Needed: A dynamic model of addiction recovery.

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20th Century Tx Model
A 21st Century Perspective on Addiction
What Changed

HOW WE BEGAN TO CHARACTERIZE RELAPSE

– Not necessarily a reflection on the effectiveness of treatment schemes.
– Not necessarily due to therapist skills.
– Not necessarily due to patient weakness of character or resolve.
RESEARCH DISCOVERED ADDICTION REALLY WAS A CHRONIC DISEASE.

- Socio-emotional maladjustment  
  *(often exacerbated by pre-existing state)*
- Mental illness  
  *(often exacerbated by pre-existing state)*
- Neurological alteration of cognitive-emotional capacities
The healthcare system is an in-out model designed and funded to treat acute illness—difficult to find financial support for long-term recovery services—easier to treat relapse than to prevent it.

Recovery services must occur mainly outside the healthcare system—acute care Tx releases patients back into the community—the community and/or the patient must take on the burden of care after treatment.

So why doesn’t the healthcare system treat addiction as a chronic disease?
Because healthcare system is not equipped to provide addiction recovery services, it is either a personal responsibility and/or a community responsibility.
Too Many Patients Recycle!

What we currently know...
- How to help addicts find entry to the system.
- How to get them off drugs once they enter.
- How to keep them in the system during treatment.
- How to delay re-entry via aftercare participation.

What we want to know...
- How to minimize time in the Tx system.
- How to sustain patient recovery by getting them into a recovery support system.
- How to help patients find the exit from the addiction Tx cycle.
Maybe part of the problem is lack of consensus about what the Addiction Treatment System is trying to accomplish?
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Eliminating dependence involves a long period of recovery.

What, exactly, is RECOVERY?
Well...
• MOST ADDICTS **relapse** unless treated early and effectively.

• MOST ADDICTS **cycle more than 3 times** through periods of untreated addiction, treatment, sobriety, and incarceration

• MOST ADDICTS experience a **trajectory for recovery** based on genotype (*severity of biological addiction*)

• MOST ADDICTS improve the odds ratio for remaining **sober after one year** of sobriety

• MOST ADDICTS achieve self-sustainable recovery (low odds ratio for relapse) **after 5 years** of sobriety

• MOST ADDICTS **take over 30 years** to achieve 5 years of sobriety.
MOST ADDICTS relapse unless treated early and effectively.

**Hser, 12-yr survival analysis**  
Abst. >24m; Early = w/in 75mos of 1st use

**Dennis, 30-yr survival analysis**  
(Abst. >12m)


MOST ADDICTS cycle through periods of untreated addiction, treatment, sobriety, and incarceration (more than 3 times !)

MOST ADDICTS experience a trajectory for recovery based on genotype (severity of biological addiction)

MOST ADDICTS achieve self-sustainable recovery (low odds ratio for relapse) after 5 years of sobriety.


MOST ADDICTS take over 30 years to achieve 5 years of sobriety.

Our Most Popular Service Model for Addiction Tx\(^1\) Is Static

Static models tell us what makes treatment effective in “all things being equal” situations.

Static models tell us **what is supposed to happen**.

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What Static Models Do Not Tell Us

• What the process of recovery looks like at the individual patient level.
• How the healthcare system works for individual patients
• What the system needs to accommodate the needs of individual patients
• What the affect of individual accommodations may be on the cost-effectiveness of services
Where is the patient in our models?
We need a model of addiction recovery that ....

- **Informs public health resource allocation**
  - What treatments?
  - Delivered at what intensity?
  - To patients at what level of severity?
  - At what stage of recovery
  - Over how long a duration?
  - With what frequency of post-release check-ups?

- **Informs case management strategies**
  - Medical System
  - Criminal Justice system
  - Social Service Systems
Needed: A dynamic model of addiction recovery.
What Dynamic Models Offer

- Medical Science cannot wait 30 years to grow a Framingham-type longitudinal database for addiction recovery
- We already have static models that can inform dynamic models
- Dynamic models can accommodate informed speculation until data are available.
Two most common classes of dynamic models used in behavioral science

Agent-Based Models

&

Dynamic Bayesian Network Models
Both models derive from theory or existing data estimates to indicate the long-term consequences of chains of decision events evolving over time.

Simulations are often derived from combining data-based probabilities (equations) with agent-based probabilities (rules) to “fill in the blanks” as it were in order to estimate how complex adaptive systems operate dynamically.
What’s the Thinking Behind Dynamic Models?
Dynamic Models Generally Derive From Complexity/Chaos\(^1\) Theory

Philosophically …

– Complexity Theory looks at how complex systems generate simple outcomes.

> *Complex adaptive systems organize themselves in fairly stable patterns of relationships that are not governed by hierarchical intent.*\(^2\)

– Complexity is the inverse of the reductionist notions of Newtonian physics that dominate much of current scientific thinking *(The whole is the sum of its parts – understand the parts [of a machine] and you understand the whole.)*

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1 Which term is used varies with discipline – Chaos was coined by physics, Complexity by biology.
Main Philosophical Differences

• Reductionism:
  – System elements interact in linear chains. A ➔ B ➔ C…
  – Outputs are proportional to inputs
  – Change is determined by planful acts
  – What does not fit a linear model is treated as error

• Complexity:
  – System elements interact in complex adaptive ways.
  – Small inputs can trigger large and unanticipated outputs.
  – Change appears to be chaotic – nonlinear – involving interactions at multiple levels.
  – Nonlinear elements are included as possible triggers of system change – especial quantum changes!
Waitaminit!

