WashU
Bursky Public Health

AI in Public Health

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Oct.22.2026

COURSE OVERVIEW

Learning Objectives

1. Define Public Health

Contrast population health and prevention with individual clinical care models.

2. Trace History

Understand how analytical tools from John Snow's map to AI drove progress.

3. Analyze Core Domains

Explore life course health, infectious disease, chronic risks, and climate.

4. Evaluate AI & Smart Care

Examine sensing, deep predictive models, and digital health infrastructure.

5. Conduct Impact Evaluation

Apply counterfactual potential outcomes, RCT designs, and economic appraisal.

6. Translate to Practice

Bridge research to clinical workflows, regulatory clearance, and health equity.

PART 01

Public Health Foundations

What is Public Health?

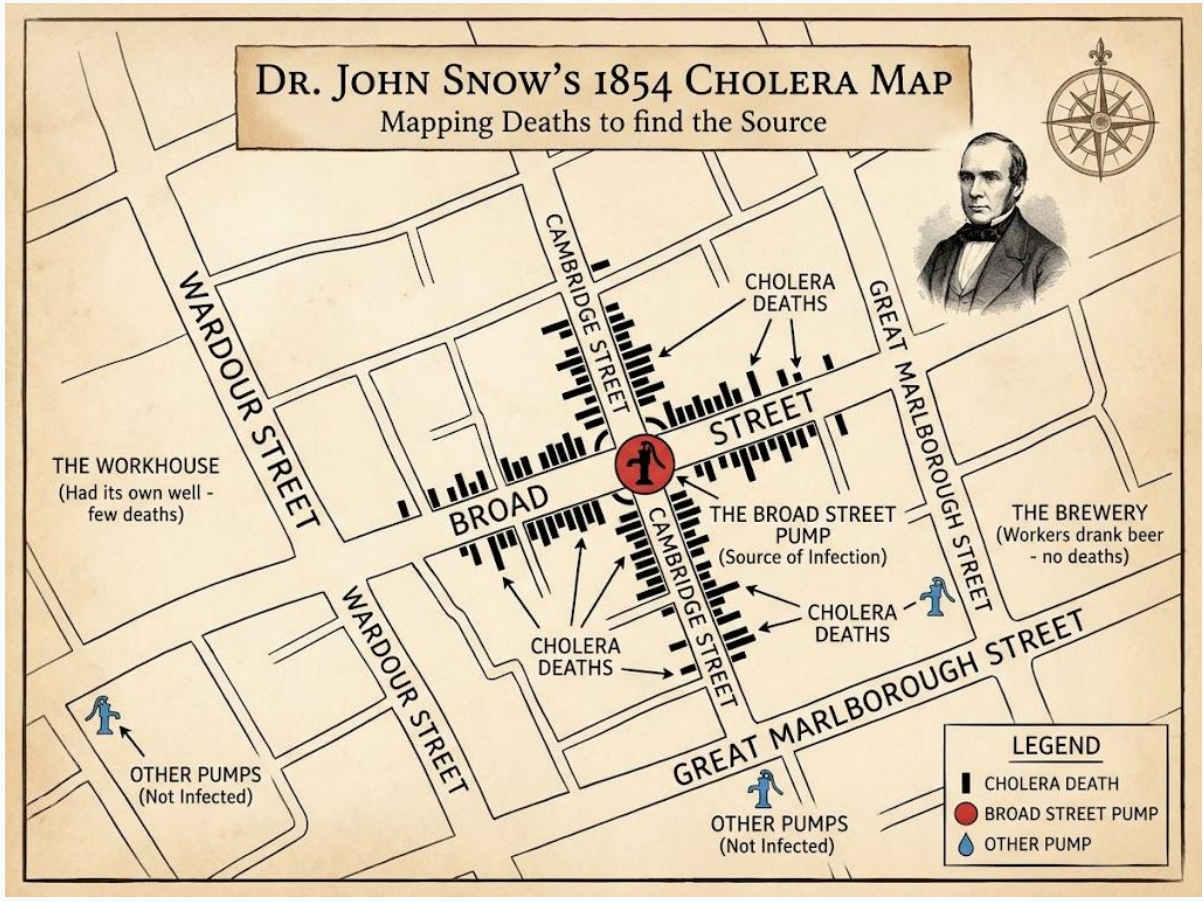

VACCINATION
HEALTH POLICY
COVID-PANDEMIC
PREVENTION
HEALTH ECONOMICS
COMMUNITY
AGING
WHAT IS PUBLIC HEALTH?
PUBLIC HEALTH
DISEASE
DISEASE CONTROL
WELL-BEING
GLOBAL HEALTH
EPIDEMIOLOGY
WELLNESS
HYGIENE

PART 02

Public Health History

From 1854 Spatial Epidemiology to Digital Surveillance and AI

Spatial Epidemiology: John Snow (1854)



- **1854 Cholera Outbreak:** Dr. John Snow recorded and mapped cholera deaths by exact street address in Soho, London.
- **Spatial Clustering:** Deaths clustered tightly around the Broad Street public water pump, refuting miasma theory.
- **Causal Mechanism to Action:** Snow deduced waterborne transmission and convinced parish officials to remove the pump handle.
- **The Public Health Loop:** Data collection -> Spatial pattern -> Plausible mechanism -> Decisive policy action.

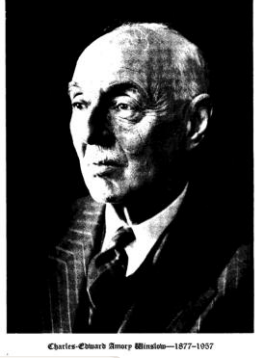




SOURCE: Snow J. On the Mode of Communication of Cholera. 1855.

What Is Public Health?

A classic definition - Charles-Edward Amory Winslow(1920)



> *"Public health is the science and art of preventing disease, prolonging life, and promoting physical health and efficiency through organized community efforts."*

THREE ENDURING GOALS

01 PREVENT DISEASE

Vaccination · sanitation · screening

02 PROLONG LIFE

Reduce premature illness and mortality

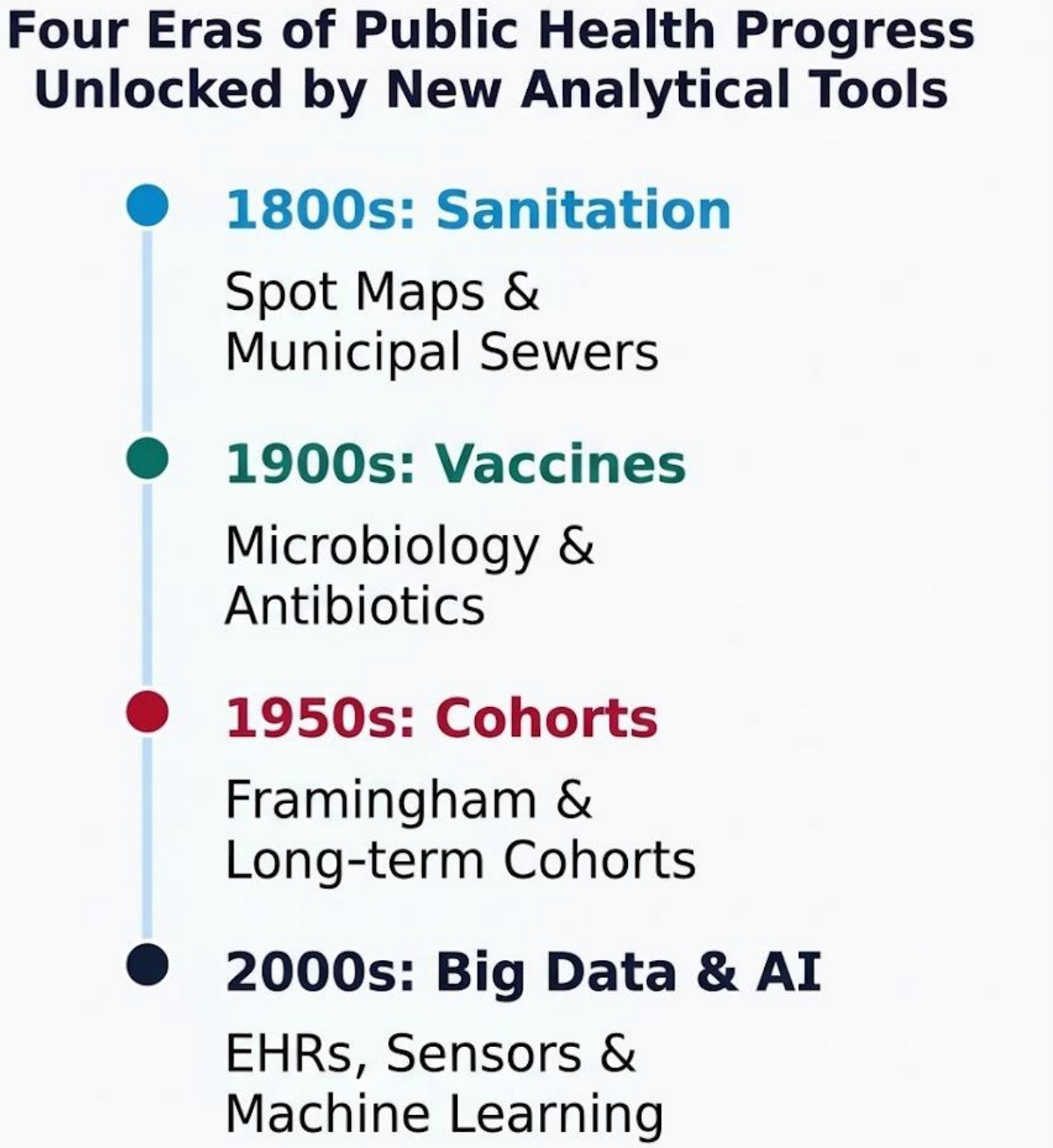
03 PROMOTE HEALTH

Improve well-being and living conditions

Core principle: Population health depends on organized collective action, and not only individual medical care.

Winslow, C.-E. A. (1920). The untilled fields of public health. Science, 51(1306), 23–33. doi:10.1126/science.51.1306.23

Four Eras of Progress



- **1800s Sanitation Era:** Municipal clean water, sewers, vital statistics registers, and John Snow's spot mapping.
- **1900s Bacteriology Era:** Germ theory, antibiotics, mass immunization campaigns, and smallpox eradication (1980).
- **1950s+ Chronic Disease Era:** Long-term epidemiological cohorts (Framingham 1948) and multivariable risk factor analysis.
- **2000s+ Digital & AI Era:** EHR aggregates, wearable physiological sensors, machine learning, and causal impact evaluation.

SOURCE: Detels et al. Oxford Textbook of Global Public Health.

Two Complementary Lenses on Human Health

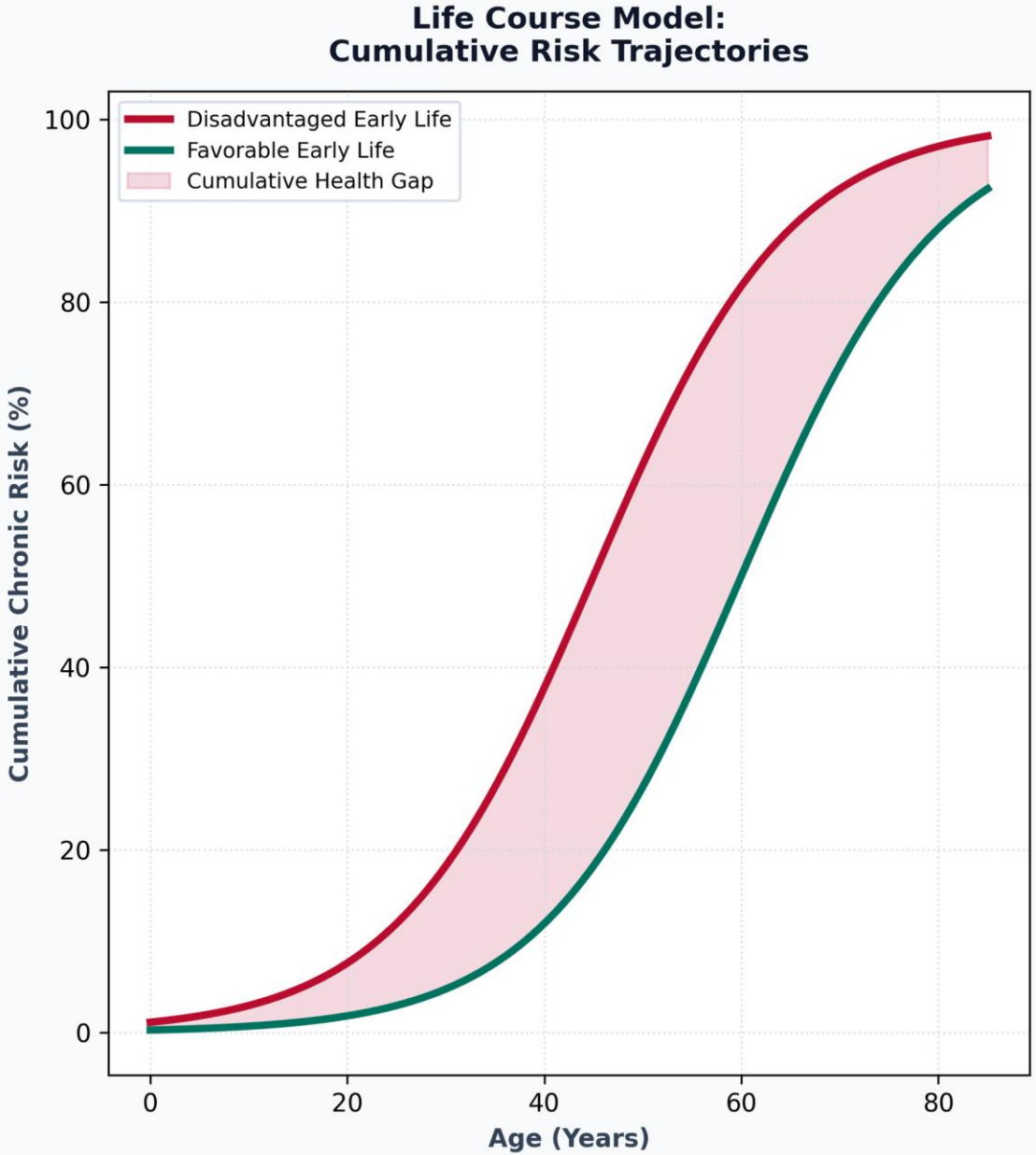
DIMENSION	CLINICAL MEDICINE	PUBLIC HEALTH SCIENCE
Primary Unit of Care	Individual patient presenting with specific illness.	Entire community, city, or defined population group.
Guiding Question	What diagnosis and therapy best heal this person?	Who is at risk, why, and what interventions protect all?
Primary Data Streams	Vital signs, diagnostic labs, individual EHR notes.	Multi-source surveillance, cohort data, environmental data, insurance claims aggregates.
Optimization Metric	Symptom resolution, cure, individual survival.	Incidence reduction, health equity, population QALYs gained.
Intervention Locus	Downstream treatment and clinical disease management.	Upstream environmental policies, vaccination campaigns, systems.

SOURCE: Adapted from Winslow (1920) and CDC Core Functions.

PART 03

Scope & The Population Lens

Multi-Level Determinants, Levels of Prevention & Core Health Domains

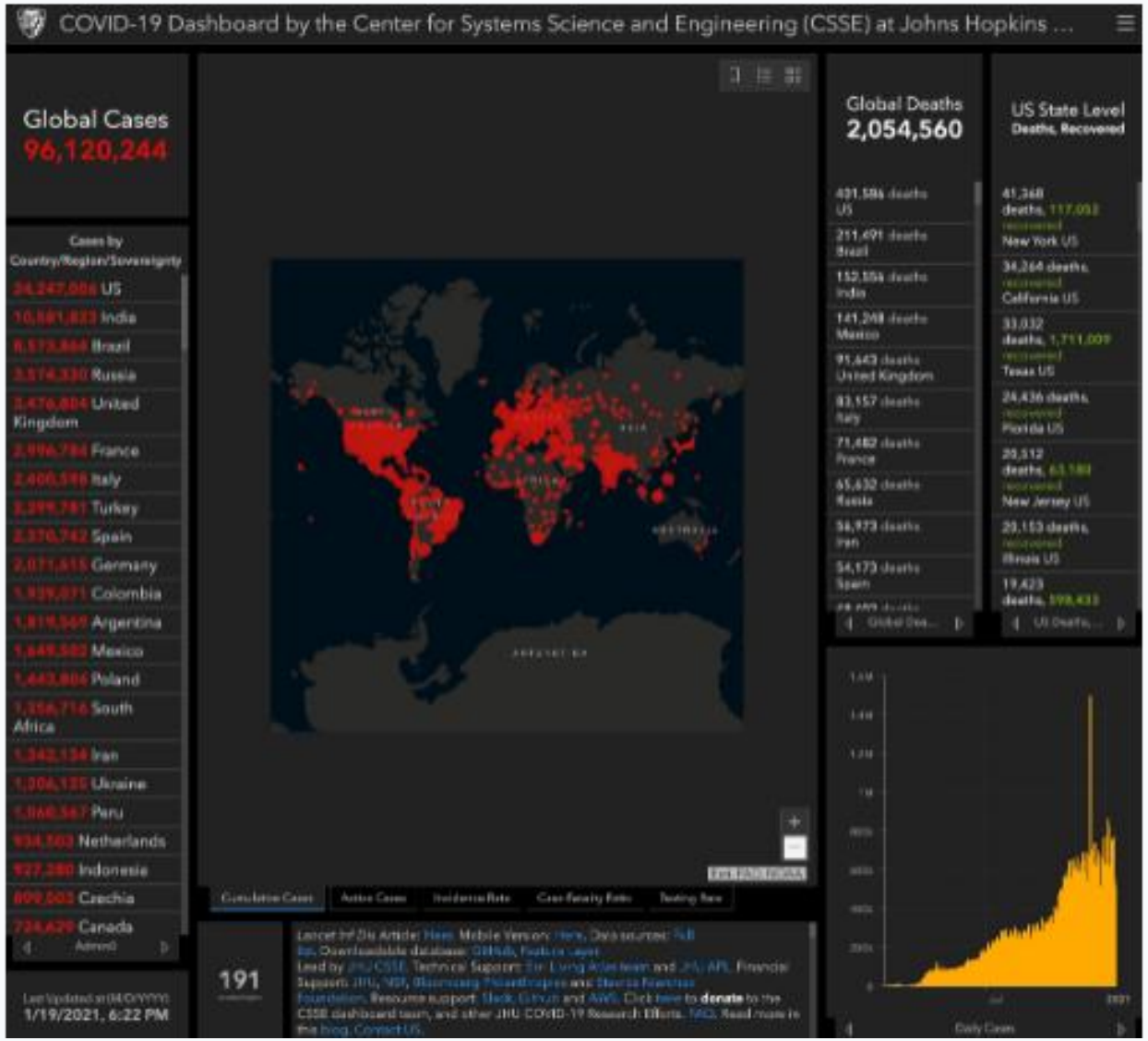


Domain 1: Health Across the Life Course

- **Pregnancy & Infancy:** Prenatal metabolic screening, ultrasound gestational dating, newborn vaccination, and maternal nutrition support.
- **Childhood & Youth:** Developmental milestone monitoring, school nutrition environments, youth mental health, and injury prevention.
- **Adulthood Prevention:** Workplace safety ergonomics, cardiometabolic risk screening, and population cancer prevention programs.
- **Older Adulthood:** Community fall risk mitigation, ambient sensor cognitive monitoring, and polypharmacy reduction.

SOURCE: Kuh D et al. A Life Course Approach to Chronic Disease Epidemiology.

Domain 2: Infectious Disease Surveillance



Real-Time Global Telemetry

Instantaneous aggregation of case counts, mortality data, and testing metrics across 190+ nations.

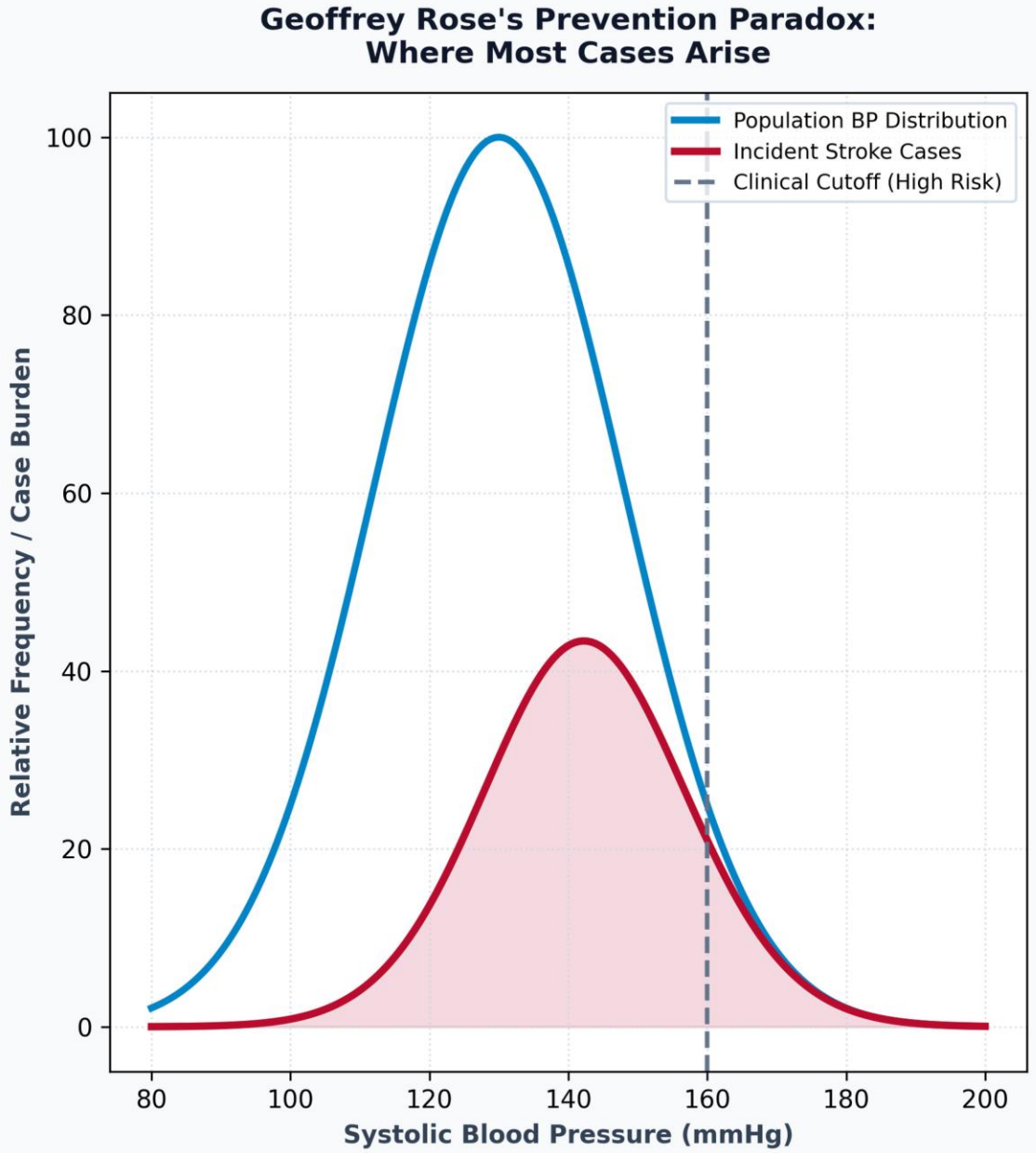
The Modern John Snow Map

Evolving from hand-drawn spot maps to automated GIS pipelines powering worldwide pandemic response.

Data-Driven Resource Allocation

Empowering health ministries to dispatch ventilators, PPE, and mobile vaccines prior to hospital saturation.

SOURCE: Johns Hopkins Center for Systems Science and Engineering (CSSE) COVID-19 Dashboard.



Domain 3: Chronic Disease & Population Health

- **Rose's Prevention Paradox:** A large number of people at low risk give rise to more aggregate disease cases than a small number at high risk.
- **Actual Causes of Death:** Tobacco use, ultra-processed diet, and sedentary lifestyles drive over 80% of premature cardiovascular and cancer mortality.
- **Dual Intervention Strategy:** Combine population-wide nudges (sodium reduction, clean indoor air) with AI risk stratification for high-risk individuals.
- **Early Biomarker Screening:** Automated non-invasive screening (retinal photography, wearable vitals) to detect subclinical vascular damage early.

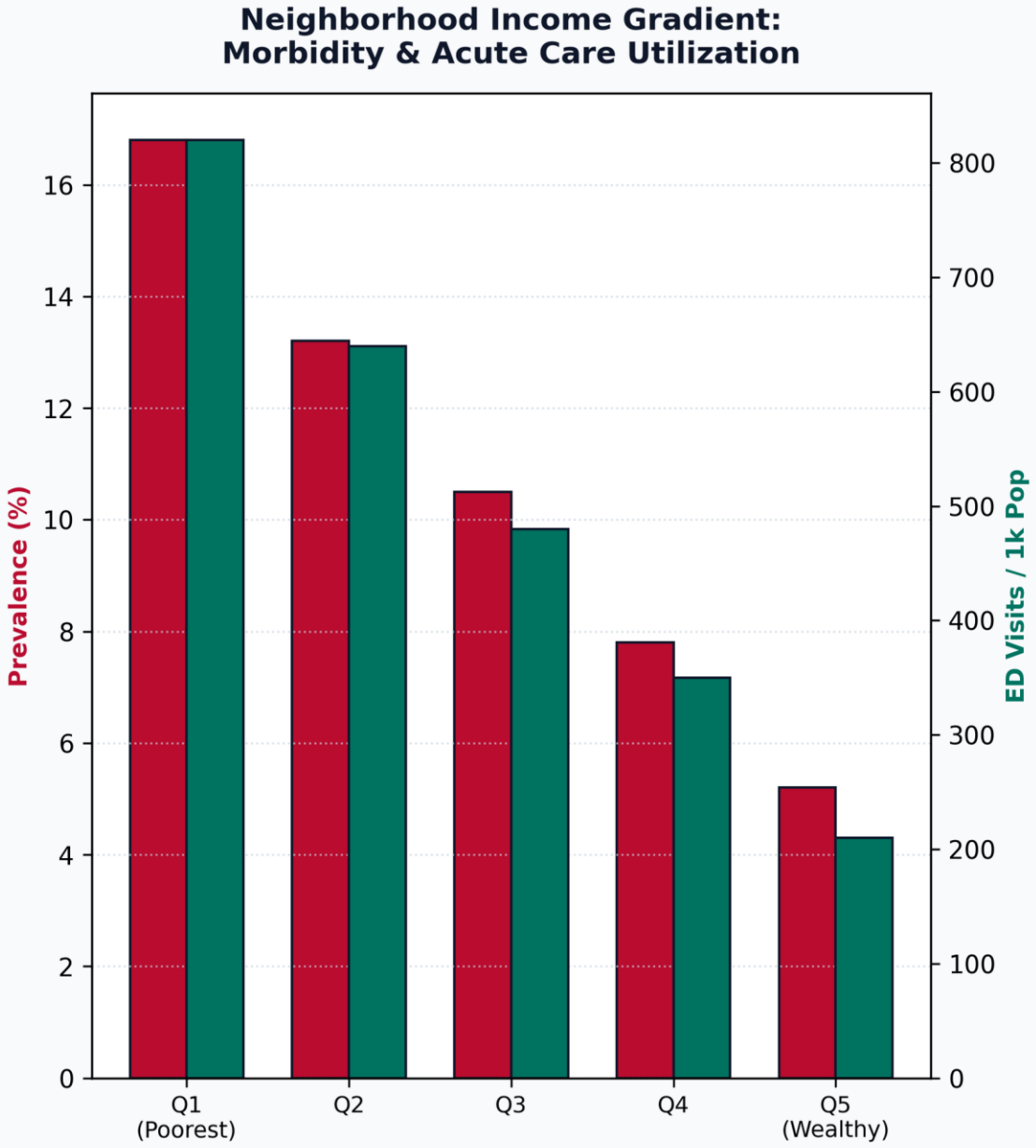
SOURCE: Geoffrey Rose. The Strategy of Preventive Medicine; CDC Chronic Disease.

