



Visualization and Prediction of Disease Interactions with Continuous-Time HMMs

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Modeling Disease Interactions along Time

□ Biological interest

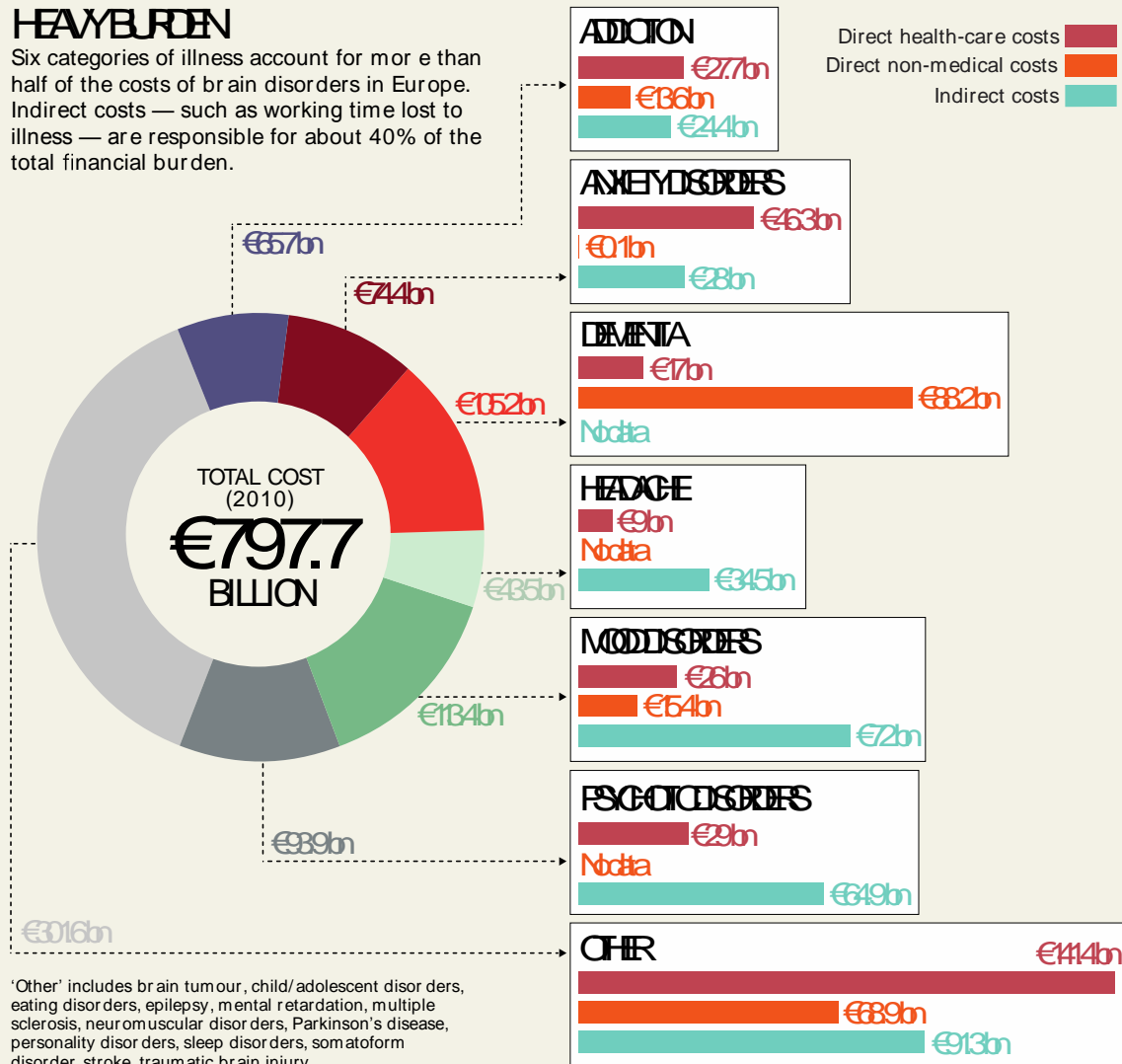
- Current state of the art does not account for the time it takes a disease to evolve to another one.
- Transitions discovered can be interpreted as causal relations.
- Underlying genetic of environmental processes may be uncovered.

Modeling Disease Interactions along Time

- Clinical interest
 - Only mental diseases cost Europe US\$ 1 trillion a year.
 - A predictive model can help provide better and earlier medical care.

HEAVY BURDEN

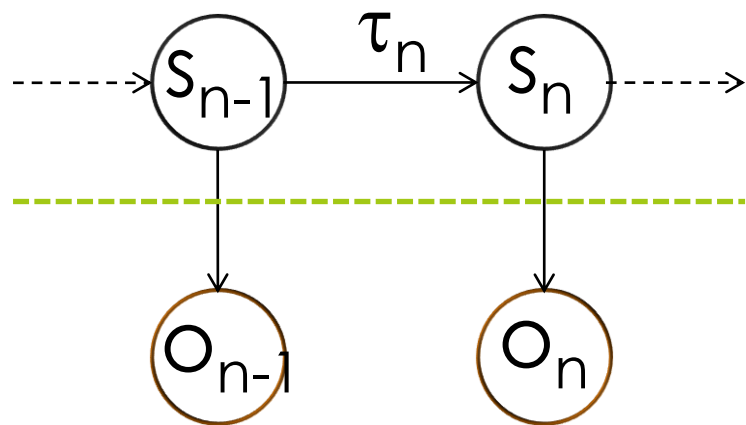
Six categories of illness account for more than half of the costs of brain disorders in Europe. Indirect costs — such as working time lost to illness — are responsible for about 40% of the total financial burden.



