Third Century Initiative: Global Challenges

THIRD CENTURY INITIATIVE
UNIVERSITY OF MICHIGAN

"…The Third Century Initiative has been established to inspire innovative programs that enhance the student learning experience and develop creative approaches to the world's greatest challenges."

“Deep monitoring” chronic disease in underserved and remote populations

Faculty:

David Burke – Department of Human Genetics
Mark Burns – Department of Chemical Engineering
Mia Woodward – Department of Ophthalmology and Visual Sciences
Joseph Myers – University Health Service, Eye Health Institute of Jamaica
Paula Anne Newman-Casey – Department of Ophthalmology and Visual Sciences
Geoff Thun – College of Architecture and Urban Planning
Kathy Velikov – College of Architecture and Urban Planning

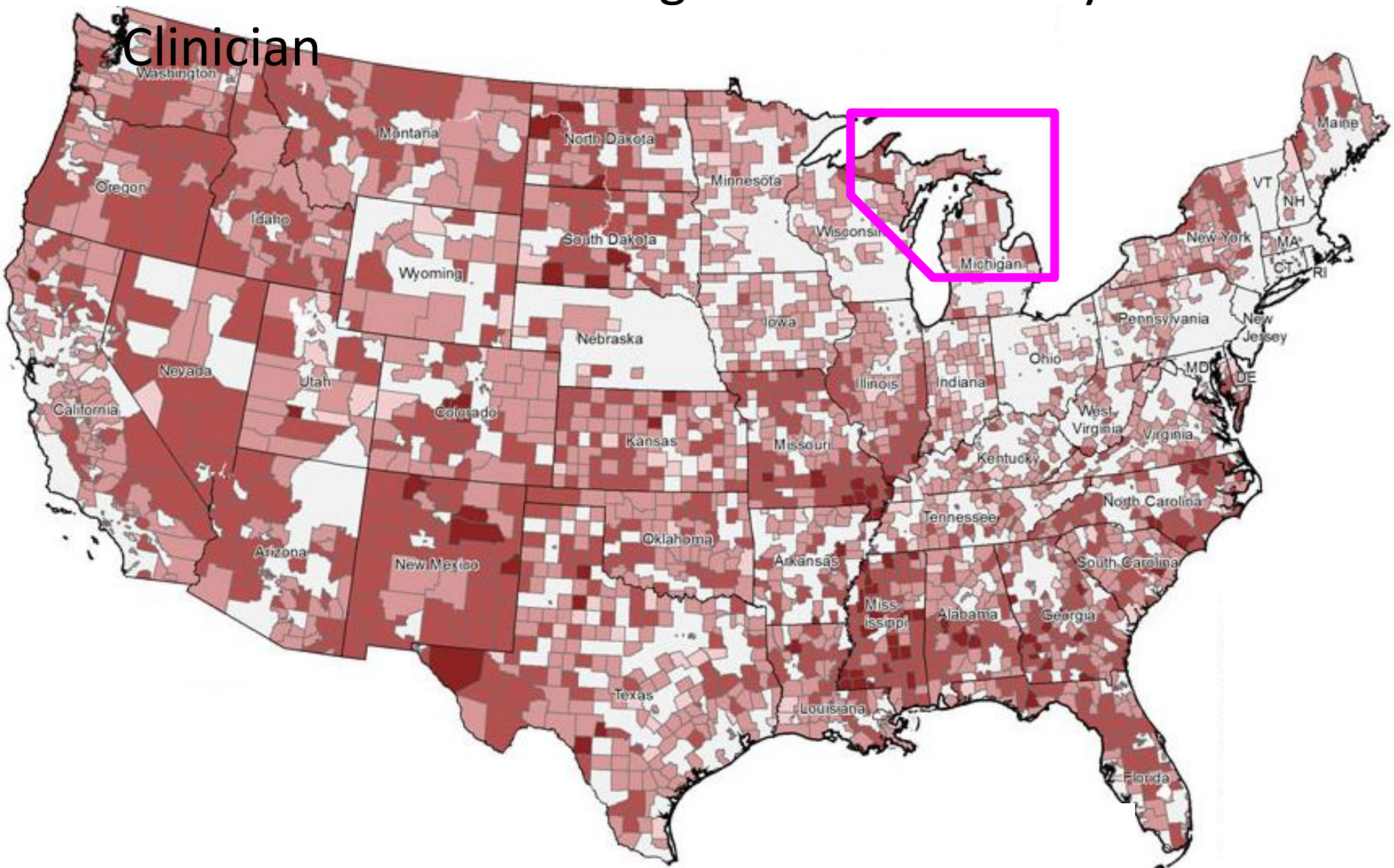
External partners:

Joy-Southfield Community Development – Detroit neighborhood wellness program
The Avalon Village – Highland Park, MI, neighborhood community
Eye Health Institute – Jamaica-USA community-based vision health project
Michigan Aerospace – optical sensors, intelligent systems, machine vision
Newline Builders – low-cost manufacturing; electronic devices; application software

