

Toward Algorithm-Based Medicine



Take-Home Message

Every breakthrough that we want (need) to happen in science & medicine can be achieved in the dog first with greater speed, reduced cost, and less controversy.

The most profound barriers to improving human healthcare — sociology, politics, and cost — are non-existent or greatly reduced in canine healthcare.

An Epic Experiment in Biology



15,000 yrs in the making

A Unique Patient Model



Same diseases, same medicines

Human Medicine is a Trade, not a Science

Inertia favors traditional practices
(e.g., NIH and non-adopted best practices)

Care is typically reactive and fragmented
(e.g., medicaid patient, 7 specialists, 7 indep't plans)



Emergent Themes in Human Healthcare

Evidence-Based - Proven clinical best practices

Precise - Targeted to causal disease mechanisms

Personalized - Tailored to patient's disease & pharmacology

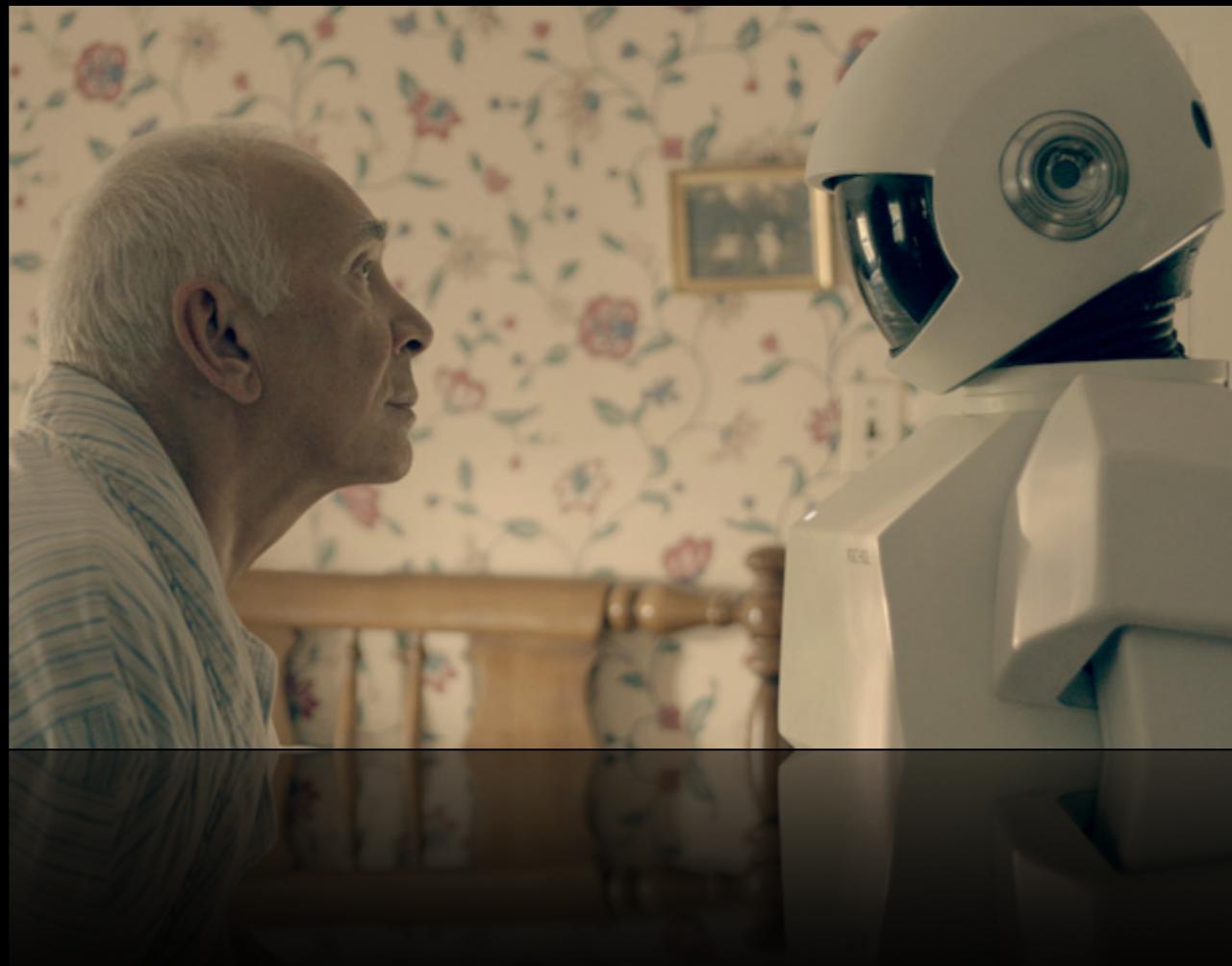
Consistent - Democratized patient benefit