Domain 4: Climate Change & Health Vulnerability

- **Extreme Heat Waves:** Triggers heat stroke, acute cardiovascular collapse, and kidney injury—especially in seniors and outdoor workers.
- **Wildfire Particulate Matter:** Spikes in fine PM2.5 penetrate deep into alveoli, exacerbating asthma, COPD, and triggering myocardial infarctions.
- **Shifting Ecology:** Warming temperatures expand geographic ranges for ticks (Lyme disease) and mosquitoes (Dengue, West Nile).
- **Disproportionate Impact:** Low-income urban heat islands lack tree canopy and air conditioning, bearing the heaviest mortality burden.



SOURCE: Mora C et al. Nat Clim Chang. 2022;12:869–875; Ssebyala SN et al. PLOS Climate 2024.



PART 03 · SCOPE & DOMAINS

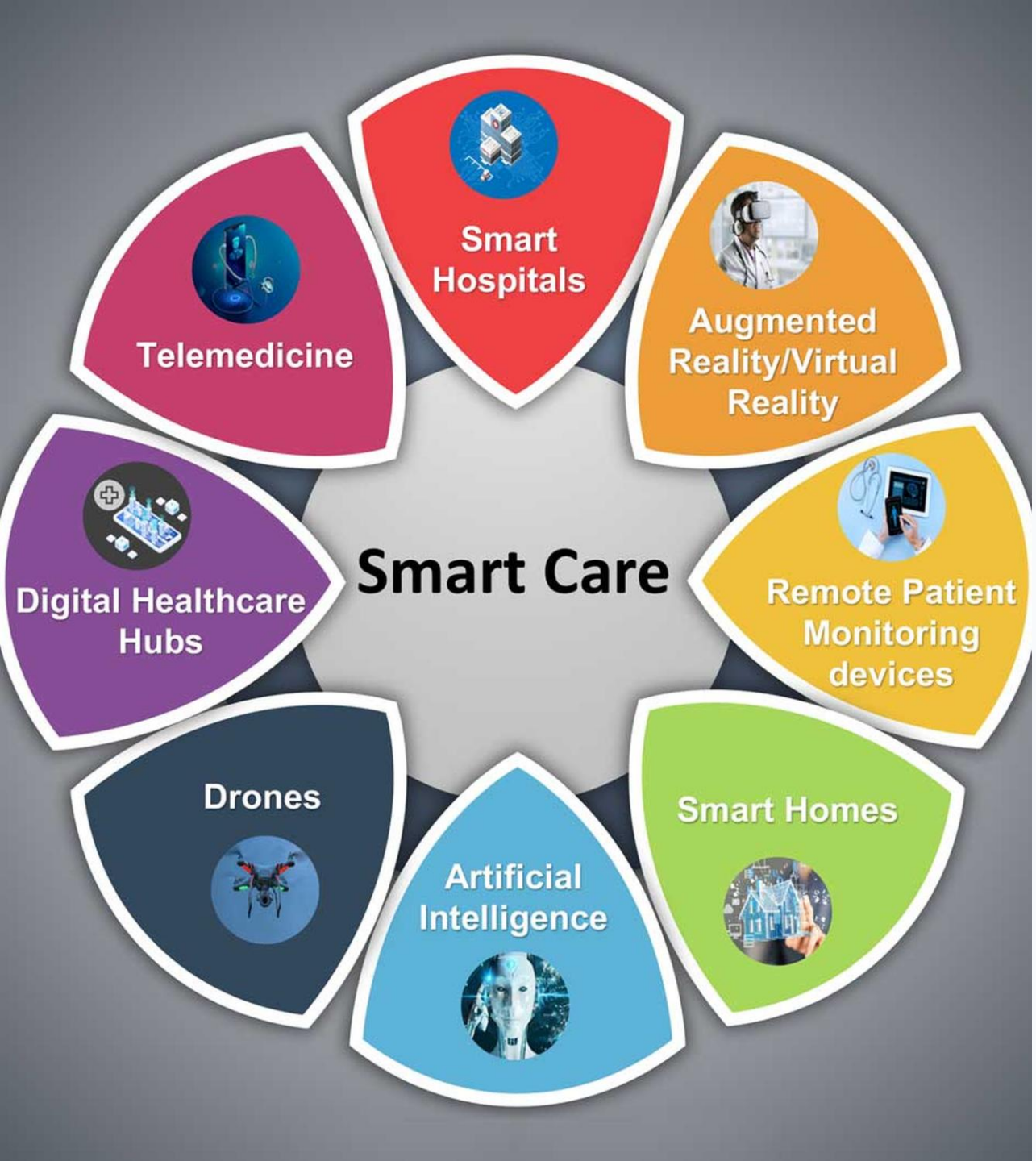
Domain 5: Health Equity & Algorithmic Justice

- **Structural Inequities:** Chronic morbidity and emergency visits follow steep socioeconomic gradients across urban zip codes.
- **Selection Bias in Data:** Digital health systems reflect who has the insurance and broadband to seek care, creating systematic data blind spots.
- **Who Receives Care?:** Algorithmic decision rules must channel care to those with highest clinical need rather than commercial profitability.
- **Equity Audit Mandate:** AI implementations must be audited across racial, linguistic, and geographic groups to ensure they narrow gaps.

SOURCE: WHO Guidance on Ethics and Governance of AI for Health.

PART 04

Public Health in Smart Care & AI



The Smart Care Ecosystem: Expanding Boundaries

- **Telemedicine Delivery:** Synchronous and asynchronous video visits overcoming geographic distance and clinic access barriers.
- **Remote Patient Monitoring (RPM):** Connected cellular blood pressure cuffs, glucometers, and pulse oximeters streaming vitals.
- **Smart Homes & Smart Hospitals:** Ambient radar sensors and smart hospital beds providing passive monitoring for vulnerable patients.
- **AI Decision Support:** Automated computer vision and clinical NLP integrated into EHR systems to guide physician triage.