- Feb 2015 to May 2018 -- $1.4 Million awarded

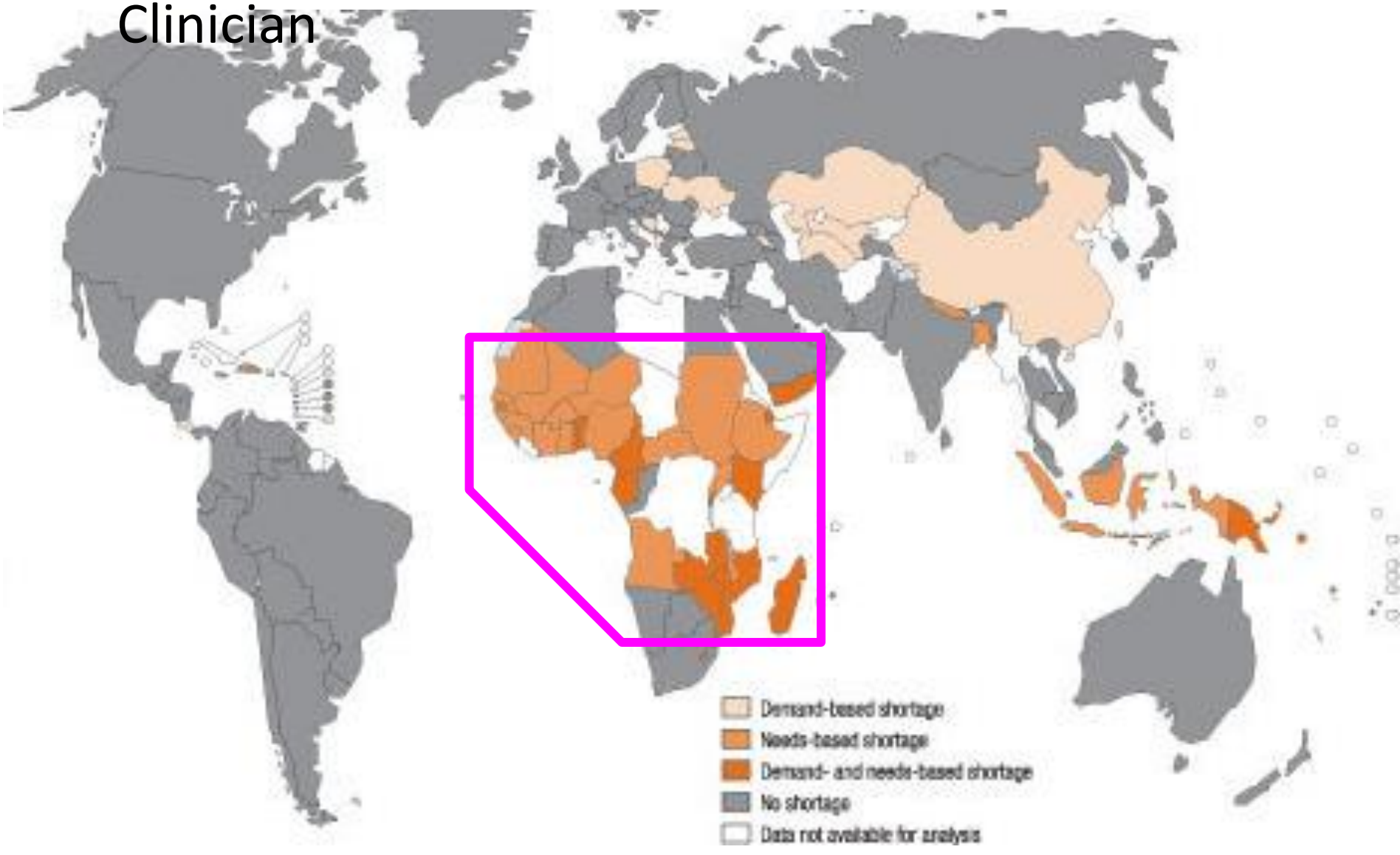
Local and global challenges

Health Profession Shortage Areas – Primary Clinician



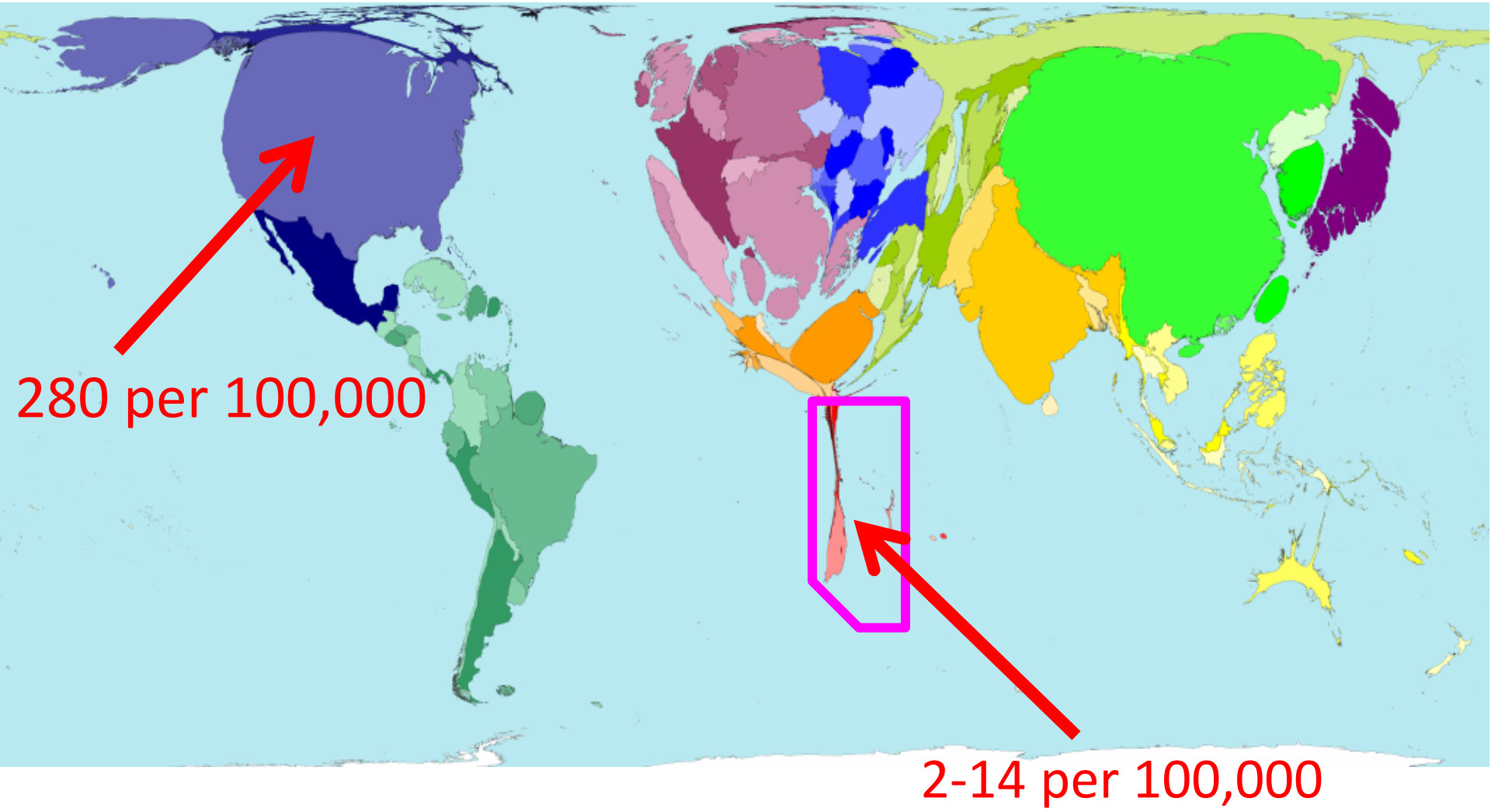
Local and global challenges

Health Profession Shortage Areas – Primary Clinician

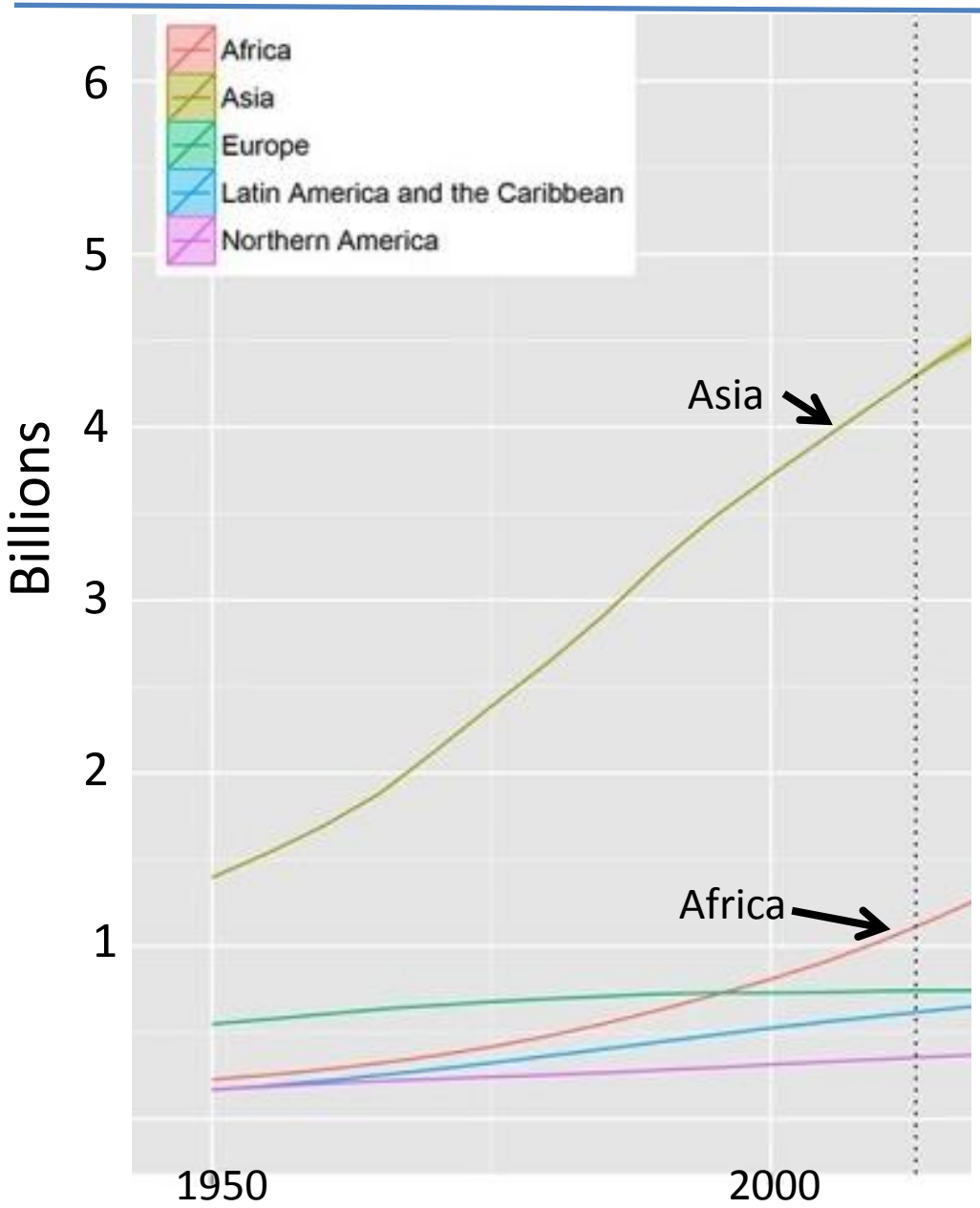


Local and global challenges

Scaled map: per capita physicians, by nation

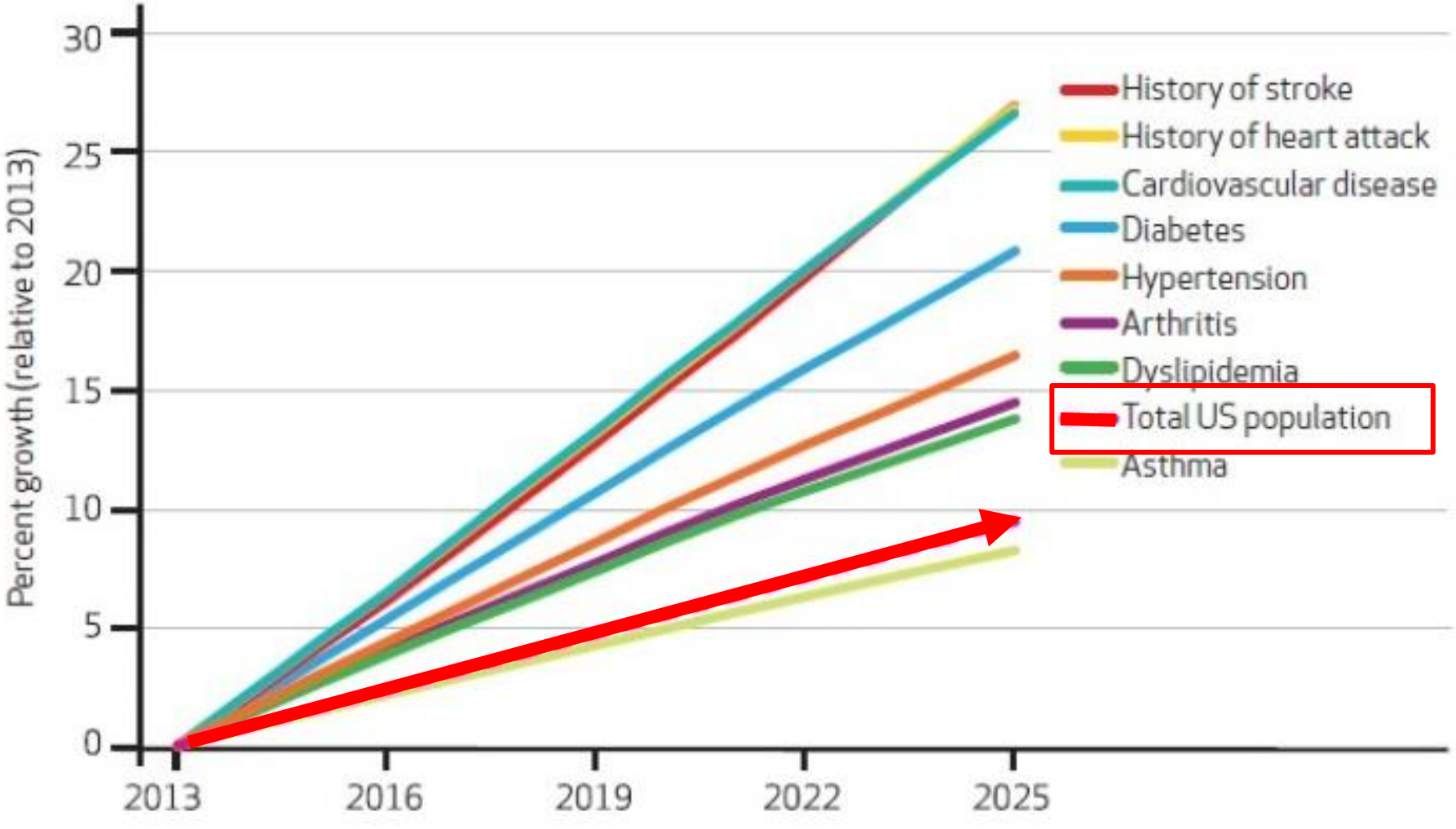


Population models for the future



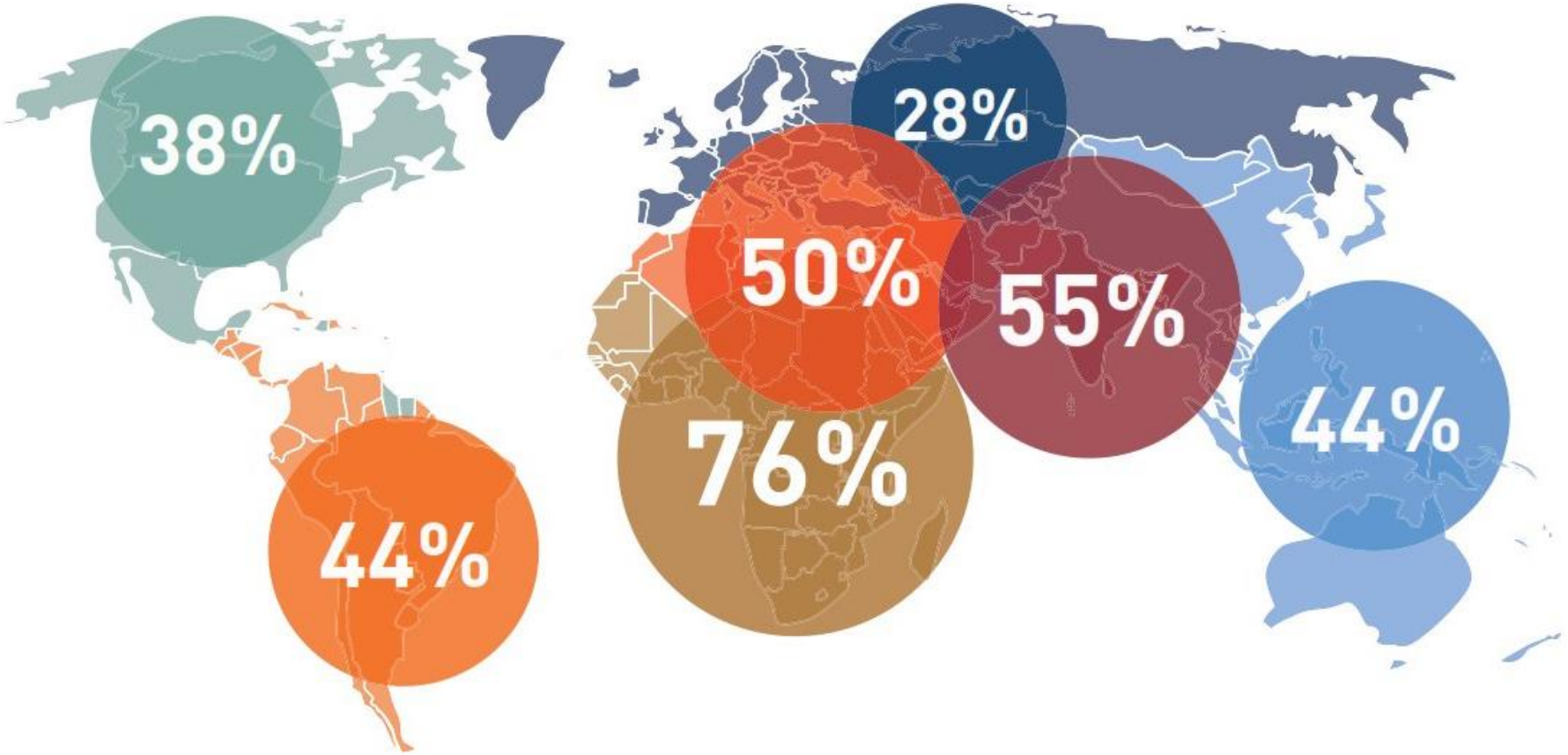
Chronic diseases: on-going and emerging

- Chronic diseases of many varieties are increasing in **RATE**, in the USA and world-wide.



Chronic disease example: diabetes

Estimated proportion of deaths between 15 and 60 years attributed to **diabetes**.



Diabetes, hypertension, kidney disease are increasing worldwide.
Infrastructure investment has focused on infectious disease burden.
Limited infrastructure to handle the chronic disease burden.

The global health care worker shortfall

- Health care is a fundamental demand of all people, regardless of location or resources.
- Population of sub-Saharan Africa will be 2 Billion in 2030.
- Estimated 10,000 – 11,000 graduates per year from medical schools in sub-Saharan Africa.
- To reach 1 physician per 1000, >2Million new physicians need to be trained. **Equal to 200 years of training**.
- Existing systems for training and deployment of medical professionals are not positioned to meet the anticipated demand.

Breaking the challenge into pieces

Four aspects of health care delivery:

1) assessment and diagnosis
2) treatment and medication
3) monitoring
4) education