Continuous - Not just reactive to disease

Preventive - Pro-active to counter patient's risks

Features of Algorithm-Based Medicine

Algorithm-Based Medicine



An empirically informed smart system that integrates and analyzes data in making continuous health predictions for a group or an individual, and that meets these predictions with an actionable plan and consistent recommendations for care

Potential & Challenges of Clinical Data Mining

Human Oncology in the U.S.



2 million patients per yr
unique tumor profiles
personal pharmacologies

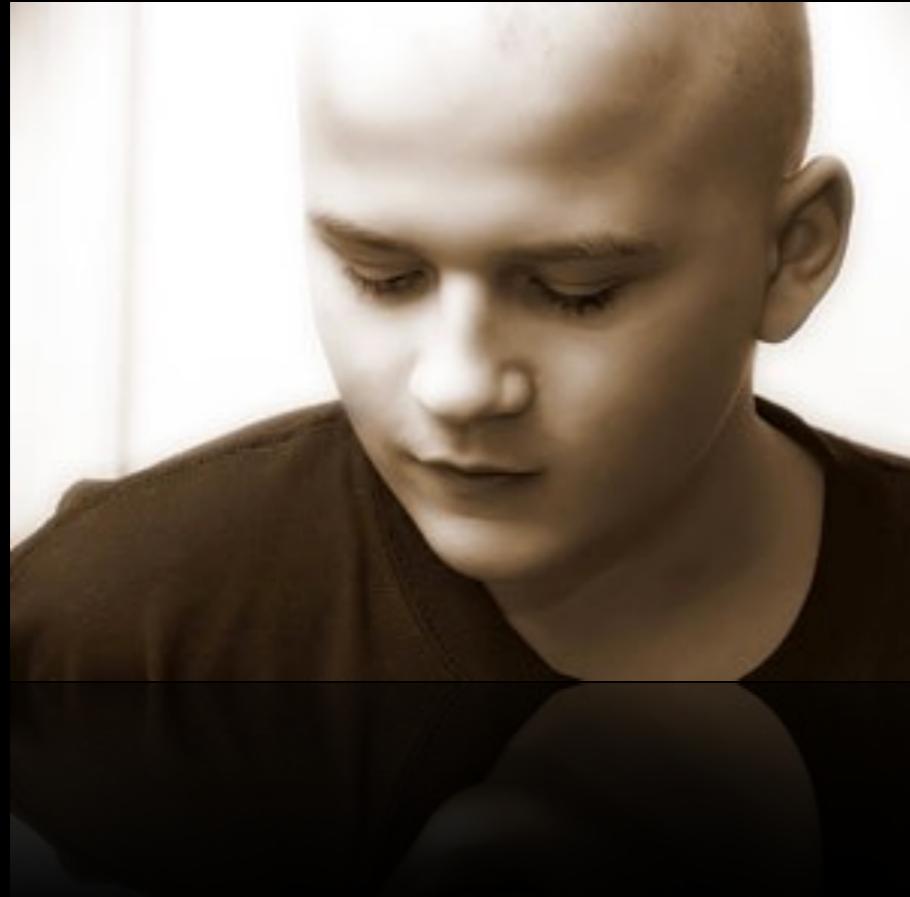
16,000 oncologists
panel of 160 drugs

Physicians independently select:
- Drugs
- Doses
- Combinations
- Regimens

A grand natural experiment in oncology (e.g., Cancer Commons)

Potential & Challenges of Clinical Data Mining

IF these data were captured.....



