A Causal Question to Study (Homework 2)

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October 20, 2022

I want to study the relationship between social mobility and number of deaths due to Covid-19: can reduced social mobility decrease the number of deaths due to Covid-19? How many deaths would have occurred if an intervention (e.g. closing the school, quarantine, ...) had been applied? Although the Covid-19 pandemic has already ended, these questions are still important to study in order to better prepare for the next potential global pandemic in the future.

We model this problem as a stochastic process $(A_t, I_t, Y_t)(t = 1, 2, \cdots, T)$, where

A_t : social mobility on week t

I_t : new infections in week t

Y_t : the number of deaths due to Covid-19 on week t

Note that we cannot simply perform a linear regression of Y_t on A_t (without I_t), because Y_t are both confounding and mediating variables: Y_{t-1} can have an effect on both A_t and Y_t, while also being affected by A_{t-1}. As a result, we introduce a new unobserved random variable I_t as a mediator. The causal effect of social mobility we wish to study can be defined as

$\varphi_t(a_1, \cdots, a_T) = E[Y_t(a_1, \cdots, a_T)]$

The relationship (or the working hypotheses) of (A_t, I_t, Y_t) is given by the following directed acyclic graph: