

Causal inference

Provides mathematical and statistical foundations to characterize cause-effect relationships with the goal of discovering how nature works and to make decisions to improve our well being

- 1) **Quantify the effect** of interventions on controlled or observed exposures
- 2) **Explain how** the cause-effect relationship comes about
- 3) **Explain why** an (health) outcome comes about

Why Causal inference?

Successful public health policy and clinical decision making rely on valid causal inferences

Two examples based on my work:

- 1) Environmental Health Sciences (EHS)
- 2) Digital Technologies in Psychiatry (mHealth)

Causal Inference for EHS

- Motivation:

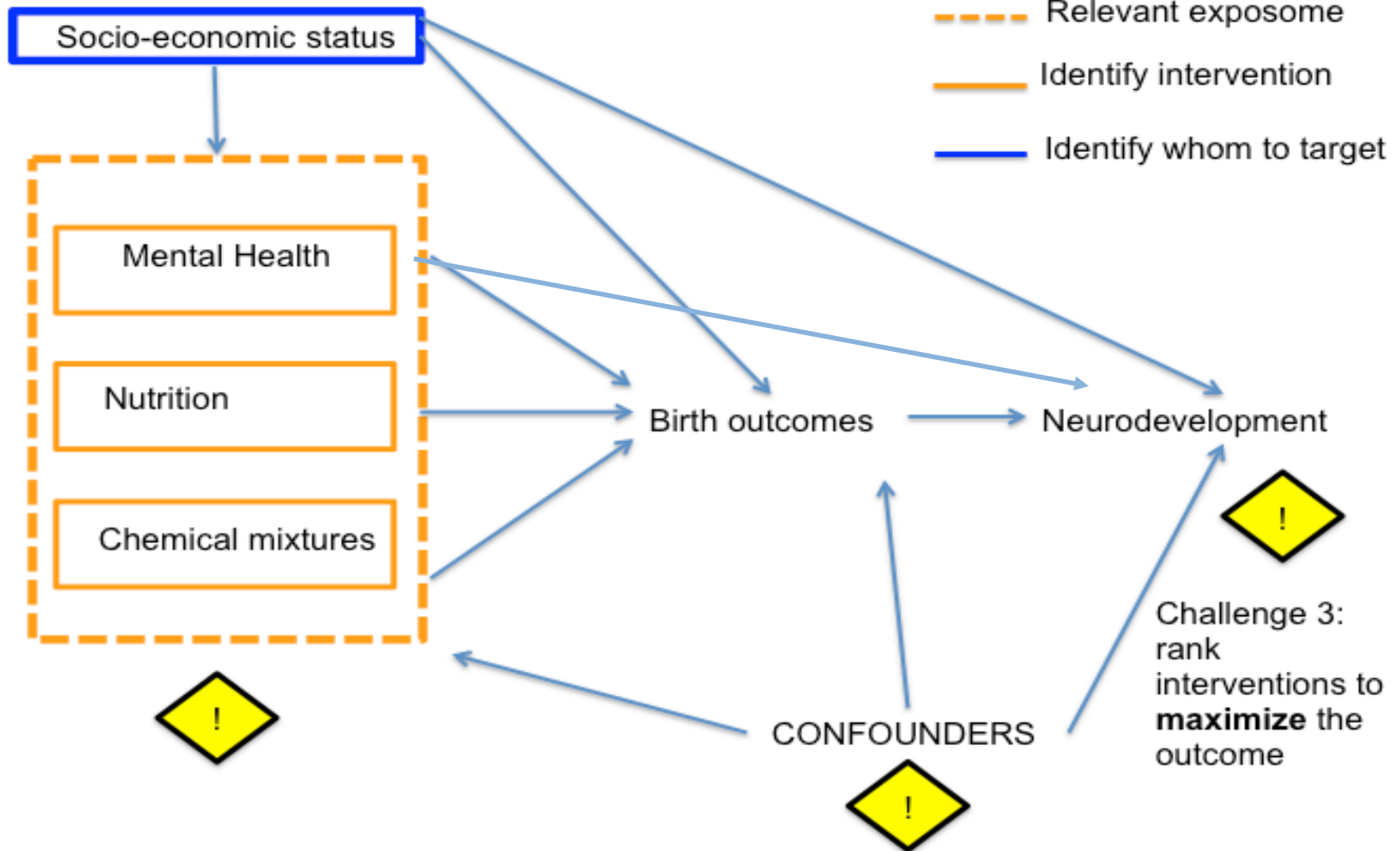
In Bangladesh heavy metals mixture exposure is an important concern, moreover socioeconomic deprivation leading to poor nutritional status and psychosocial stress impacts the health of mothers and children

- Informing Policy:

Can we learn **when and on which environmental and social factors intervene** to improve child neurodevelopment?