Detect patterns among

- Patients
- Treatments
- Tumors

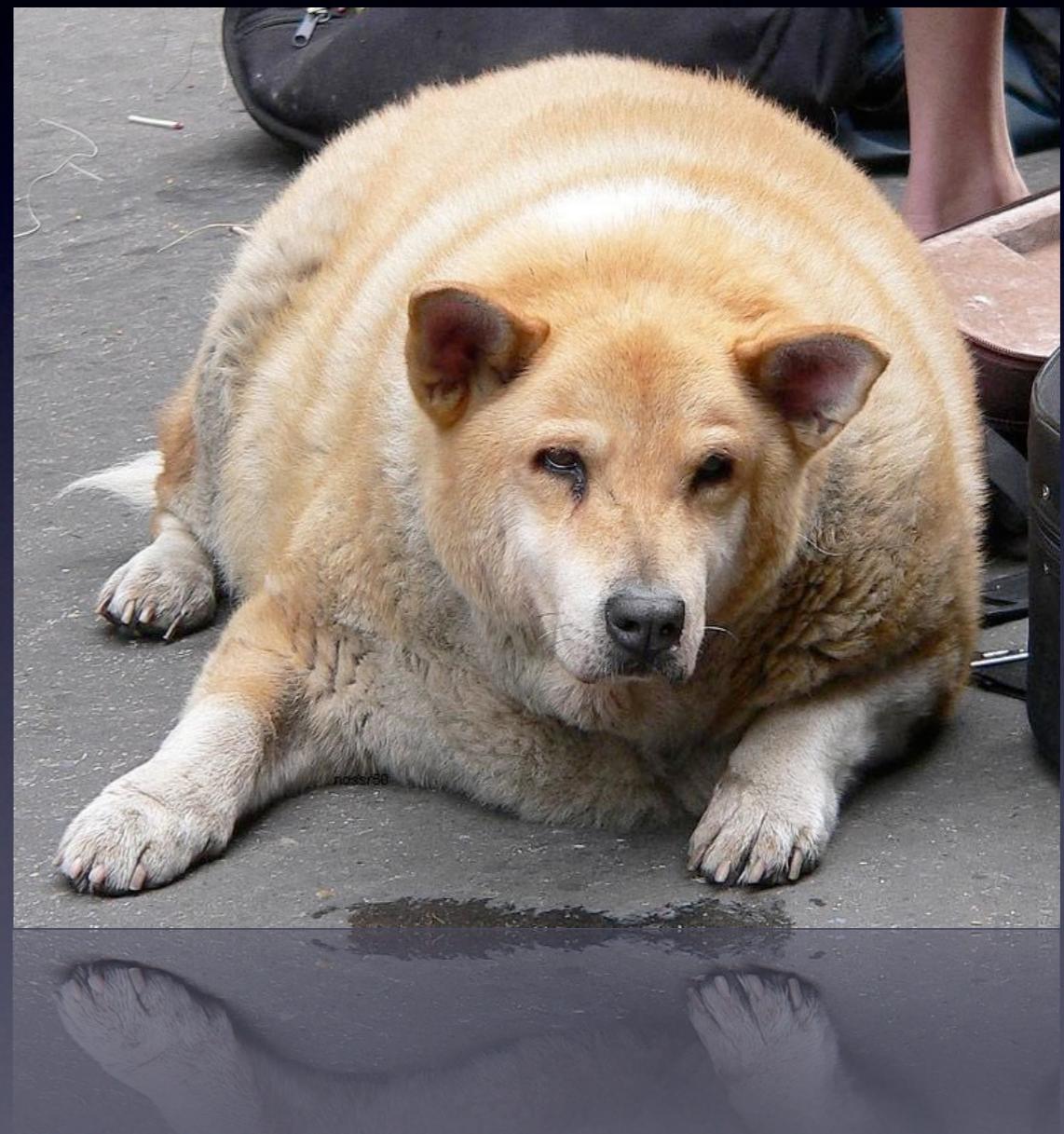
1. Identify correlates of best outcomes
2. Prove efficacy
3. New standard of care
4. Iterative cycle

Obstacles to Mining Clinical ‘Big Data’

- Lack of standardized medical ontology
- Lack of comprehensive medical informatics
- Disjointed and discontinuous patient care
- ‘Silos’ of patient cohorts
- Time demands on physicians
- HIPAA/Privacy restrictions
- Inherent complexity (of human biology)
- Chronologically long clinical timeframes

An Epic Experiment in Medicine

Cancer
Metabolic Disorders
Immune Dysfunction
Cardiovascular Disease
Neurodegenerative Disease
Neuropsychiatric Disorders
Longevity