Is this Science?
Is this for Real?
Is this Science?

- There are researchers using complexity theory in every branch of science.
- Complexity models have been published in probably all top-tier journals including Nature, Science, American Journal of Physics, even JAMA!
- Complexity researchers are probably on every campus.
Until Today!
ABM Show-n-Tell

Axtell’s Teen Smoking Model
MEDICALLY ORIENTED POPULATION
THAT IS WHY
Healthcare Systems Are Too Complicated to Simulate or Even Model!
The Archimedes Model developed by Kaiser already includes:

- Populations
- Clinical physiology, biomarkers, signs and symptoms, clinical outcomes
- Prevention, screening, diagnosis, treatment, follow-up care
- Physician and patient behaviors, performance, and compliance
- Protocols, guidelines, practice variations
- Delivery systems, logistics and utilization
- Quality of life
- Financial costs

These Diseases:
- Diabetes and complications
- Coronary artery disease
- Hypertension
- Congestive heart failure
- Stroke
- Dyslipidemia
- Obesity
- Metabolic syndrome
- Asthma
- Colon cancer
- Breast cancer
- Lung cancer

Don’t tell David Eddy
Archimedes Model

• Ranges from the metabolic to the macro service system levels.
• Roughly 500,000 variables
• Each variable behaves according to empirically—derived equations
We use the virtual world of the model to simulate the real-world trial.

People → Real clinical trial → Real Outcomes

Treatments

And we compare the results

We use the same criteria to select people.

We have simulated physicians follow the same treatment protocols.

We let the model do its thing.

We count the outcomes, using the same definitions and protocols.
You can think of these validations as being previews of real applications

- We used the populations that were in the trials
  - But we could have used the population that would be candidates for your guideline (or performance measure, etc)

- Similarly for the tests, treatments, outcomes, etc.
Example

Major Coronary Events in Heart Protection Study
The Model has been run on 74 RCTs with $R=0.99$
It means the virtual world can be used for many purposes, such as

- Guidelines
- Performance measures
- Disease management programs
- Continuous quality improvement
- Strategic goals and priority setting
- Research planning
- Estimating patient-specific outcomes
Where does one start?
Start with what we know from static models and designs...

What does the “typical” addiction career look like?
Median career = 27 yrs with more than 3 treatment episodes

By Age 65, most addicts have either become abstinent or deceased

Building Virtual Longitudinal Data

• You can build the model based upon what you know – then run it out in time as long as you wish.

• You can create agents to augment parts of the model that are still speculative to:
  – Add greater depth (more variables)
  – Create what-if scenarios to estimate the effect of select elements
Questions

• What moderates recovery rates at each cycle of relapse?
  - Gender
  - Severity
  - Age of onset
  - IQ
  - Comorbidity
  - Chronol. age
  - Criminal status
  - Dependents
  - housing

• What moderates the duration of relapse cycles?
• What moderates cycle heterogeneity of variance?
• What affects variance skew?
Questions

- What moderates rates of movement between states at each cycle of relapse?
  - Gender
  - Severity
  - Age of onset
  - IQ
  - Comorbidity
  - Chronol. age
  - Criminal status
  - Dependents
  - housing

- What moderates the duration of relapse cycles?
- What moderates cycle heterogeneity of variance?
- What affects variance skew?
Potential for Longitudinal Research

• Imagine the effect size one might get if one could experiment with implementation schemes …
  – Before investing in a trial
  – Before investing in a new EBP

• Imagine the pace of discovery for prevention, financing, etc. if we modeled the dynamics of complex systems of care?
“I’m afraid we have a skeptic among us ....”
“Perhaps not surprisingly, chaos theory and nonlinear dynamics have met considerable resistance within the scientific community. In fact, we would not be surprised if our article evokes some resistance. For public health professionals, adopting a complex systems approach may require reconceptualizing how and why we influence change.”

If you want to explore dynamic models as a possible complementary tool for your research...

See the handout entitled:

Where to Start Searching For Evidence of Complexity Science in the Universe
(If Google is Broken)
Apply for an NIH grant!

PAR-08-224, Using Systems Science Methodologies to Protect and Improve Population Health (R21)

• Projects that address policy resistant problems related to the prevention and treatment of chronic relapsing diseases such as heart disease, diabetes, cancer, addiction, and mental illness. For example, a project might develop a computational model that can identify triggers for relapse as well as optimal low-cost interventions based upon context and patient characteristics such as genotype. The model might A) define the optimal frequency with which health status checks ought to occur, depending on the circumstances, B) produce odds ratios for relapse based upon check-up data, and C) identify cost-effective intervention options that minimize costly acute care episodes.

• Projects that address policy resistant problems related to health behaviors that seem to cluster as there may be common causal pathways or complex interrelationships between them. For example, projects could examine how tobacco use is associated with other risk behaviors (poor diet and nutrition, physical inactivity, substance abuse, etc.) and how these associations serve to undermine effective interventions, programs, or policies