Conceptual model



Challenge 1: estimate **complex** joint effects

Challenge 2: mimic a **RCT**

Challenge 3:
rank
interventions to
maximize the
outcome

Bayesian Kernel Machine Regression

- 1) High dimensional exposures (variable selection and variable importance)
- 2) High dimensional confounding (mimic an RCT)
- 3) Flexible modeling (characterize the joint relationships)
- 4) Transportability

- Y_i : health endpoint
- M_i : mediator
- A_i : exposure measures
- C_i : potential confounders
- $h()$: is an unknown but smooth function
- w : is a multivariate weighting function constructed to adjust for confounding

$$\begin{bmatrix} Y_i \\ M_i \end{bmatrix} = h_w(A_{1i}, \dots, A_{si}, A_{s+1i}, \dots, A_{Ki}) + \epsilon_i$$

(Bobb et al, 2016; Valeri et al., 2017; Devick et al., 2019)

Diversity in EHS studies

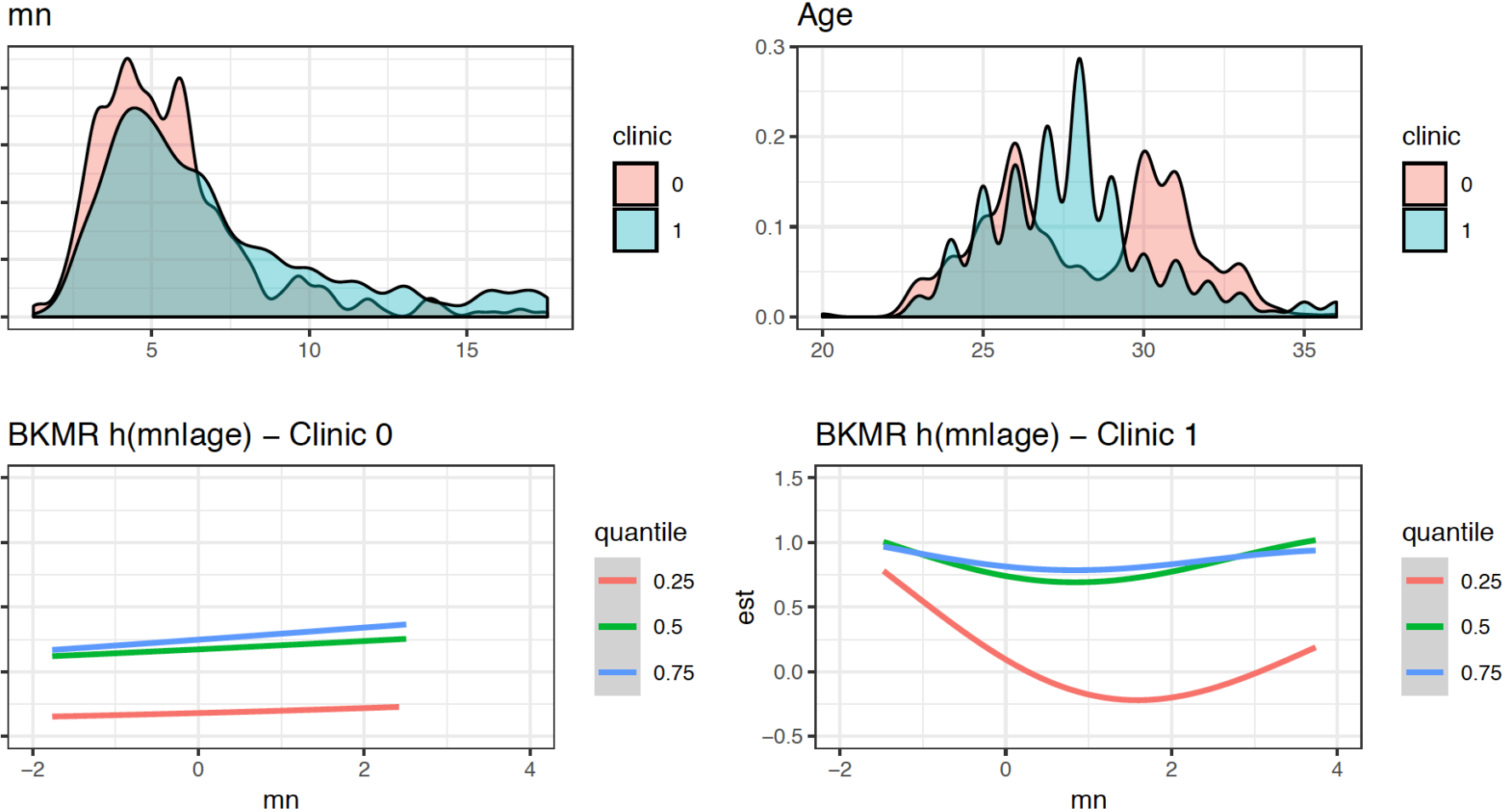



Fig.1 TOP: Distribution of one of the metal exposures (mn) and age at cognitive testing (age) in clinic 1 and 0
