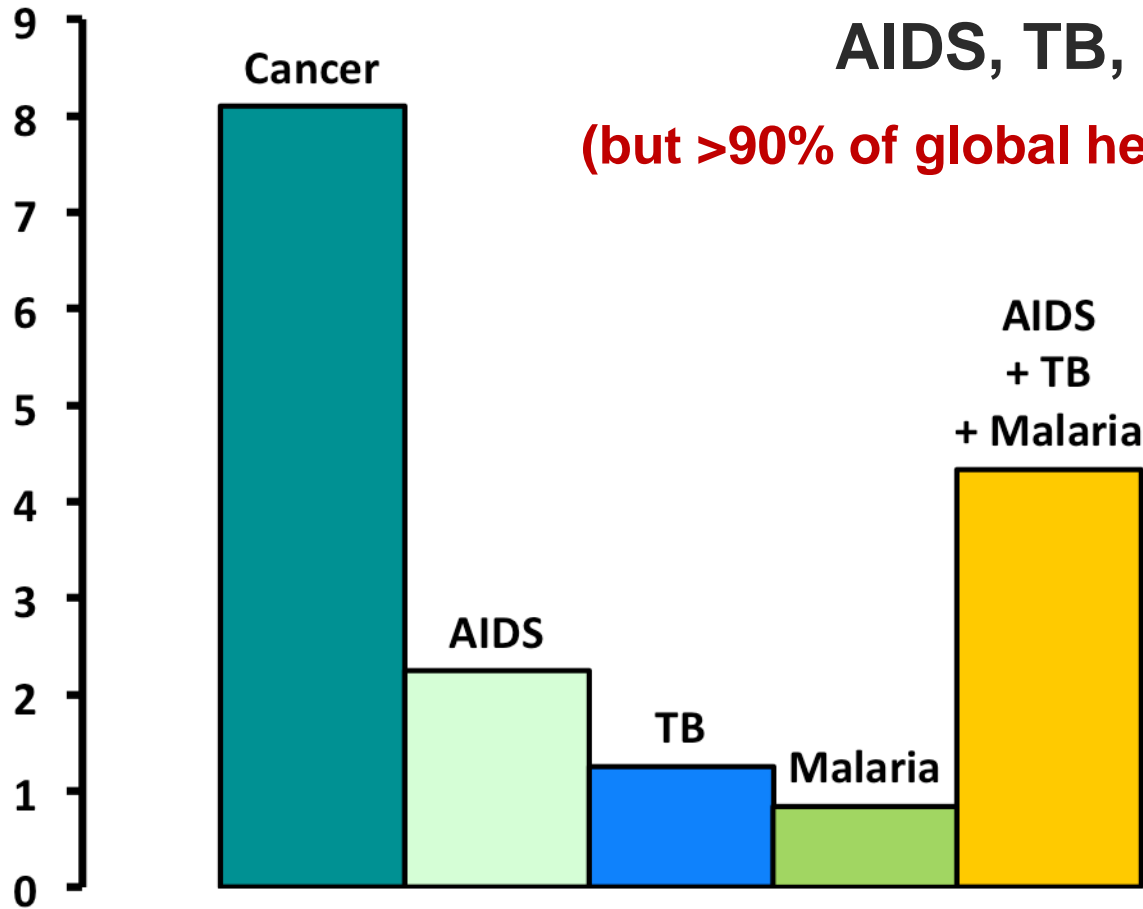
- Of 57 million deaths in 2008, 36 million (63%) were from NCDs vs. 21 million from communicable, maternal, perinatal, and nutritional (CMPN) conditions.
- Cancers accounted for 7.6 million deaths or 13% of the total (~1 in 8 deaths).
- Nearly 80% of NCD deaths occur in LMICs
- The risk factors for the individual NCD's heavily overlap, so prevention efforts can impact more than one NCD.

Data derived from World Health Organization

Deaths (Millions)

# Cancer Kills More GLOBALLY Than AIDS, TB, & Malaria

(but >90% of global health aid goes to ATM)



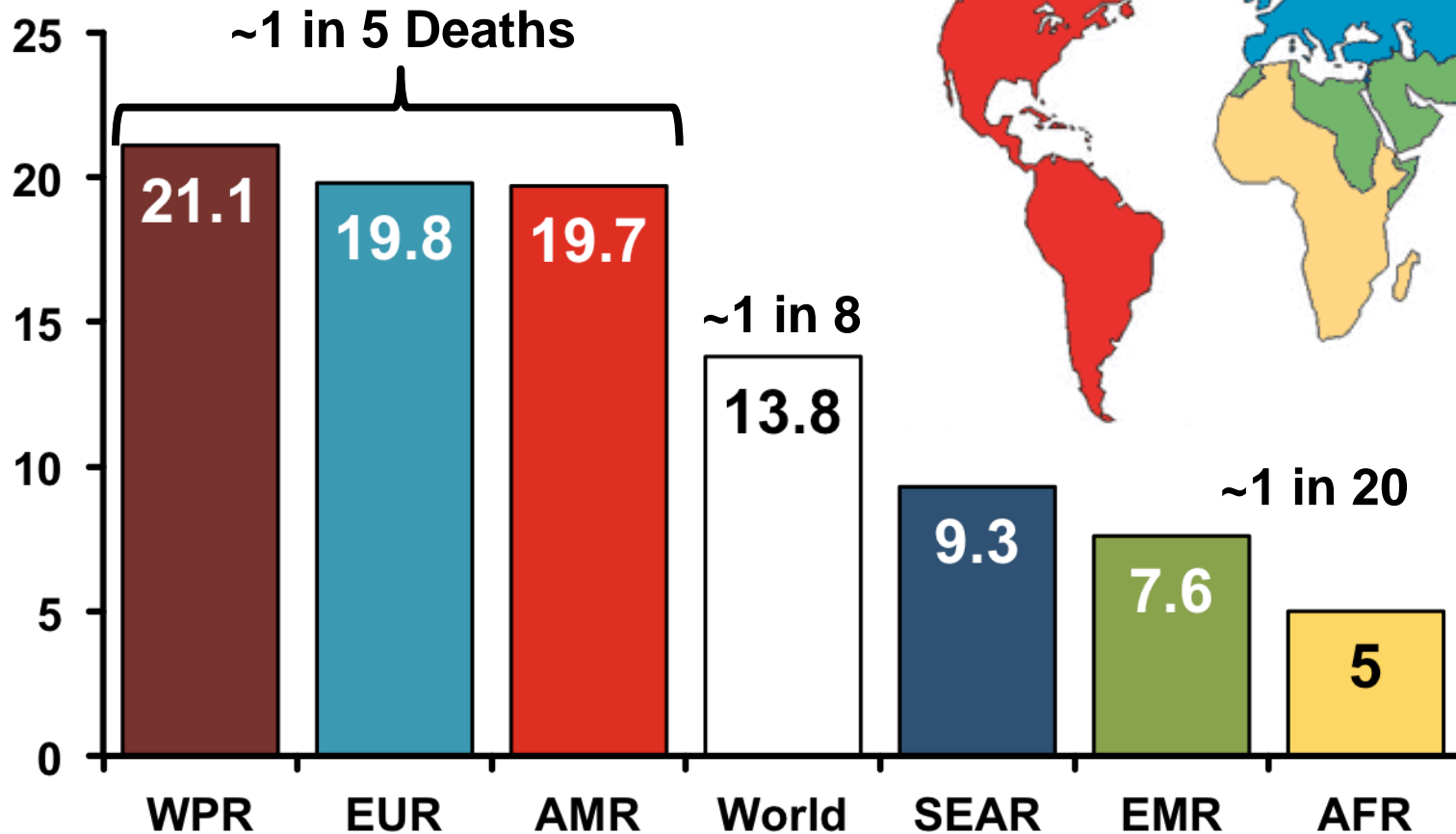
Most AIDS, TB, & malaria deaths occur in sub-Saharan Africa

