# An instance of inference: treatment effect estimation

**Some general goals**

- Predict the health state of an individual after treatment.
- Develop a strategy for steering the treatment over time.
- Understand the mechanisms underlying illness and recovery.

**Variables**

- Holistic: health state, treatment, individual, environment.
- $x$: quantifiers of the health state.
- $z$: factors characterizing the patient and the current conditions, including current or past values of $x$. Some may be known or measurable, some latent.
- $a$: features of the treatment under consideration.

**Observations** $o$ from past and the current patient: values of $x$, $z$ and $a$, or of quantities related to them.

## General tasks

- Build a model for the effect of action $a$ on the outcome $x$, qualified by factors $z$:

  $a, z \to x$: regression, classification

  $\rho(x|a, z)$: conditional probability estimation

  $x^i \sim \rho(:|a, z)$: simulation
- Uncover hidden parameters: factor discovery, clustering, dimensional reduction: $x, a \to z$
- Figure out the current state and model parameters: filtering, data assimilation, diagnosis: $o^{1,\dots,n} \to z^n, \alpha^{(n)}, x$
- Steer the treatment: optimal control, reinforcement learning: $z, x \to a$

# Tensions and challenges 1

**Interpretability**

Do we care more about predicting or understanding? Model simplicity versus accuracy and detail.

Model versus data-driven inference: a full palette between field knowledge-based models and black boxes.

# Tensions and challenges 2

**Identifiability**

A model detailed enough to be deemed realistic by a practitioner may include parameters that the data cannot robustly pin down.

**Big data.**

Lacking the right tools for analysis, excessive information may, somewhat paradoxically, deteriorate the quality of a prediction.

**Some partial solutions**

Regularizers: for robustness, to enforce regularity, to promote interpretability and to mitigate overfitting. Examples: penalizers –such as ridge regression– and priors on the parameters.

Cross-validation: training and testing populations.

# Tensions and challenges 3

Observational studies vs. randomized experiments

Individualization of prediction vs. aggregation of data

Variability of data type

Reliability of data, robustness to outliers

Fairness