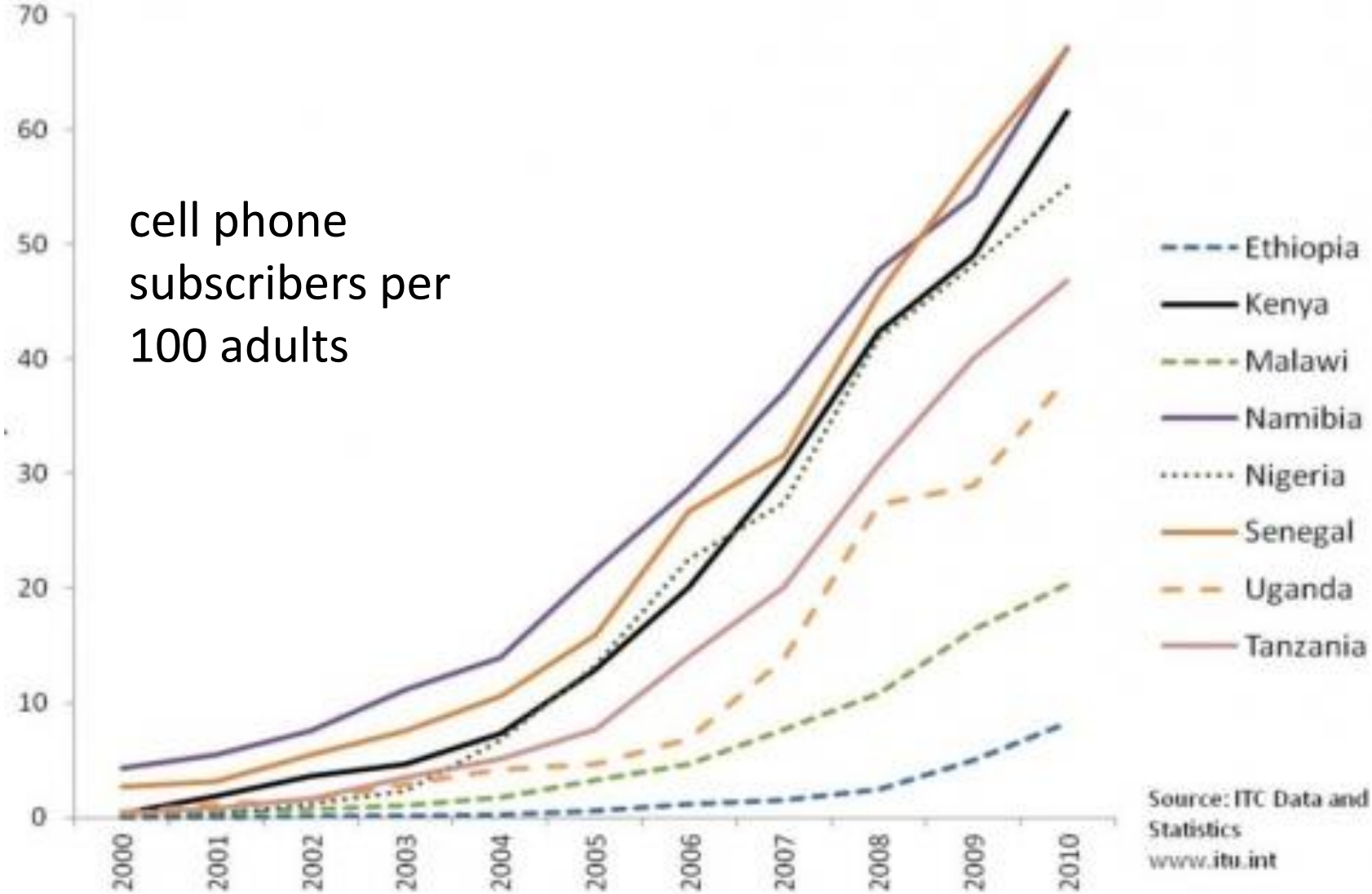
physician

technology

- In chronic diseases, monitoring and education are essential for long-term control.
- **Monitoring and education** can be addressed with technologies that supplement trained health workers.

Strategies toward a solution

- Digital techologies can be rapidly manufactured and deployed in large numbers using existing manufacturing infrastructure.



Strategies toward a solution

- Breaking the requirement for co-location of patient and health care provider.
- TeleMedicine or eMedicine.
- An established model exists in x-ray imaging:
  - skilled technician obtains digital data
  - electronic transfer to high-level professional
  - separation of data collection and data analysis
  - no loss of quality plus increased efficiency
- Reduced patient and provider travel time and costs for post-diagnosis, long-term, continous monitoring.

Strategies toward a solution

- Remote, high-quality, digital medical data is poised to become an integral part of health monitoring.
- The underserved are likely to benefit from new medical technologies – **if** designed for their resources and abilities.
- Low capital costs are the single most important technology driver for the underserved.
- The resources of the University can develop, deploy, and *validate* monitoring technologies rapidly.

Digital health monitoring technologies may provide a scaleable, low-cost supplementation for physician presence.

Two parallel technology strategies

Co-opting of **existing** low-cost, high-volume technology systems and strategies.

Strategy 1:

High-volume manufacturing of digital electronics and consumer products.

Strategy 2:

Standardized transportation using intermodal shipping containers and vehicles.

Goal: merging of the two strategy concepts into one integrated system

Global Challenges – Deep Monitoring

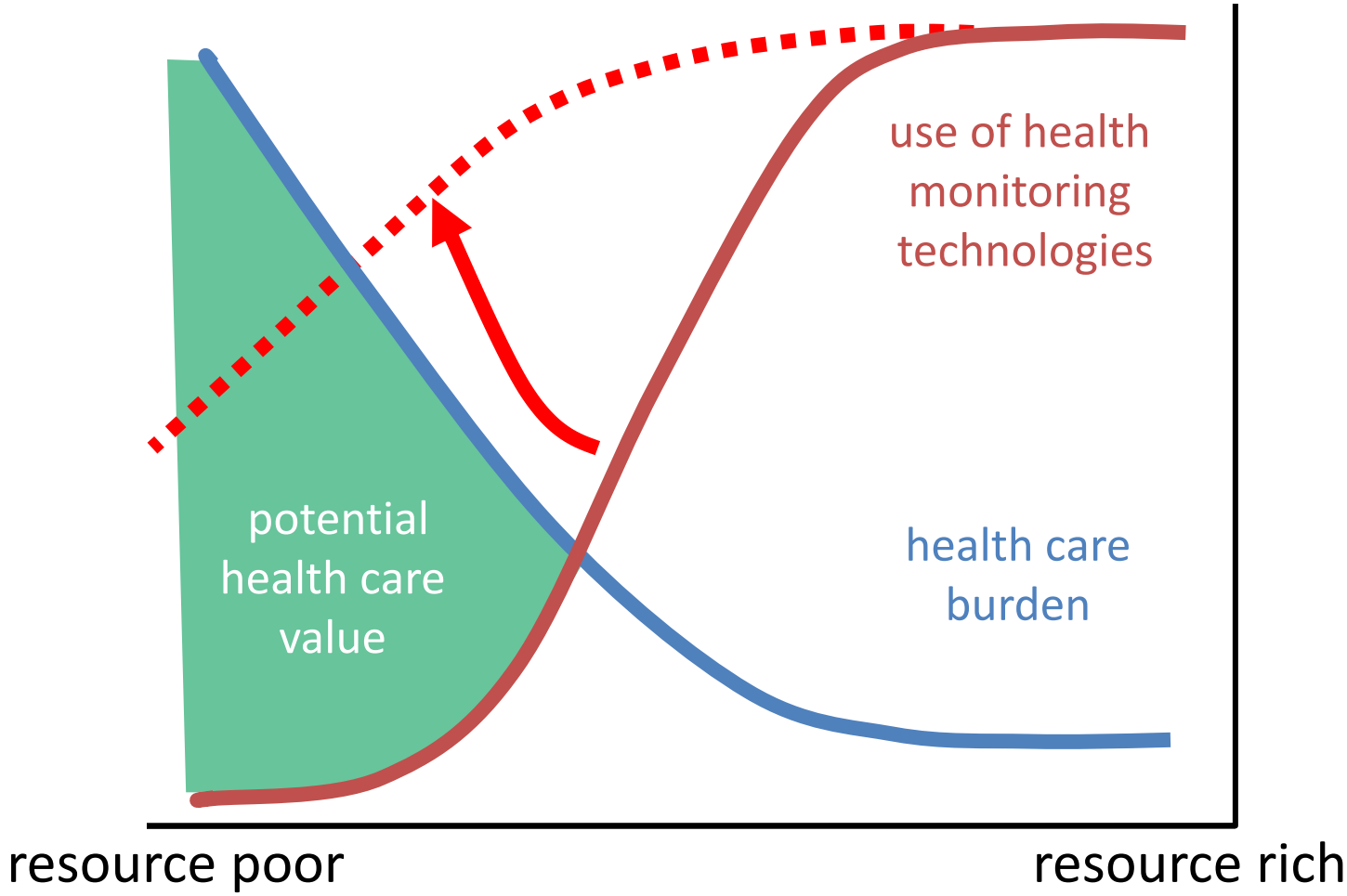
Develop and manufacture low-cost, physician-tested technologies for personal health assessment and education.

With community partners, design and build convenient, transportable health-monitoring stations that meet local needs.

Harness the existing manufacturing, communication, and transportation infrastructure.

The systems can be replicated in large numbers and can reach communities throughout the world.