BOTTOM: Mn effect on cognitive scores by quantiles of age by clinic

Causal Inference for mHealth

- Motivation:
 - Schizophrenia (SZ) is a severe mental illness challenging to characterize and to treat.
 - Digital technologies are revolutionizing the field providing real time monitoring of patients' behaviors and symptoms and real time interventions.
 - Digital data is high dimensional in continuous time, leading to both opportunities and challenges in causal inference

- Informing Policy:

Can we leverage real time information on patient's symptoms and behavior to **prevent relapse** in SZ and to **deliver interventions** in the moment using digital technologies?

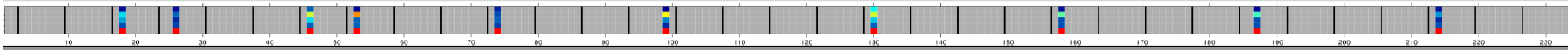


Study: BLS **DX: SZA**

Patient Info		Phone Info
Participant ID: 7NE49		Device OS: Android,5.1.1
BEIWE ID: 949iuit		Phone Model: MotoG3
Demos: 37, White, F		BEIWE Vers: 1

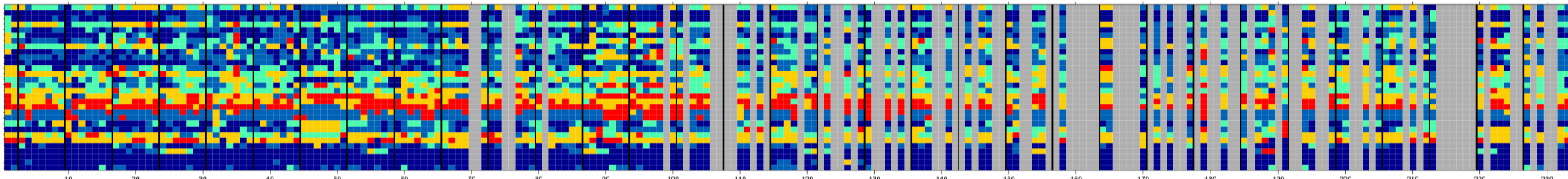
Report Generated: Tue 04 Oct 2016 03:13:21 PM EDT

Clinical Scales:



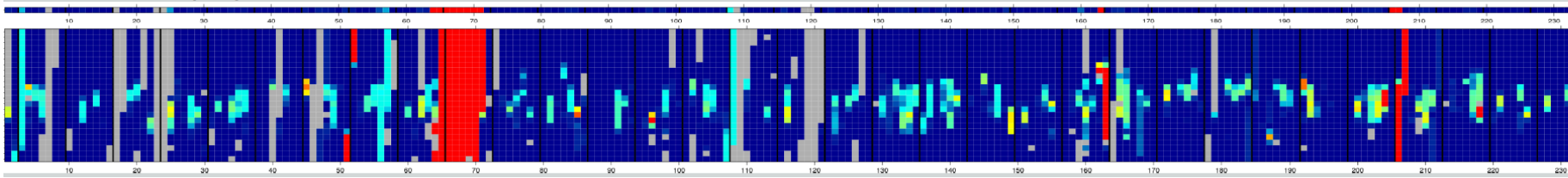
Active Measures

Survey Answers: 161 of 235 surveys completed

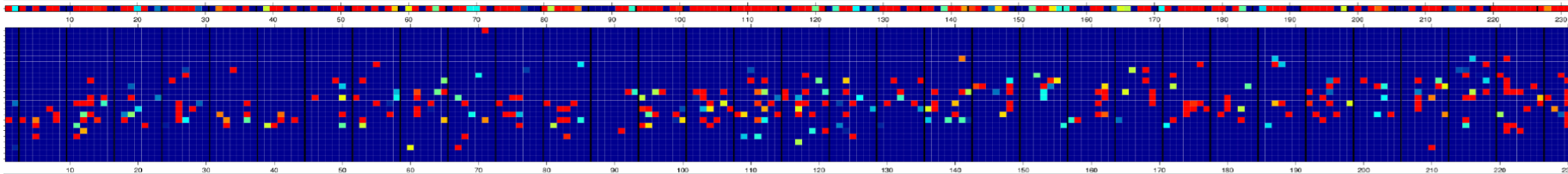


Passive Measures

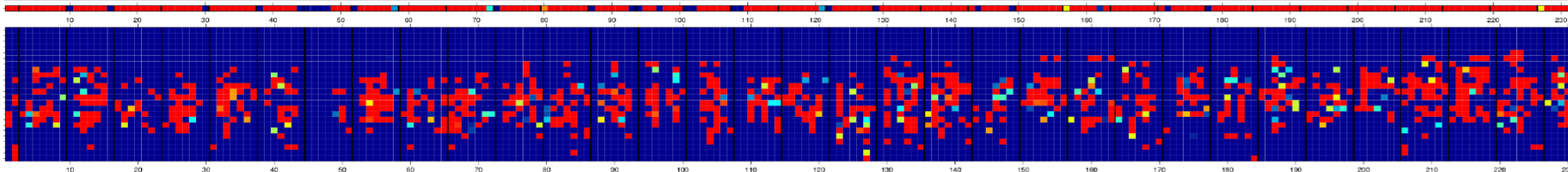
GPS Distances (KM): 5127 of 5640 hours collected