In sub-Saharan Africa AIDS, TB, & malaria deaths outnumber cancer deaths by ~7:1

Data derived from World Health Organization

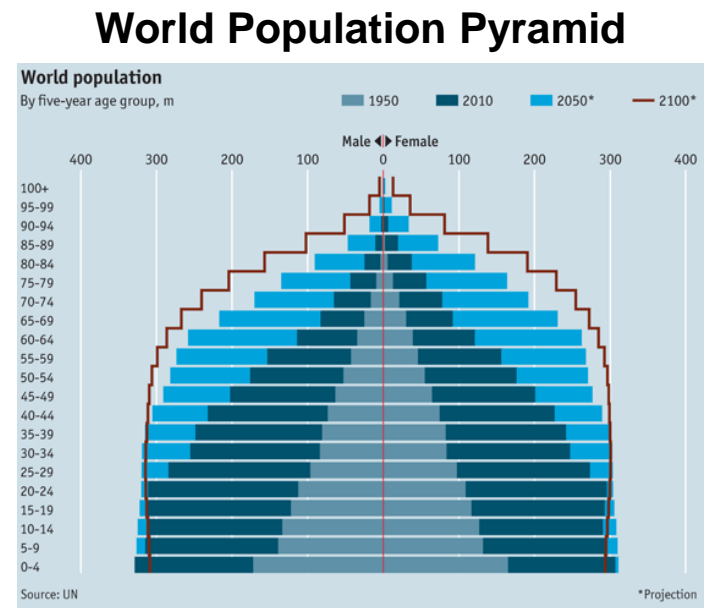
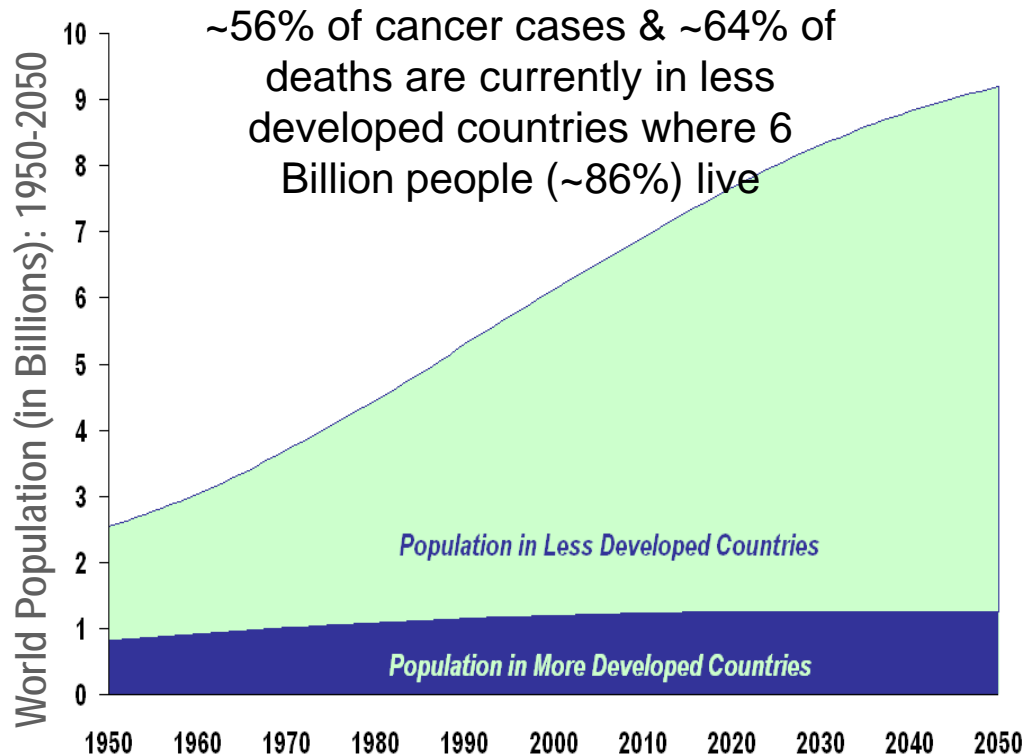
## % of Deaths by Cancer: WHO Regions

> 8 million people died  
from cancer across the  
world in 2012



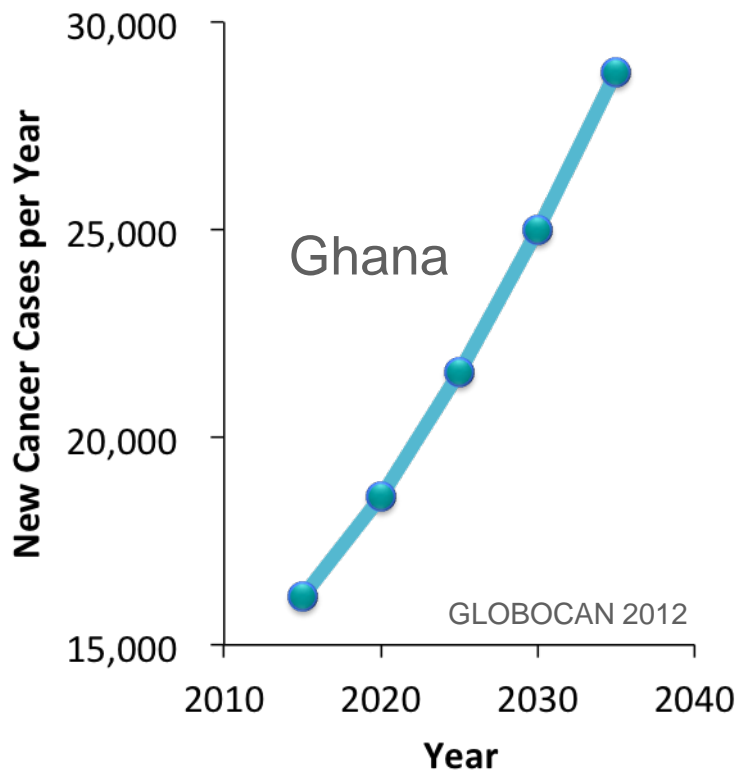
# Q. Why Is Cancer Growing Around the World?