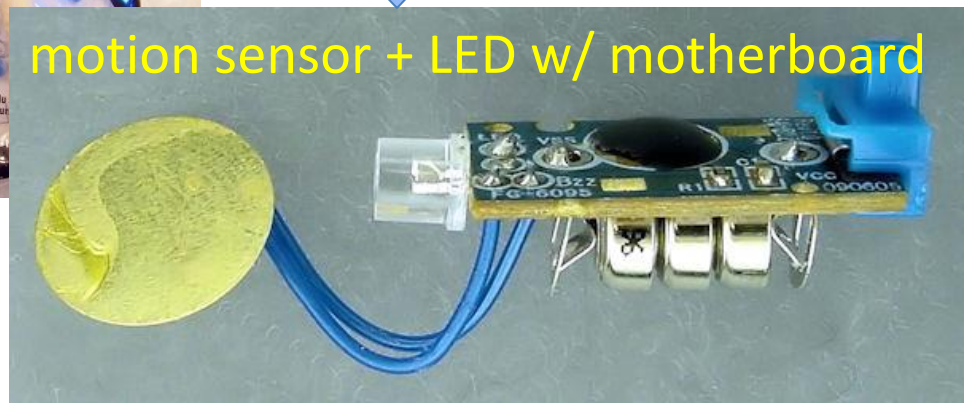
Resources and monitoring technology



Program implementation: Strategies

- Medical professionals are engaged at all stages.
- High quality data are trusted by physicians.
- *Monitoring* is the primary target application.
- Technologies are tested in clinical settings.
- Technologies move from UM-controlled clinical locations to more remote locations.
- After performance measures are achieved, technologies released for professional use.
- **Co-opting** components and strategies accelerates engineering development, reduces manufacturing costs, and yields robust systems.

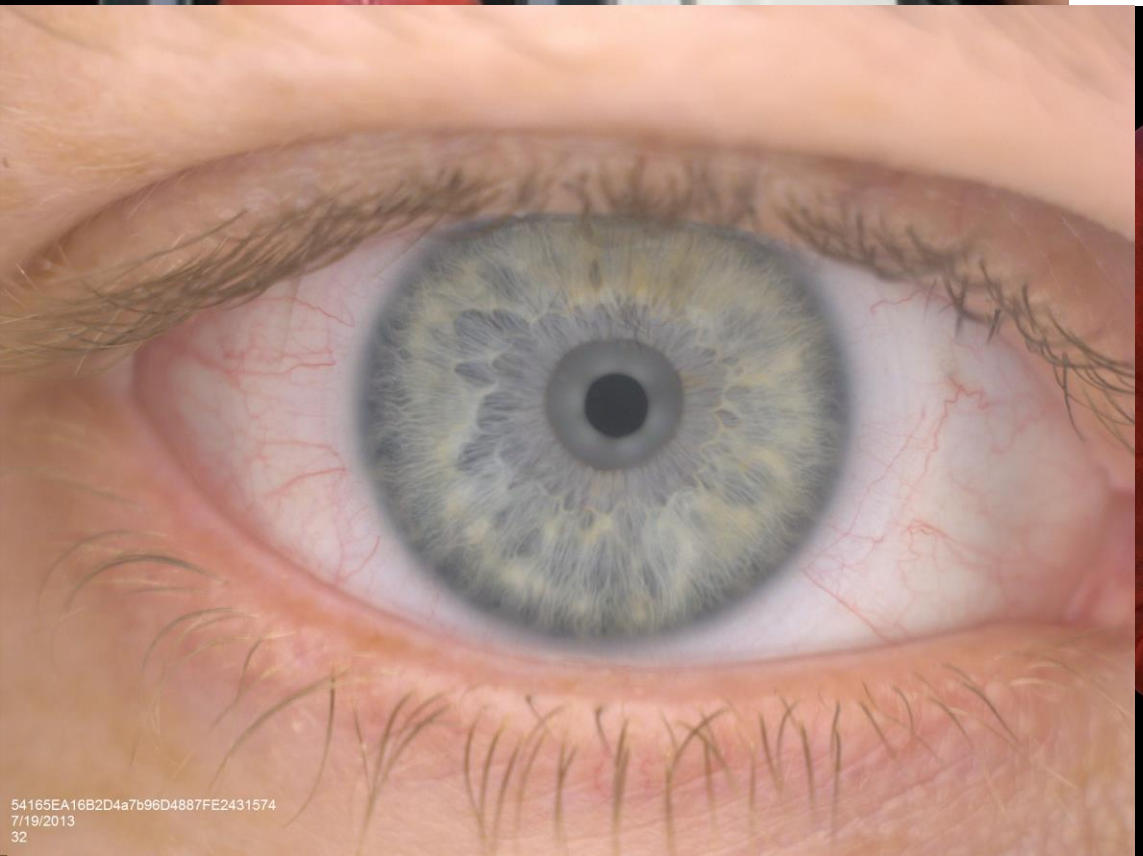
High volume low cost manufacturing

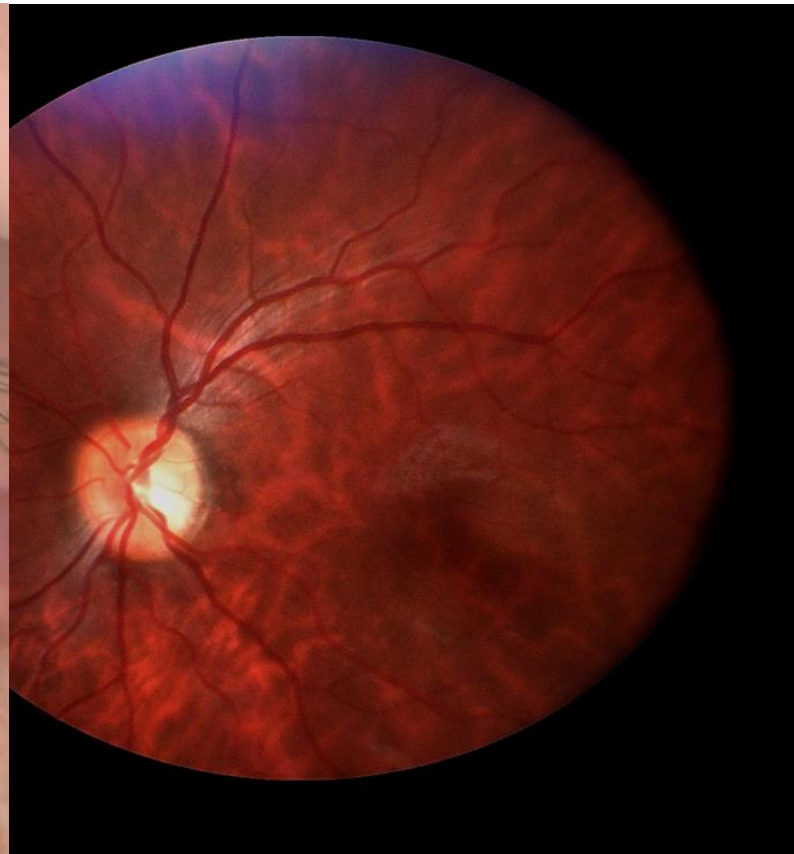


- McDonalds pre-orders >30 million of each toy
- Manufacturing cost per toy of $1.00 or less.

Digital cameras: an existing technology

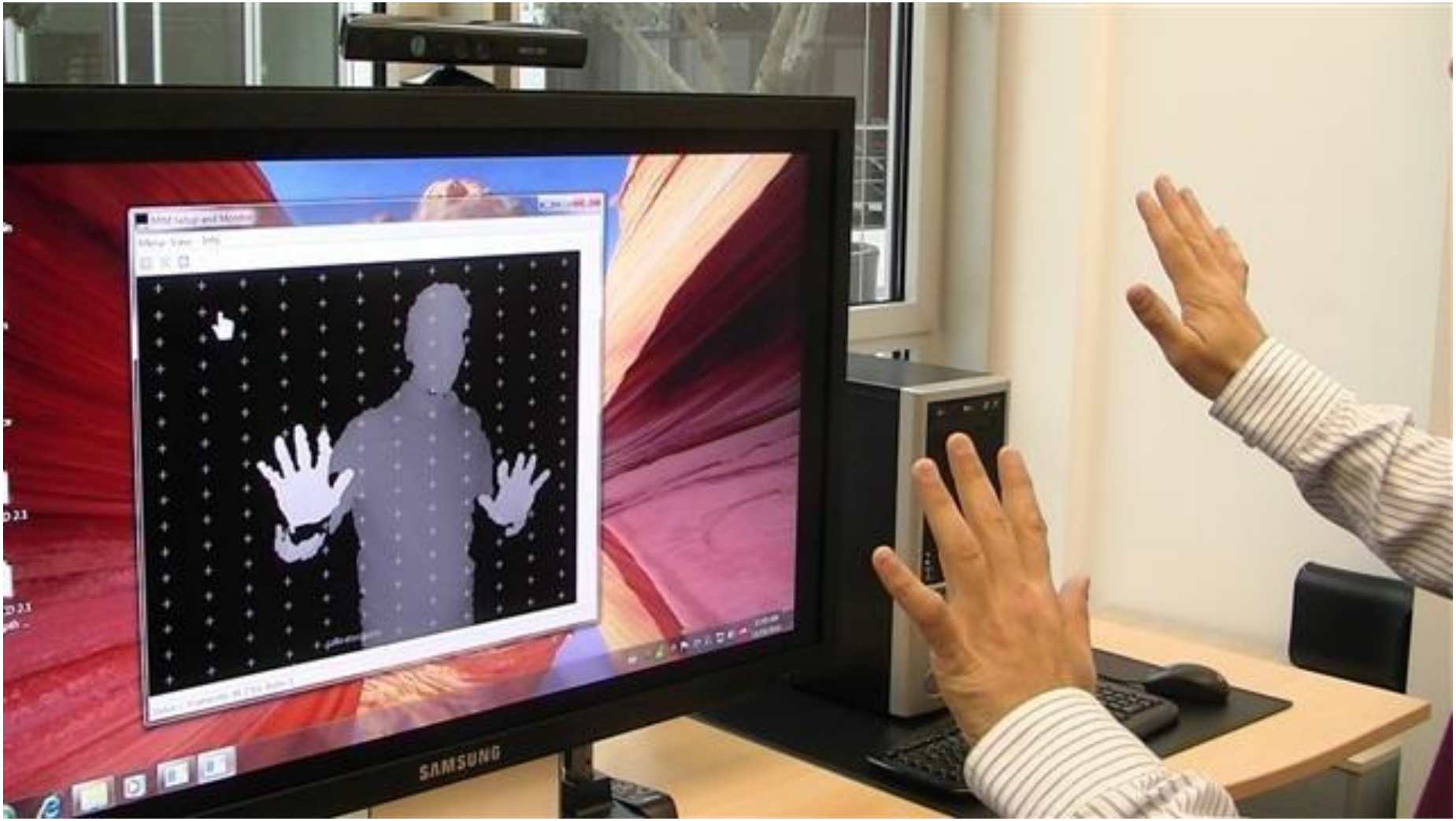
5Mpixel images captured, stored, and transferred with wireless communication.