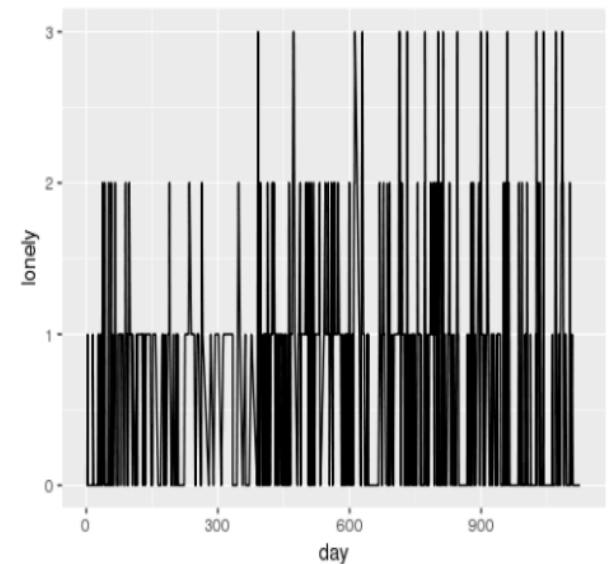
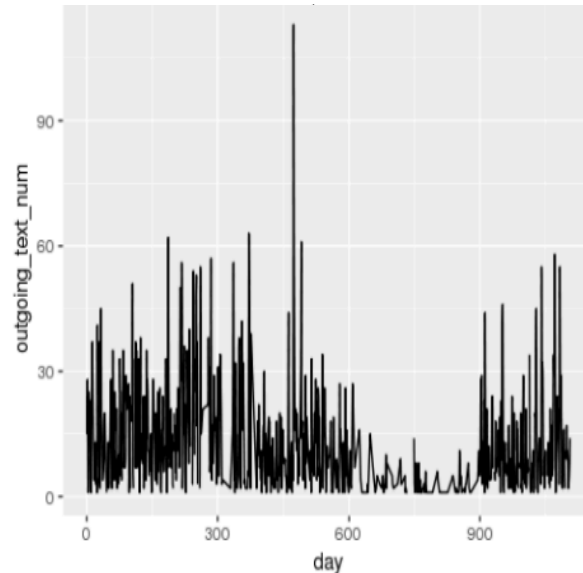
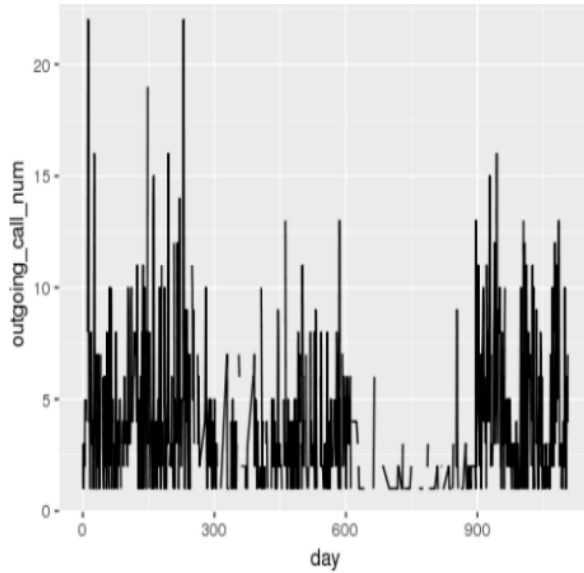
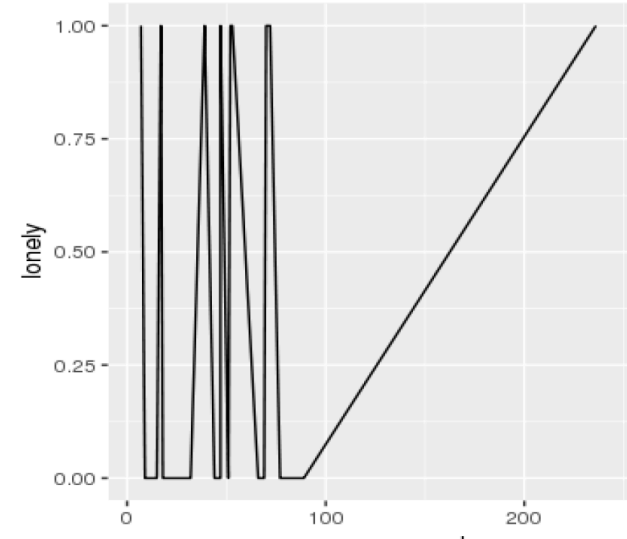
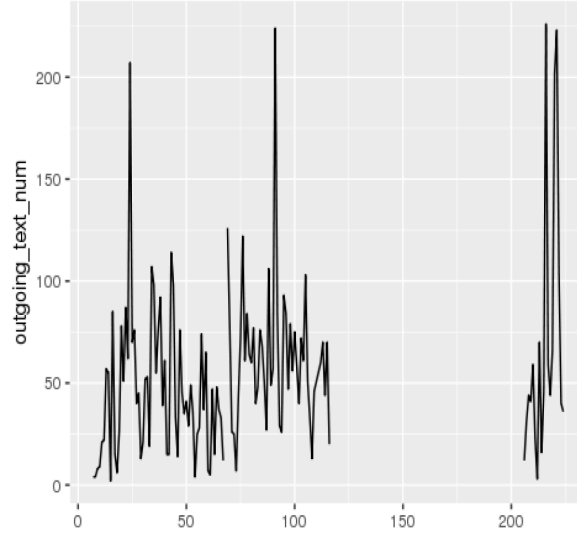
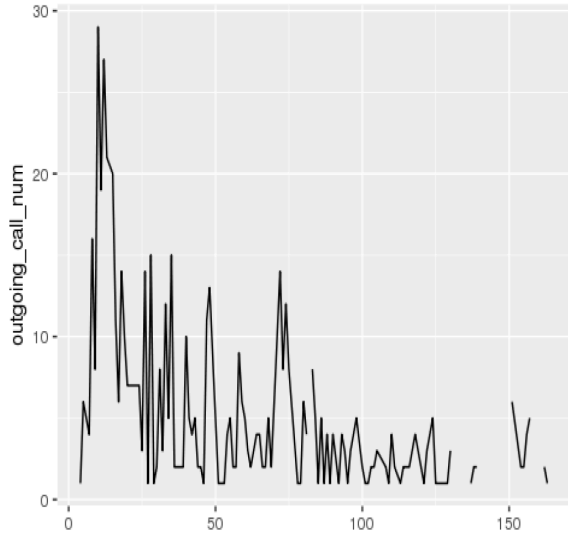
Call Logs:



Text Log:



Diversity in mHealth for SZ



A. Number of Outgoing Calls

B. Number of Outgoing Texts

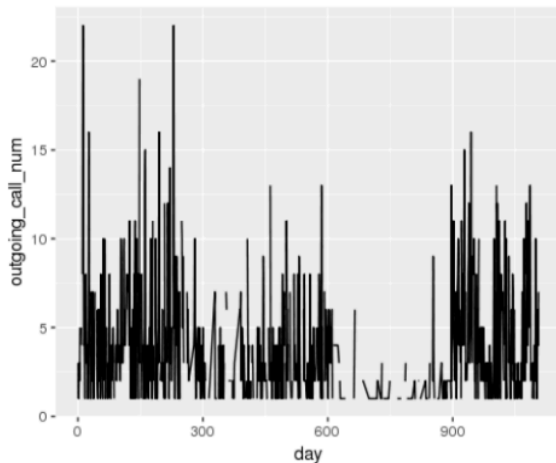
C. How lonely do you feel? (range: 0-3)

From association to causation

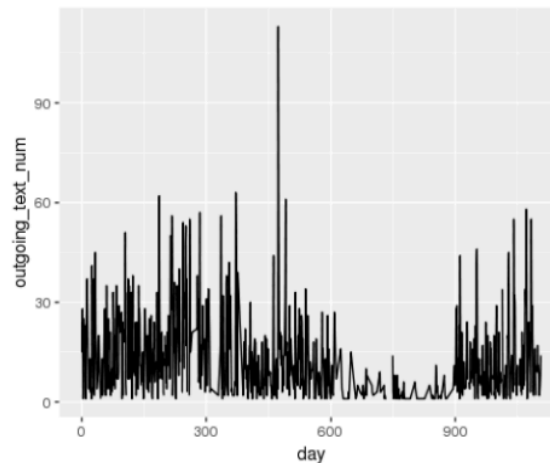
INTERVENTION: pins to encourage social interaction have the potential decrease loneliness and improve engagement in psychotic patients?

Challenges:

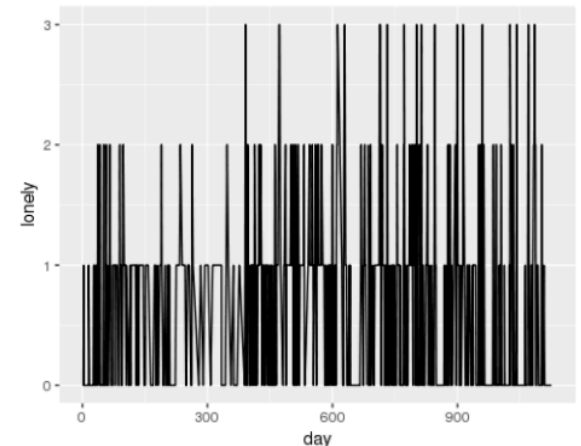
- 1) **Benefits vs Risks**
- 2) Assumptions needed to **mimic N-of-1 trials**
- 3) Time series analysis to **evaluate causal effects in continuous time**



A. Number of Outgoing Calls



B. Number of Outgoing Texts



C. How lonely do you feel? (range: 0-3)

Causal Inference @ Columbia Biostat

- **P8122 - Statistical Methods for Causal Inference (Fall semester)**
- **CAUSAL INFERENCE LEARNING GROUP** gathers students and faculties of our department and beyond to discuss cutting edge approaches for causal inference and the public health impact of the application of such methods.

Just **e-mail** me if you want to sign up or learn more about the course!

Thank you!

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