Dogs naturally suffer the same diseases as humans

Shared Medical Applications

Same Diagnostics



Same Medicines



Proves disease drivers are conserved between human and dog

A Parallel Healthcare Universe



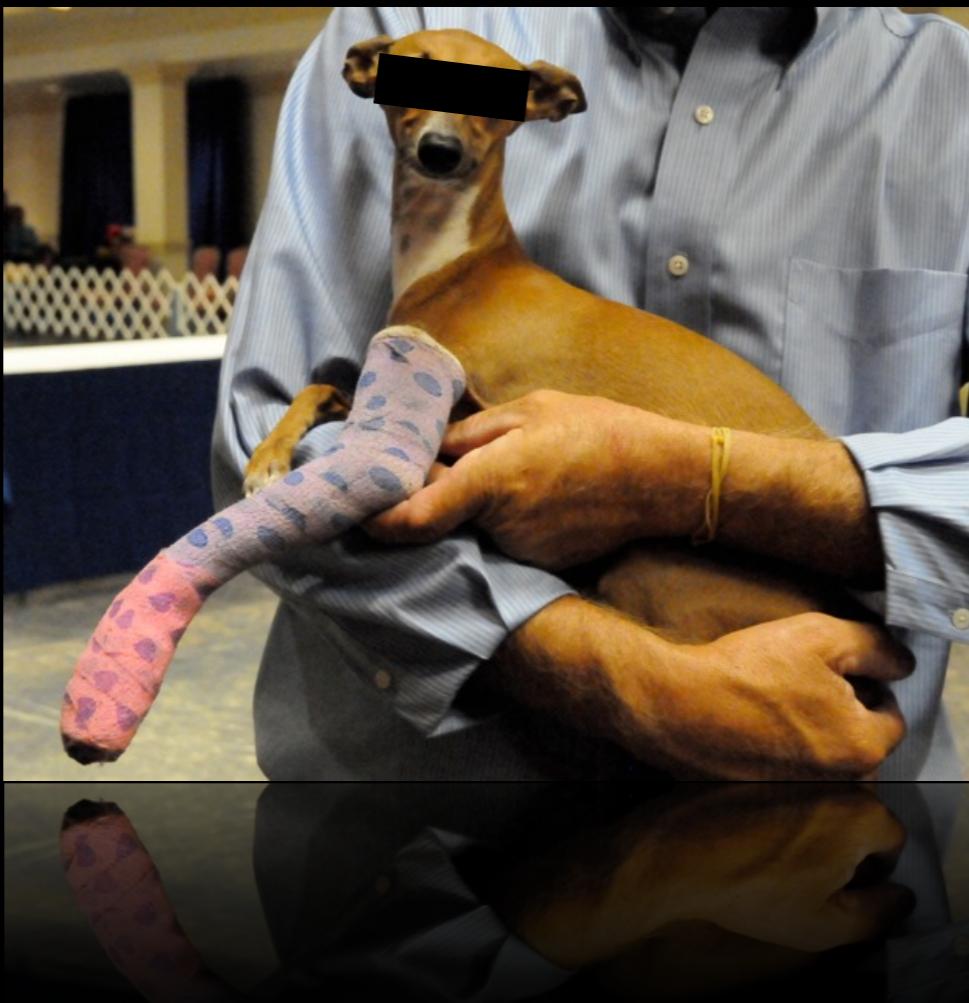
83 million dogs
enrolled in
veterinary
healthcare

Power of Genetic Isolates



Breed homogeneity ‘simplifies’ disease biology in dogs

Reduced Privacy Concerns



Additional advantages

- Compressed lifespan
- Accelerated timeframes
- Faster clinical trials

Breed homogeneity ‘simplifies’ disease biology in dogs

Empowering the patient, democratizing health care

Patient Communities



Innovative Networks



Personalized Genomics



Health Apps



Health Instruments



Nanoscale Diagnostics



Wellness



“out of the hospital, into the home”

Clinical Big Data

Key Issues & Considerations

- Costs/Benefits of capturing, storing, & analyzing
- Feasibility of capturing, storing, & analyzing
- Non-static data landscape
 - Volume
 - Velocity
 - Veracity
 - Variety
- Data Models
 - Structured, Semi-Structured, Unstructured..

Discussion

- Web resources to reach/engage/influence
- Integrating disparate information ecosystems
- Machine learning/AI algorithms vs Heuristic
- Medical informatics and veterinary medicine
- Aggregating data across patients
- Aggregating data across time

Background Materials

- Cancer Commons
 - *Big Data from the natural experiment of oncology*
 - M. Tennenbaum, Founder of Cancer Commons
- The Creative Destruction of Medicine
 - *How the Digital Revolution will create better health care*
 - E. Topol, MD Director of the Scripps Translational Science Institute
- The Reinvention of Medicine
 - *Dr. Algorithm, v0-v7 and beyond*
 - V. Khosla, Director of Khosla Ventures