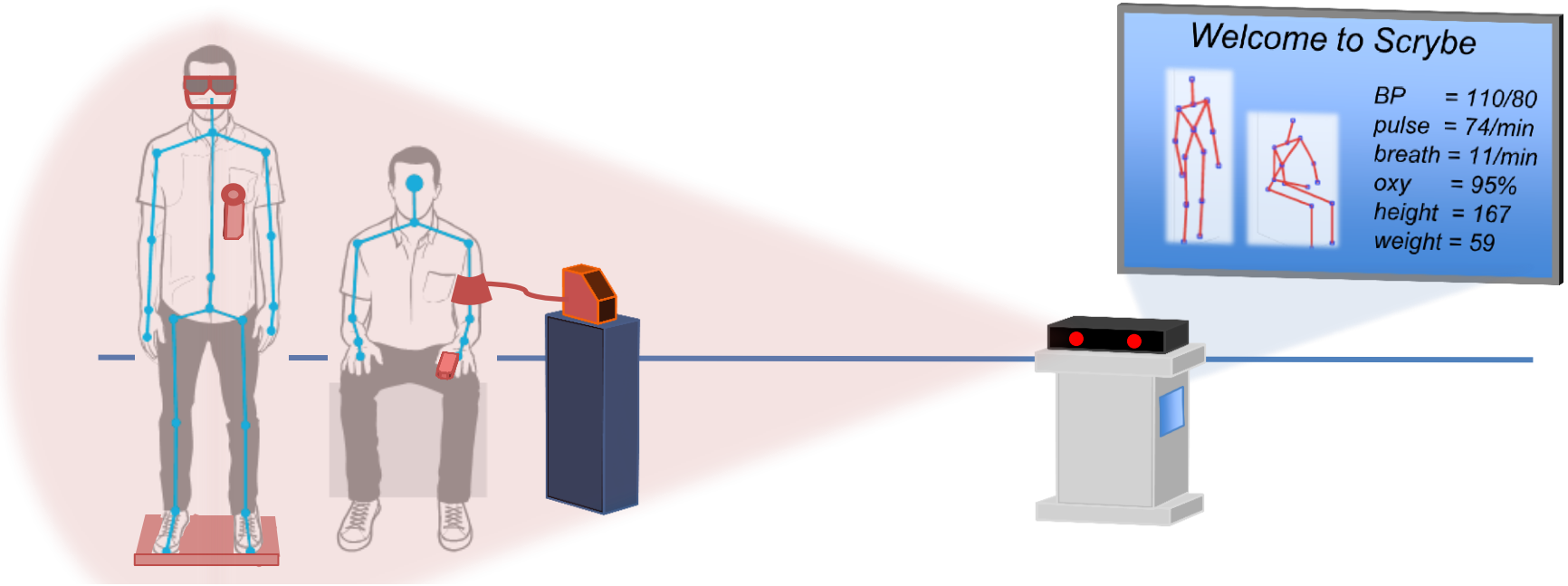
Movement tracking: a co-opted technology

Xbox Kinect Infrared 3-D movement scanner.



$150 per unit plus computer

“Scrybe”: remote health monitoring



Peripheral Sensors

$300-$500

- LCD-panel glasses
- air flow sensor
- stethoscope
- weight scale
- *CO_2/H_2O sensor*
- *multi-spectral camera*
- blood pressure cuff
- pulse oximeter
- surface temperature
- otoscope videocamera
- micro videocamera
- *muscle force sensor*