## A. Population Growth & Aging Especially in LMICs



# Projected Increase in New Cancer Cases (Example: Ghana)

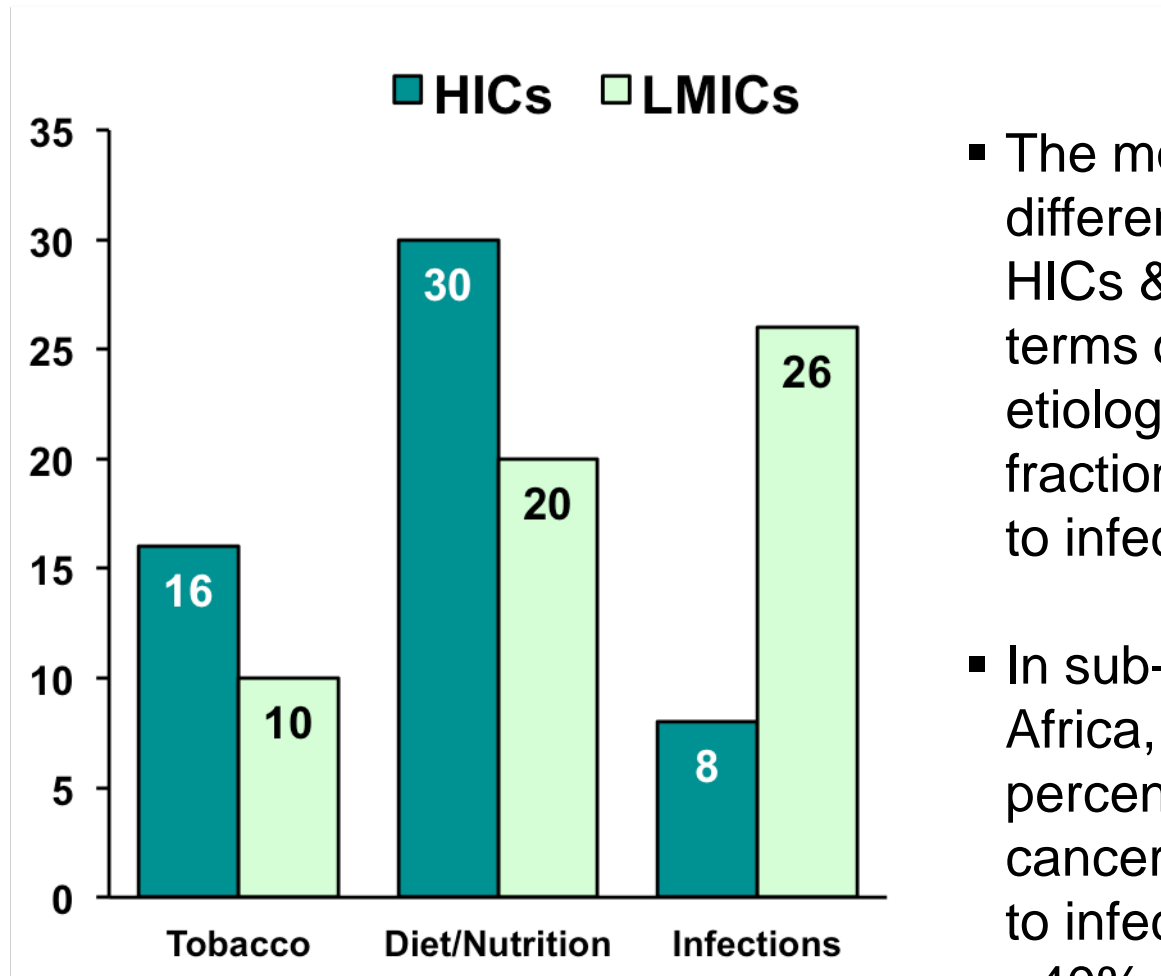
Globally, 14M cases in 2012 to 24M by 2035 (>60% in LMICs)



- In Ghana, new cancer cases are projected to increase by 82% between 2012 and 2035. (Compared to In the 37% in the U.K. over the same period).
- These projections are based ONLY on demographics (a growing & aging population).
- Any increase in risk factor exposure (more tobacco use, increased obesity, lower fertility rates, etc.) will add further to the burden of disease.
- Similar increases will occur in all other LMICs, & these countries are not well-positioned for an increased cancer burden.