Examples of new programs nationally… (huge fiscal investments)

	New Programs and Health Policy Reforms
Telehealth 	• 1990s-2000s: Pilots in remote areas • 2010s: Covered by insurance payments • 2020: Federal Medicare (aged at or above 65) started to pay for telehealth
Electronic Health Records (EHR) 	• 2009: Health Information Technology for Economic and Clinical Health Act (HITECH Act) promoted nationwide adoption • Since 2015: Shift toward promoting Interoperability (CMS meaningful use)
AI in Healthcare	• 2015-2018: Surge in investment • 2020: Applications in AI diagnostic support, imaging, robotics, doctor notes

PART 05

Causal Impact Evaluation

From Predictive Accuracy to Health Outcomes, Counterfactuals & RCTs

“Gold Standard” ➔ Randomized Control Trials

Crop field trials



Zero



What is the counterfactual?

“Gold Standard” ➔ Randomized Control Trials

Medical









Zero

What is the counterfactual?

Real-world examples

Smart Health Interventions

Telehealth



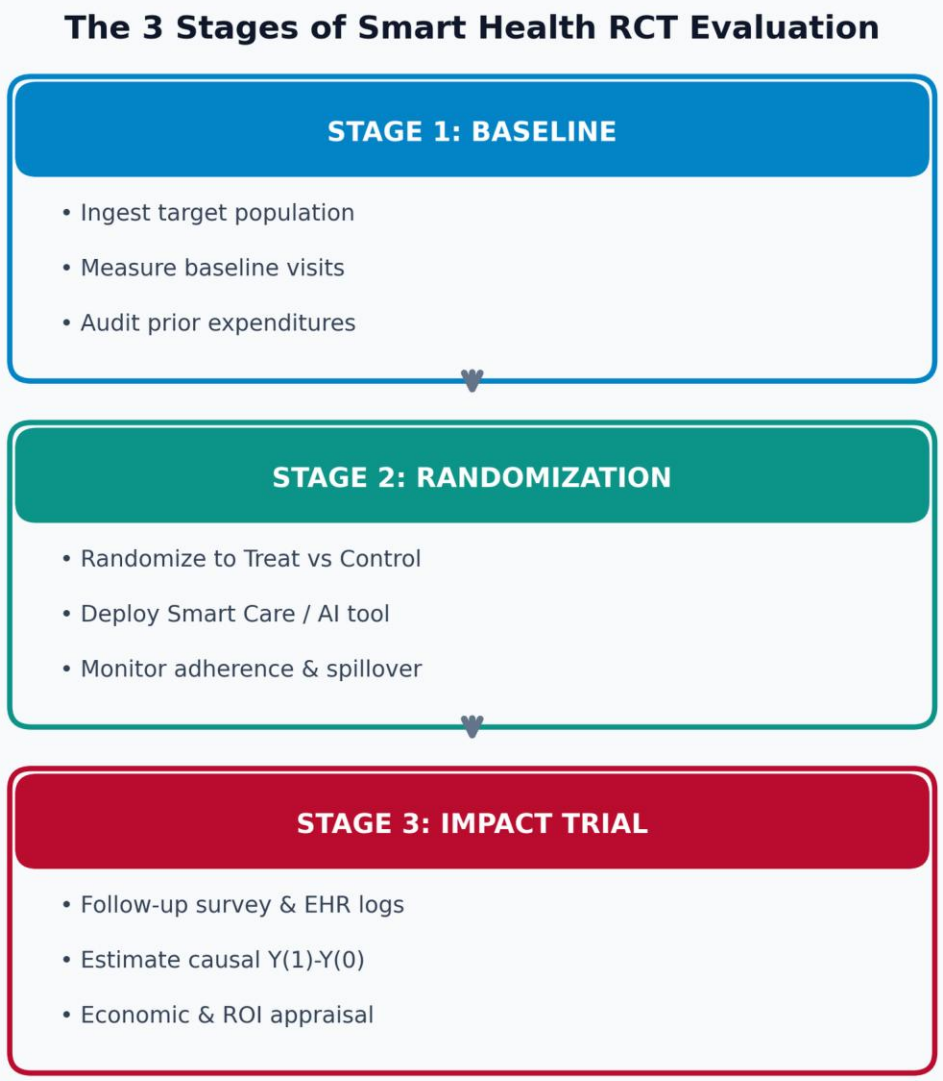
Remote Patient Monitors



AI +Smart Home



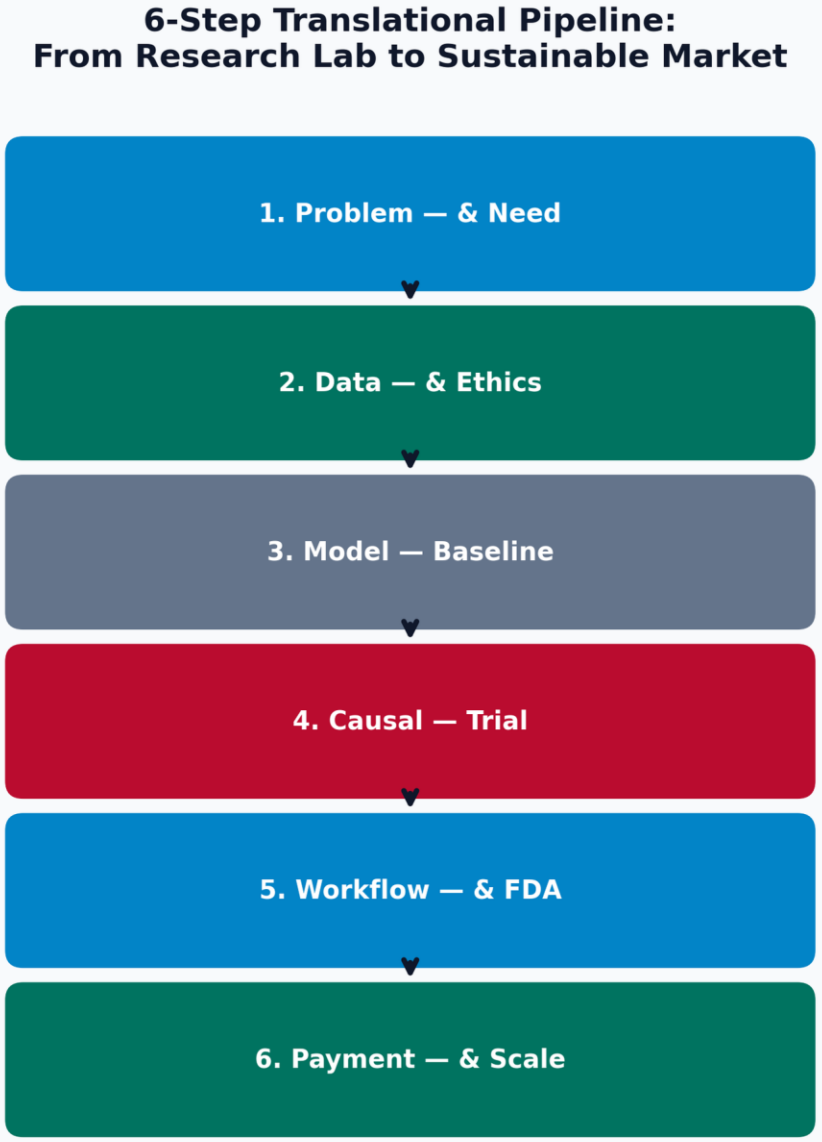
- **Zhang Z**, Bundorf MK, Gong Q, Shea CM, Gilleskie D, Sylvia SY. Telehealth payment parity and outpatient service utilization: evidence from privately insured workers. Health Affairs Scholar. 2025;3(4):qxaf068. doi:10.1093/haschl/qxaf068
- **Zhang Z**, Bundorf MK, Gong Q, Trogdon JG, Gilleskie D, Sylvia SY. The Role of Telehealth Payment Parity on Recommended Care and Emergency Department Service Utilization Among Workers With Chronic Conditions. Medical Care. 2025;63(10):779. doi:10.1097/MLR.0000000000002185
- **Zhang Z**, KM Cudjoe T, Ashida S, Massare J, Chae K, Phan P, Abadir P, I Arbaje A, Unberath M, Schoenborn N, The Ways in Which Stakeholders Make Decisions About AI and Novel Technologies for the Health Care of Older Adults: Qualitative Interview Study, JMIR Aging 2026;9:e86148, doi: 10.2196/86148



Lifecycle of an RCT: The Evaluation Stages

- **1. Design & Baseline Survey:** Define target population, power sample size, and measure prior hospital visits and baseline medical costs.
- **2. Random Assignment & Rollout:** Randomize units to treatment (smart health) vs control; deploy tool and monitor adherence and spillover.
- **3. Evaluation Survey & Analysis:** Collect follow-up data across both arms, estimate causal impact Y(1) - Y(0), and test statistical significance.
- **4. Health Economic Appraisal:** Determine if observed reductions in acute hospitalizations and Emergency Department visits offset hardware and operational costs.

From Lab to Market



- **1. Problem & Decision:** Who is the end user (doctor, health officer), and what specific clinical decision or workflow action changes?