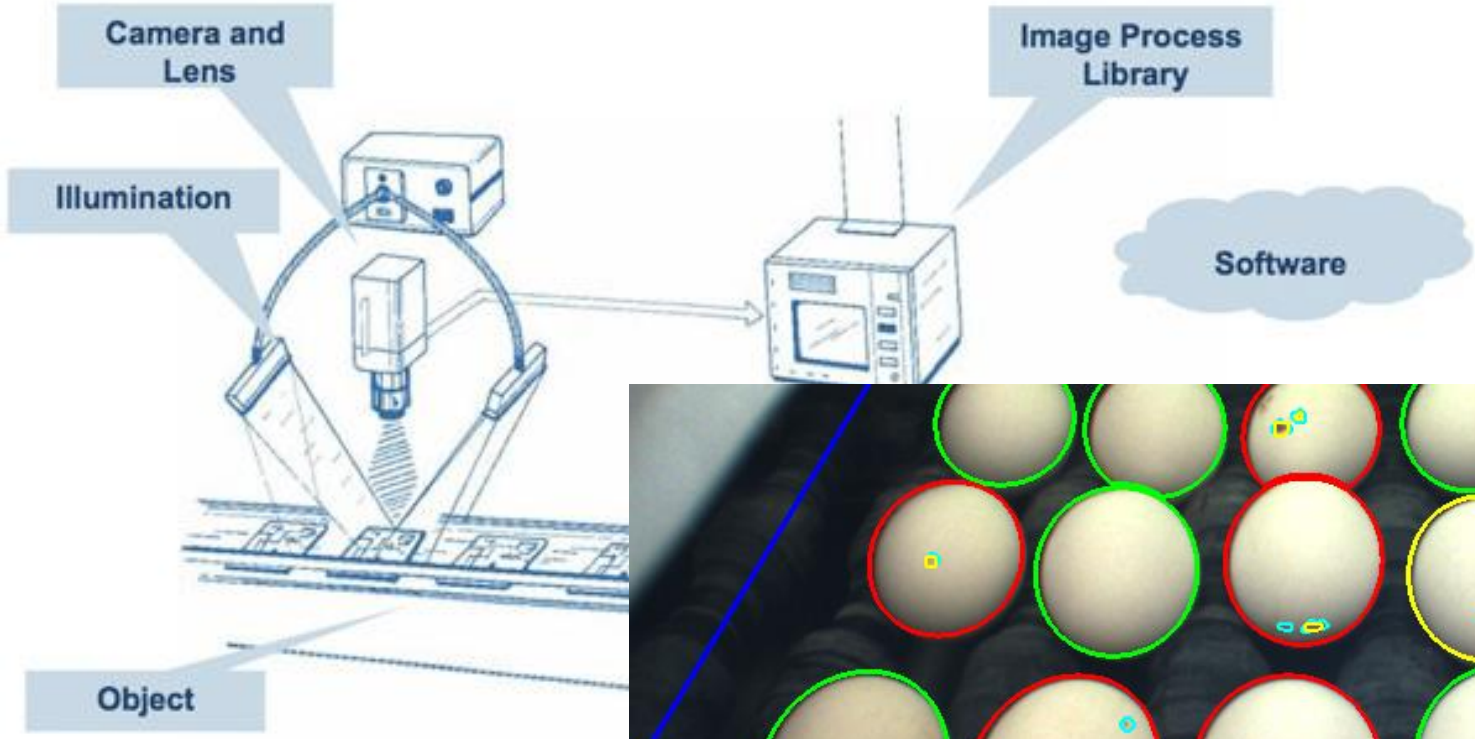
Scrybe Core

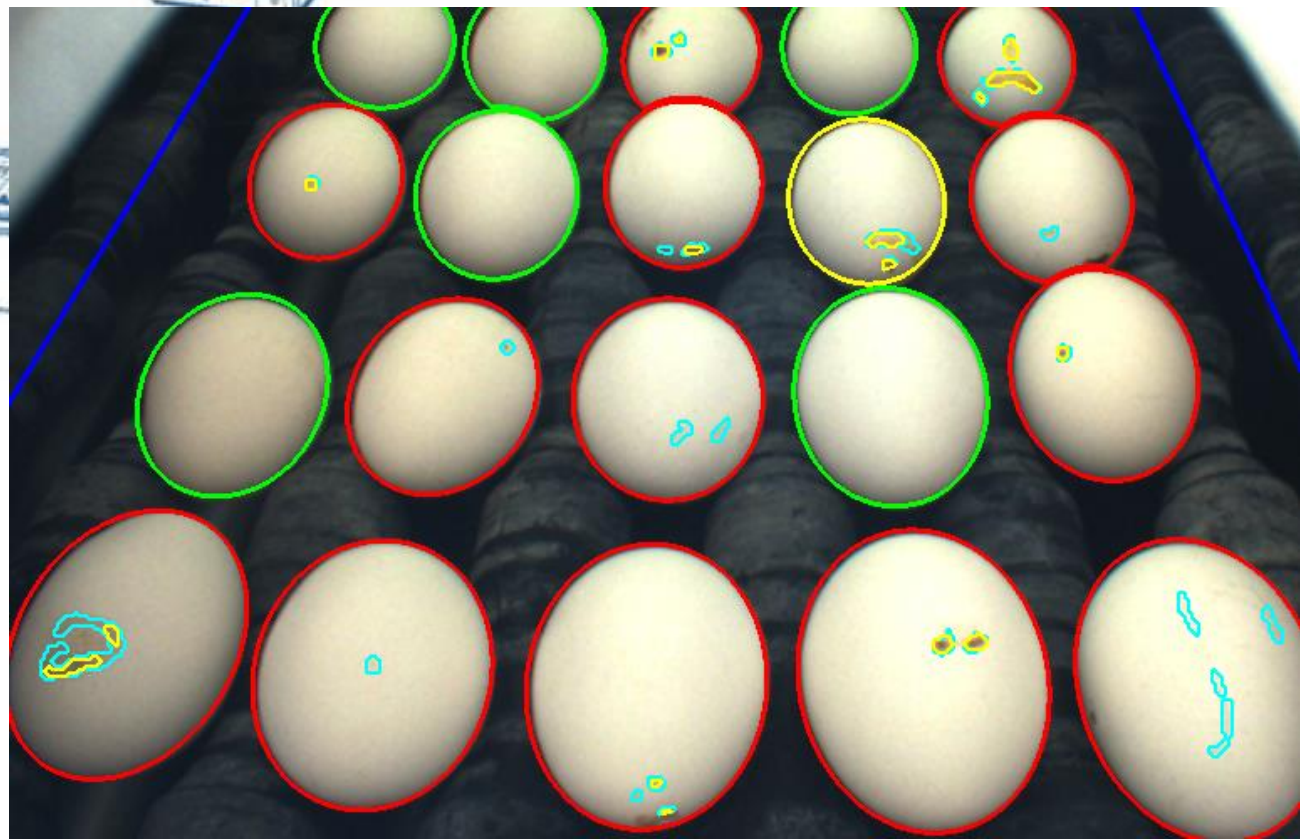
$700-$900

- Microsoft Kinect v2
- WiFi router hub
- processor (Surface Pro4)
  - Windows10 OS
  - OpenCV/SimpleCV
  - Visual Studio/C#
- monitor or projector