Source: "Trillion dollar brain drain", Nature 6 (478), 2011

*'Other' includes brain tumour, child/ adolescent disorders, eating disorders, epilepsy, mental retardation, multiple sclerosis, neuromuscular disorders, Parkinson's disease, personality disorders, sleep disorders, somatoform disorder, stroke, traumatic brain injury.

Continuous Time Hidden-Markov Models



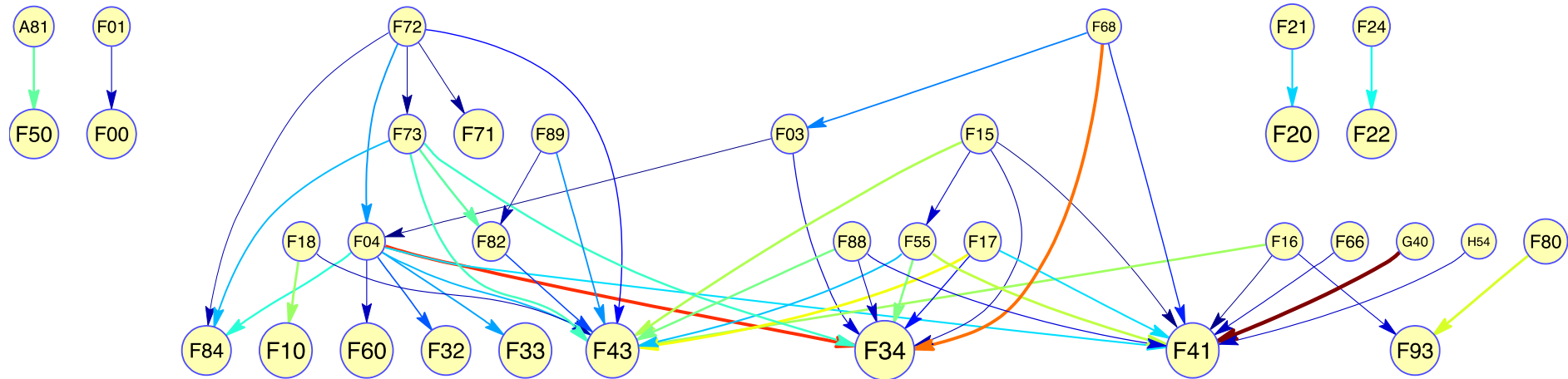
Underlying states: diseases

Observations: human diagnoses

- Parameters of the CT-HMM: $\{\pi_i\}$, $\{b_i(k)\}$ and $\{q_{ij}\}$

Graph of causal relationships

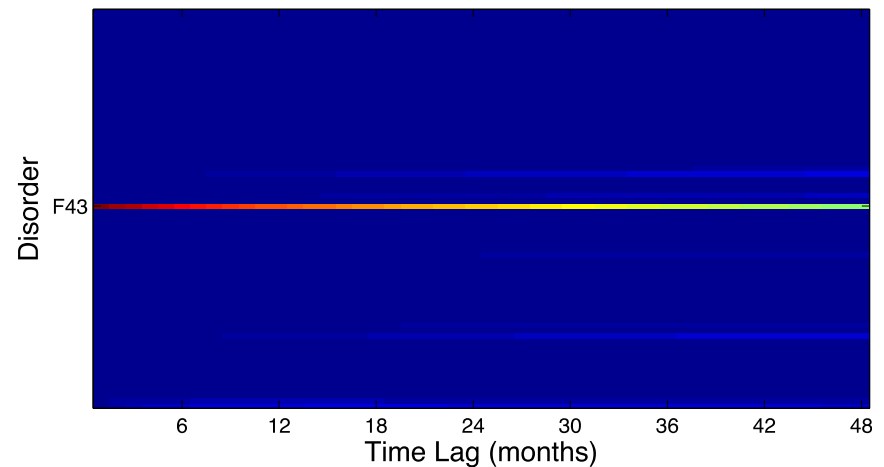
Highest elements in matrix Q



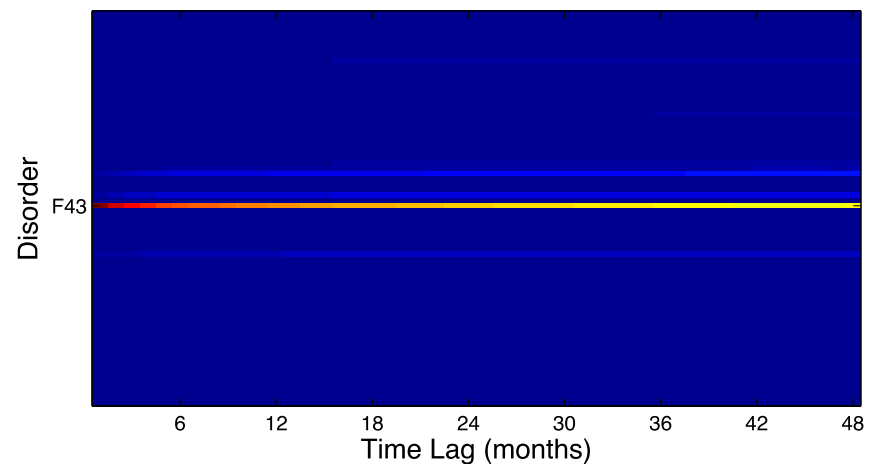
Predicting the evolution of diseases

Stable Disorder

Predicted evolution
for F43



Real Trajectories
from F43



Predicting the evolution of diseases

Diseases strongly connected

Transition from A81 to F50

Real Trajectories