- **2. Data & Ethics:** What data exists, who owns it, how is patient privacy secured, and how do you guarantee demographic fairness?
- **3. Model & Baseline:** What is the simplest viable statistical or ML model, and what established clinical baseline does it outperform?
- **4. Causal Validation:** How will you design an RCT or quasi-experimental study to prove real-world health and cost improvements?
- **5. Rules & Reimbursement:** Is it an FDA-regulated SaMD device, does it integrate into EHRs, and who pays (Medicare, ACOs, commercial payers)?

PART 07

Translational Workshop: Research to Market

Small-Group Innovation Lab, Pitches

Group Collaborative Challenge: Four Tracks – AI in Public Health

GROUP A: LIFE COURSE

- **Problem:**
- Early identification of high-risk pregnancy, pediatric developmental delay, or older adult falls.
- **Data to Consider:** EHR records, portable ultrasound, home sensors, actigraphy, school assessments.

GROUP B: INFECTIOUS

- **Problem:**
- Syndromic early warning, wastewater outbreak tracking, vaccine misinformation, contact tracing.
- **Data to Consider:** Wastewater PCR titers, emergency room chief complaints, flight mobility, genomics.

GROUP C: CHRONIC CARE

- **Problem:**
- Population screening for diabetes and hypertension, digital adherence nudges, worker routing.
- **Data to Consider:** Retinal fundus images, continuous RPM vitals, claims data, food desert indices.

GROUP D: CLIMATE HEALTH

- **Problem:**
- Heat-health warning for outdoor workers, wildfire smoke alerts for asthmatics, vector maps.
- **Data to Consider:** Satellite AOD, microclimate meteorological stations, emergency visits, housing age.

Report-out Pitch

Your Pitch Structure

- **1. Public Health Need:** What disease, hazard, or disparity are you solving?
- **2. Target Population:** Who is affected, who is vulnerable, who benefits?
- **3. AI Innovation:** What sensing or prediction capability do you add?
- **4. The Action and Impact:** What concrete decision or intervention changes?
- **5. Market Pathway:** Who adopts, who pays, and how does it scale?

PART 08

Summary and Takeaways

Four Guiding Principles

1. POPULATION FIRST

- **Beyond Individual care:**
- Look past isolated clinical visits to the systemic and environmental conditions shaping community health.

2. ENGINEERING RIGOR

From Lab to Field:

- Technical accuracy matters only when paired with robust sensors, clean data pipelines, and workflow integration.

3. CAUSAL EVIDENCE

- **Causal impact:**
- Predictive accuracy needs causal evaluation proving tools reduce hospitalizations and costs.

4. EQUITY BY DESIGN

- **Ethical Alignment:**
- Objective functions encode societal policy choices. AI must be actively audited to close historical disparities.

Thank you!

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