Intermodal shipping: a co-opted infrastructure

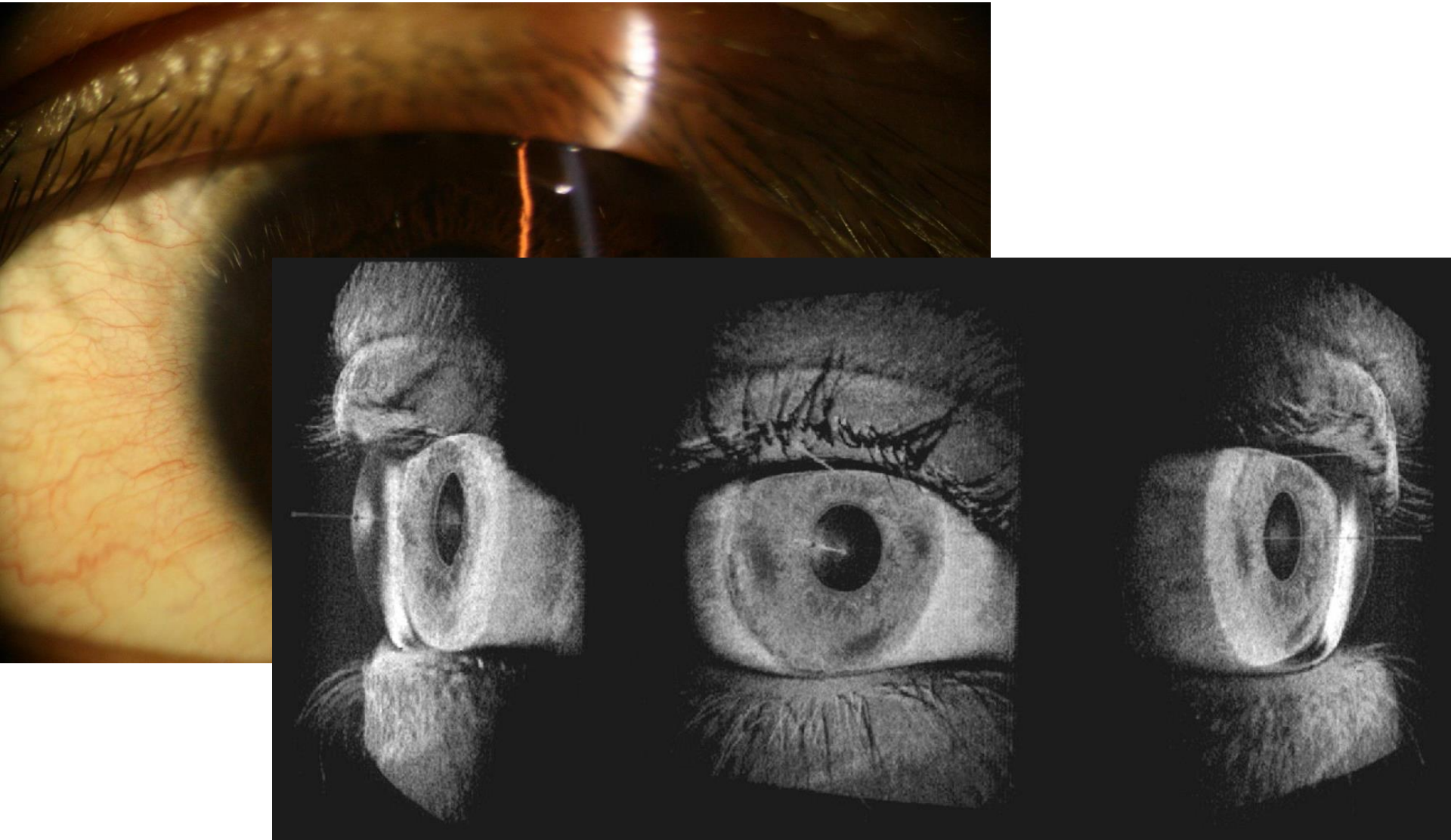
Machine vision: a co-opted technology



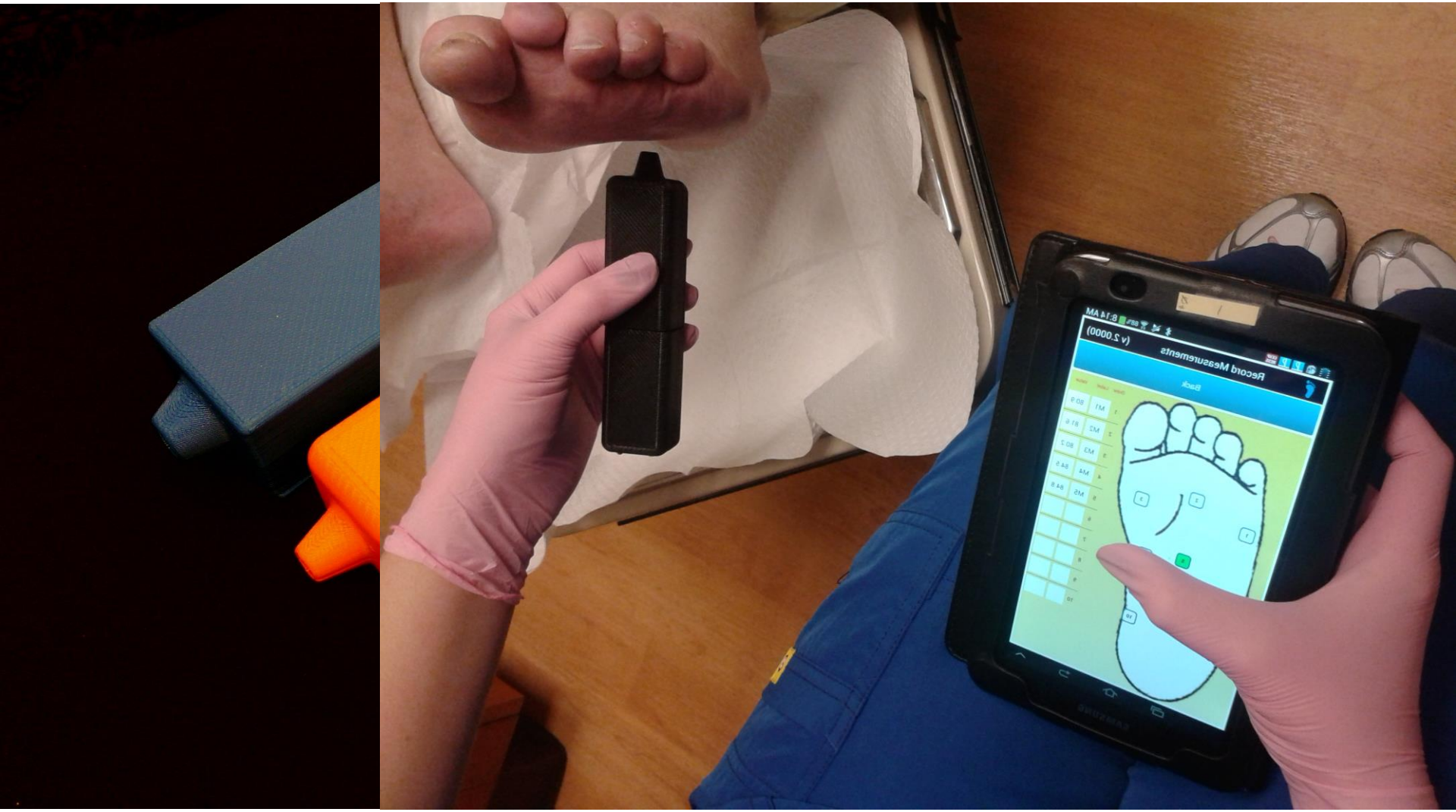


Machine vision: a co-opted technology

Cornea eye monitoring using structured light and 3-D modeling.



Wireless temperature sensors: a co-opted technology



Technology targets

- *Rapid development and implementation*
  - infrared temperature sensor; distal neuropathy, foot ulcers.
- *Moderate development challenge*
  - sound sensor; breathing volume and stethoscope.
- *Significant development challenge*
  - aqueous chemistry sensor; urinalysis, tear analysis.
- *Novel exploratory challenges*
  - 3-dimensional high-resolution eye imaging; corneal and retinal diseases.
  - motion-detection interface; self-monitoring and health care provider interaction.

University of Michigan test platforms

- **Kellogg Eye Center**

- **University Health Service Clinic**

Affiliated test platforms

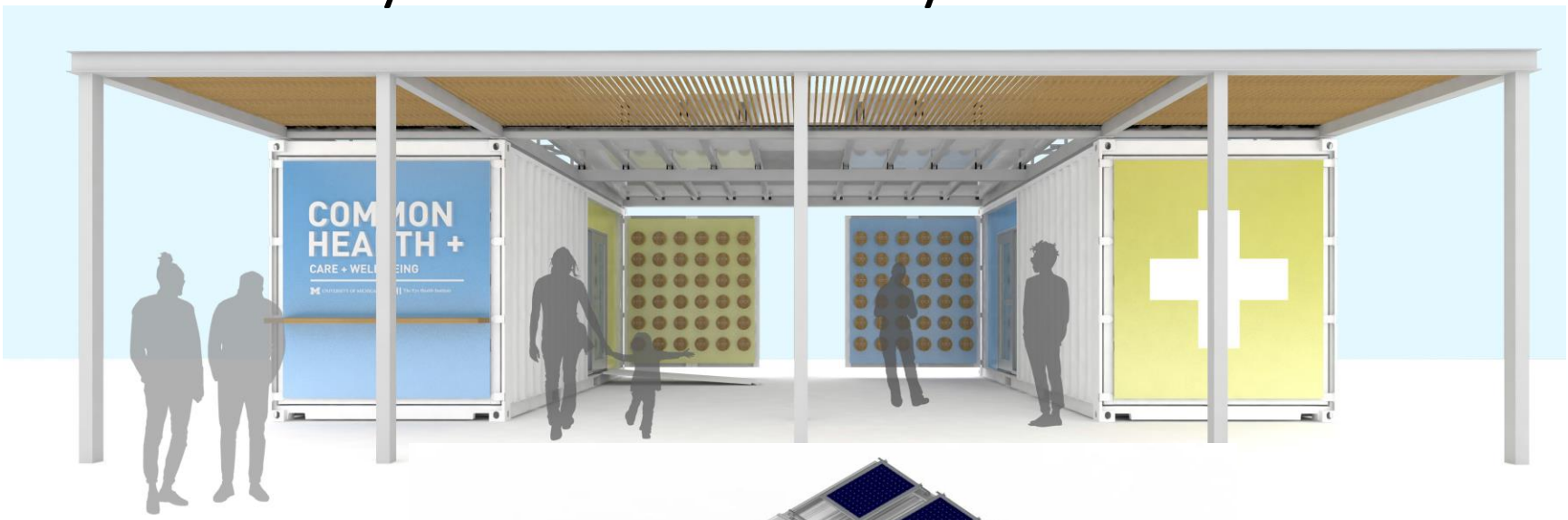
- **Eye Health Institute Jamaica**

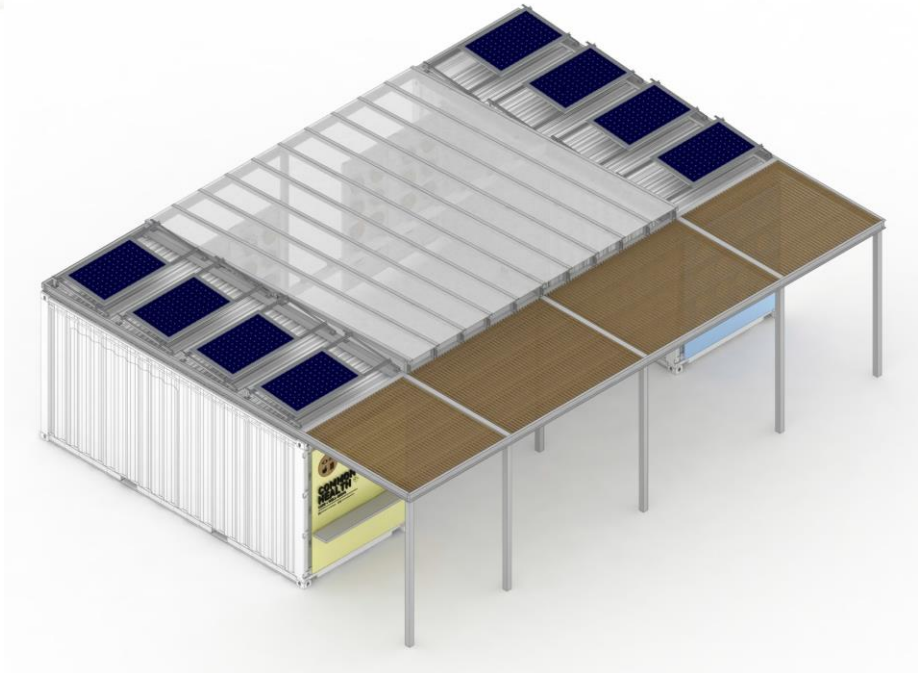
- **Joy-Southfield Community**

An eye clinic in Jamaica

Community Projects – 2017-2018

Trelawney Parish Jamaica – Eye Health Institute





Value to the University of Michigan

- **Service**: Inexpensive monitoring technologies impact individual ***and*** population-level health care.
- **Education:**
  - UM Engineering, Public Health, Information, Medicine, Nursing, Public Policy, Business/Davidson Institute.
  - Partner locations MI community, Jamaica, Africa.
- **Research**:
  - Novel health technologies and strategies.
  - Clinical studies of monitoring on health outcomes.
  - Quantitative data from dense, highly-distributed, quality-assured medical measures (“Big Data”).

Value to the University of Michigan

- https://youtu.be/_qfhuoYZoIY
- https://youtu.be/GiiZ58SoREE

Additional technology targets

- blood pressure
- pulse oximeter
- breath volume sensor
- electrocardiograph
- urine chemistry sensor
- balance and motion
- vision examination
- retinal camera
- height and weight
- vision-impaired/hearing-impaired questions

Future technologies in health care

Can new technologies impact the health and everyday lives of people who are underserved?

Can the University – with its wide range of knowledge and skills – lead in the development of these new technologies?

What are the unique features of human health, health care, and health maintenance that can provide a focus for technology development?