# Risk Factors Vary In Their Contribution To Cancers In Different Settings

Percentage of Cancers Attributable to Risk Factor

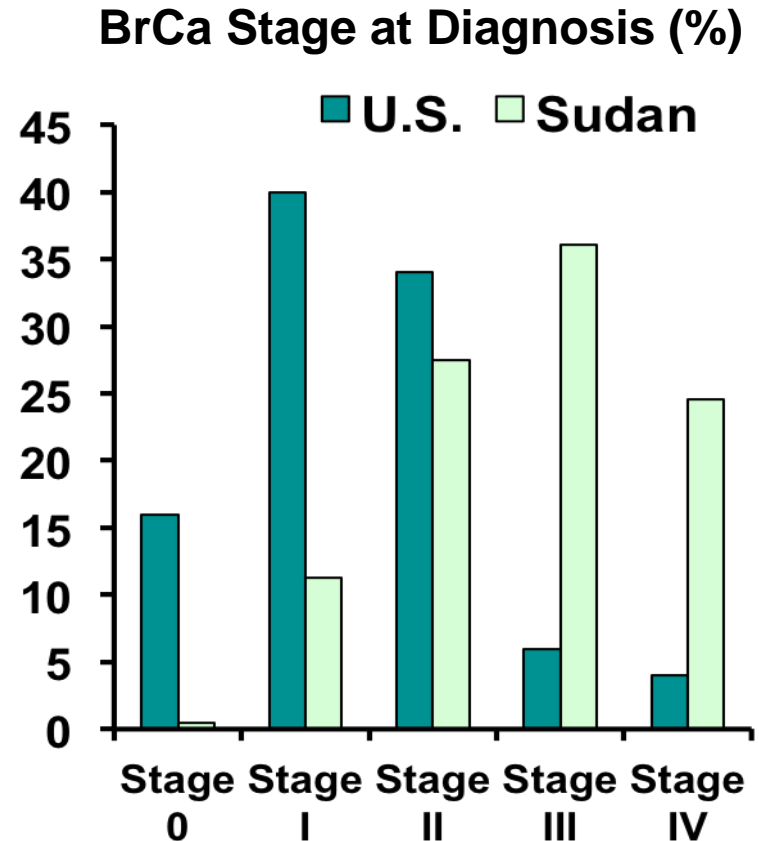


Source: *The Cancer Atlas*

- The most striking difference between HICs & LMICs in terms of cancer etiology is the fraction attributable to infections.
- In sub-Saharan Africa, the percentage of cancer attributable to infections is ~40%.

# Late Diagnosis of Cancer

- Relatively late diagnosis of all cancers leading to late treatment is common in LMIC's.
- Cancer survival rates are relatively lower in LMIC's, and late diagnosis likely contributes to the higher mortality to incidence ratios.
- Total delay (time from first symptom to treatment) is made up of patient delay plus system delay, and both occur.
- Research on barriers contributing to patient delay and deficiencies contributing to system delay in LMICs is scant and much needed.



Sources: US stage data from SEER Survival Monograph (NCI), 2007; Sudan data from Elgaili et al., 2010, Int. J. Woman's Health 2:77.



# Cancer Treatment is Limited in LMICs (Africa as Example)

- Radiotherapy is an essential part of cancer treatment but far from trivial to deliver safely and effectively.
- >50% of patients should receive radiotherapy at least once & ~25% might receive a 2<sup>nd</sup> course (Barton et al., 2006).
- Radiotherapy is useful for both curative treatment & palliation.
- Only 23 of 52 countries in Africa have radiotherapy (in urban centers).
- Diagnostic services (pathology) as well as oncologic surgeons and medical oncologists are also in very short supply.

External Beam Machines (2010)



# Availability of Anticancer Drugs in Sub-Saharan Africa

## Often available

Doxorubicin, cisplatin, fluorouracil, capecitabine, folinic acid, steroids, dactinomycin, vincristine, methotrexate, etoposide, hydroxyurea, melphalan, cytarabine, mercaptopurine, L-asparaginase, daunorubicin, and thioguanine

## Available on request\*

Irinotecan, oxaliplatin, carboplatin, vinorelbine, gemcitabine, fludarabine, interferon alfa, epirubicin, topotecan, taxanes, dacarbazine, ifosfamide, bleomycin, pamidronic acid, zoledronic acid, metoclopramide†, dexamethasone†, ondansetron†, and lorazepam†

## Rarely available

Trastuzumab, bevacizumab, rituximab, erlotinib, sunitinib, imatinib, temozolomide, ibandronic acid, domperidone†, granisetron†, erythropoietin†, and granulocyte colony-stimulating factor†

**\*Available on request means that if a doctor orders a drug specifically and the patient is able to pay, it can often be procured.**

**†Supportive drugs.**

# NCI Center for Global Health (CGH): Mission and Vision

- CGH's vision is to be a catalyst for strengthening research to reduce the cancer burden worldwide.
- Our mission is to advance the mission of NCI by supporting and facilitating cancer research in the U.S. and abroad, building partnerships among cancer research institutions, and training scientists to address global cancer challenges.
- **Global health technology research is one such avenue.**



“Successful campaigns to control cancers with existing methods and to improve current strategies through research will increasingly depend on a multinational consensus and collaborative work. In that spirit, we intend to take the lead in areas that are within our remit.”

~ Harold Varmus and Harpal S. Kumar

Science Translational Medicine, 6 March 2013

# Affordable Cancer Technologies (ACTs) Program

- Rapid progress in several fields is contributing to the development of a new generation of POCT.
- POCT impacts are felt in lab environments, homes, and treatment centers.
- Despite this promise, the unique design constraints presented in low-resource settings, coupled with the variety of country-specific regulatory and institutional dynamics, have made it difficult for investigators to clinically validate and translate successful POC cancer interventions to the LMIC markets.
- In response to this need, the NCI partnered with the National Institute of Biomedical Imaging and Bioengineering (NIBIB) to create the Affordable Cancer Technologies (ACTs) program.
- In an effort to further bolster translational efforts in this space, the Center for Global Health has partnered with the NCI SBIR/STTR Development Center to support commercially-driven global health technology research.

# Example: Advancements in In-vitro Diagnostics

### A First generation of POC diagnostic testing

**Typical samples**  
Oral fluid  
Urine  
Capillary blood

**Common test formats**  
Lateral-flow test  
Vertical-flow test

**Detection targets**  
Antibodies  
Antigens  
Simple biochemical reactions

**Examples**  
Rapid test strips and dipsticks (HIV antibody and antigen, malaria antigen, urine biochemistry, and pregnancy tests)  
Simple instruments (glucometers and hemoglobin meters)

### B Second generation of POC diagnostic testing

**Test cartridges**  
Sample (e.g., capillary blood, oral fluid, or urine) is inserted into disposable test cartridge

**Small instruments process and read results**

**Detection targets**  
Whole cells  
DNA or RNA using PCR or other nucleic acid detection method

**Examples**  
CD4-cell count  
HIV viral load  
Tuberculosis diagnosis and potential drug resistance

### C Next generation of POC diagnostic testing

**Samples**  
Capillary blood, oral fluid, urine, breath, and other samples

**Multiple test formats**  
Handheld lab-on-a-chip devices  
Disposable tests (no instruments)  
Doctor's office desk-based devices

**Transmission of results**  
Devices are likely to have wireless connectivity to transmit result data

**Potential detection targets**  
Nucleic acid sequencing  
Advanced protein analysis (proteomics)

**Examples**  
Antiviral and antibiotic drug-resistance screening  
Differential diagnosis (e.g., viral rash and fever, childhood diseases, antenatal tests)  
Home-based self-testing

- Similar trends can be observed in imaging technologies, ablative therapeutics, etc.

# Observations

*Global Oncology Focused  
POCT Research at the NCI*



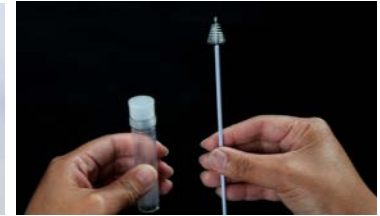
# In-vitro Detection and Diagnosis

## Common Themes:

- Precision prevention of cancer focused on early, POC diagnosis of cancer-associated infections.
- Tests have moved on from primarily antigen-based tests to include nucleic acid based tests.
- Tests for specific subtypes of viruses favored over pooled tests.
- Automated/simplified sample prep.
- Use of microfluidics to create low-cost POC in vitro assays.
- Paper-based tests making it easier to meet cost constraints in low-resource settings



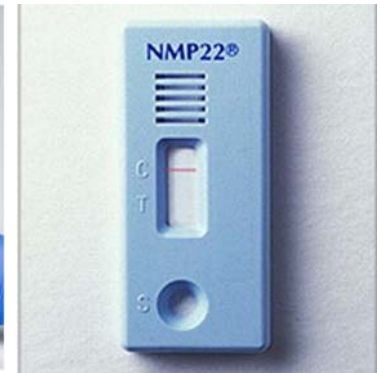
careHPV NA  
Hybridization Assay



Self-collection of  
Samples



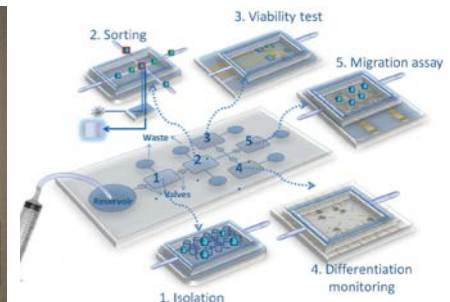
Digital PCR with  
Simple Sample Prep



POC Proteomic Assay  
(for recurrent bladder cancer)



Lab-on-Paper



Lab-on-a-Chip

# Imaging

## Common Themes:

- Quantitative image analysis algorithms playing a key role in simplifying workflow.
- Use of training data and machine learning for image classification.
- Emerging technologies simplified sample prep and POC digital pathology.
- Handheld image acquisition.
- Smartphone and tablet image display.
- Portable.

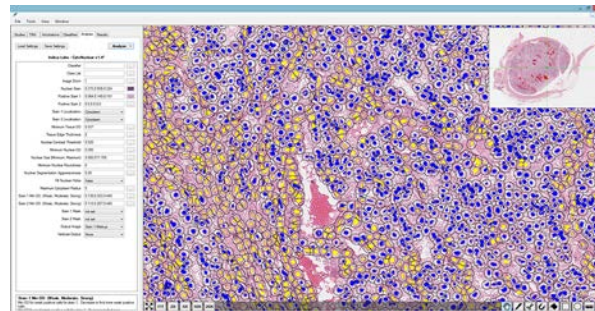
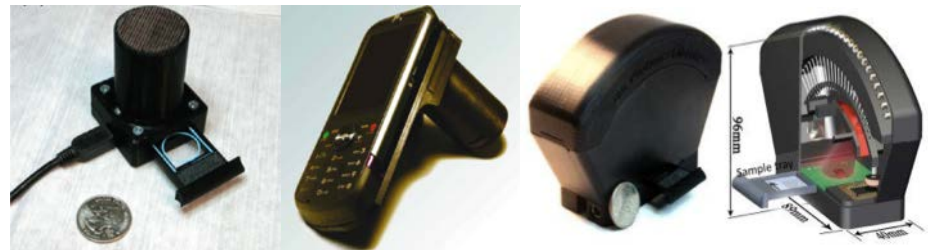


Image Segmentation and Classification



Portable Image Acquisition



Lens-Free Microscopy and Tomography



Portable Image Acquisition and Display



# Treatment

## Common Themes:

- Ablative technologies.
- Targeted drug delivery.
- Focus on treating pre-cancers/pre-invasive disease.
- Focus on addressing power/consumables.
- Image-guided treatment with quantitative image analysis algorithms.
- Need for surgical adjuncts and affordable infusion pumps to deliver chemotherapy safely.



Photodynamic Therapy



Thermocoagulation

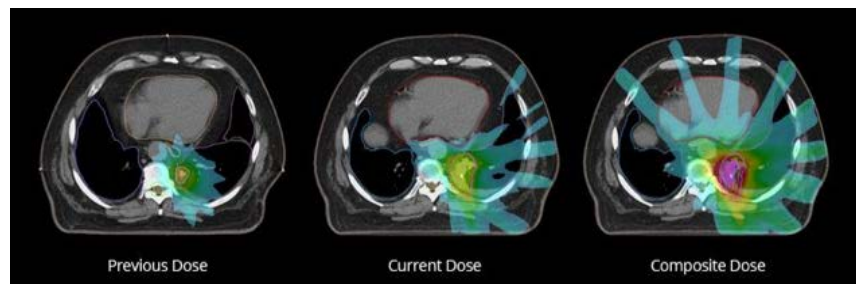


Image registration for planning and delivery of therapy.

# Conclusions and Future Directions

- The NIH's portfolio of funded work in POCT is expected to continue to expand.
- The following trends are also expected:
  - Micro-scale tests will deliver significant dividends in low-resource settings.
  - Next-gen sequencing will drop in price and scale, enabling proteomics at the POC.
  - Cost and size of image capture and display devices will continue to drop.
  - Advanced manufacturing and 3D printing will further reduce component costs.
  - Future research in translation of technology to practice settings likely to employ existing and new frameworks of implementation science research.

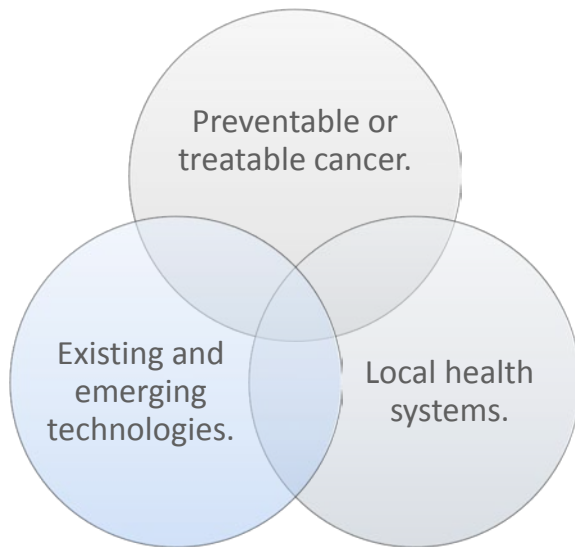
**Investment in translational research focused on the validation and dissemination of POCT in an LMIC context also has significant potential for address cancer health disparities in high-income country settings.**

# Shared Challenges

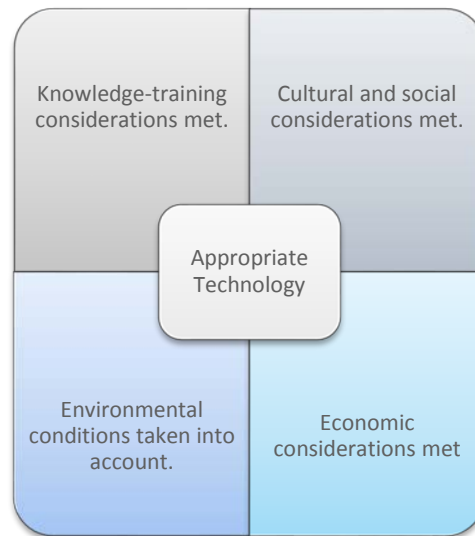
- Lack of market incentive for development
  - Due to limited potential for return on investment, companies may not invest in technologies focused on LMIC needs.
  - As such, efforts beyond clinical validation are needed to ensure that technologies can be inserted successfully into the continuum of care in LMICs, especially given the range of variation in disease burdens and health systems. **Implementation science research is essential here.**
- Regulatory
  - Lack of regulatory harmonization as well as hurdles associated with WHO preclearance continue to stymie efforts to go to scale.
  - There is a need to disseminate the results of programs such as ACTs beyond the investigator community to the broader biomedical, policy, development, and philanthropic community.

# Critical Elements

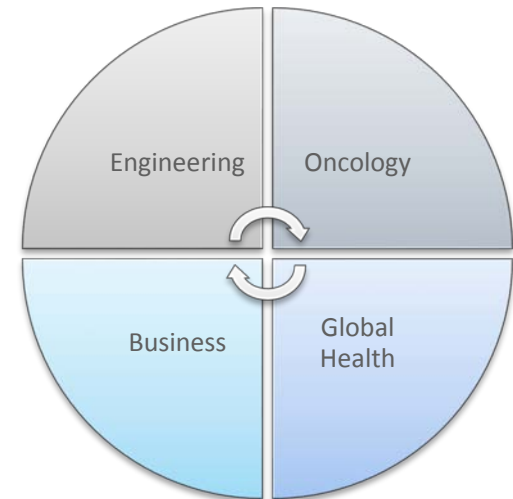
## Scope



## Focus



## Teams



Pearlman, et al. Journal of Translational Engineering in Health and Medicine (2016)



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CANCER  
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[www.cancer.gov/espanol](http://www.cancer.gov/espanol)