Pre-Analysis Plan

COVID-19 Thanksgiving Messaging at Scale

This Draft: November 25, 2020

1. Introduction

In prior work, we have found that video messages delivered by doctors increase knowledge of COVID-19, and in some cases, lead to viewers taking actions consistent with the messaging. In a scale-up phase, we plan to use Facebook ads to show a 15 second video clip recorded by 6 MGH, Harvard and Lynn Community health center doctors to approximately 40,000,000 Facebook users. The ads will be shown between November 14-29 and focus on staying safe – limiting travel, social distancing and mask-wearing. We are randomizing exposure to the ad campaign at the ZIP code and county level to study whether the videos change mobility and Thanksgiving holiday travel and whether there are any detectable impacts on the spread of COVID-19. Using information about Facebook social network connections and mobility patterns between counties, we also plan to measure whether exposure to the ad campaign spilled over along the network.

2. Sample Frame and Treatment

2.1 Treatment

Facebook users will be exposed to an ad campaign featuring a set of videos about Thanksgiving travel. 6 doctors from MGH, Harvard and Lynn Community health center have each recorded one short message (15 seconds) using an identical script: "This Thanksgiving, the best way to show your love is to stay home. If you do visit, wear a mask at all times. I'm Dr. XX from XX, and I'm urging you: don't risk spreading COVID. Stay safe, stay home."

The video messages will be posted to a project Facebook page titled "The Doctors for Coronavirus Prevention Project". Users will see the ads and the name of the Facebook group associated with the ads on their feeds. Watching the videos in the ad posts is completely optional for Facebook users.

Within treated geographies, Facebook's algorithm will be used to place the ads to users 18 and older. We expect each treated individual to see the ads approximately 3 times over the course of the ad campaign.

2.2 Sample Frame

We rolled out the campaign in 2 phases:

- Phase 1:
  - 13 states were chosen based on the availability of zip-code level COVID-19 data. We used a 2-stage randomization with both county and zip-code level variation.
  - 820 counties
  - 6998 zip codes
  - Campaign duration: November 14-29
- Phase 2:
  - Facebook was interested in scaling up the campaign to 15 additional states with high COVID-19 case rates and relatively low levels of compliance with preventative behaviors.
  - 1069 counties
  - Campaign duration: November 23-29

We expect that approximately 40,000,000 Facebook users will be exposed to the videos across the two phases.

2.3 Treatment Assignment

The experimental design differed across phases.

- Phase 1: 2-stage randomization with both county and zip-code level variation
  - 50% of counties in the 13 states assigned to Low Intensity treatment
    - 25% of zip codes in the low intensity counties treated (exposed to the campaign)
  - 50% of counties in the 13 states assigned to High Intensity treatment
    - 75% of zip codes in the high intensity treated (exposed to the campaign)
- Phase 2: 1-stage randomization at the county-level.
  - 80% of counties the 15 target states treated (exposured to the campaign)

Treatment intensities were decided based on Facebook's ad budget constraints.

In the Zip-code level treatments, ad targeting may not be perfect. If individuals do not share their location data with Facebook, then IP address is used to proxy for geographic location.

3. Hypotheses

Main hypotheses:

1. Do the ads change the behaviors of those in the treated zip areas?
    - Do they travel less?
        - Within zip
        - To places outside of zip? Do they travel shorter distances?
    - Do they host fewer visitors?
    - Do they wear masks more?
2. Do the ads change the type of interactions that happen?
    - Super-spreading interaction (high degree)
    - Sneaky interaction (low-degree)
3. Do the ads affect COVID rates and syptoms in treated areas?
4. Do the ads spill over onto other areas that are connected to the treatment ZIPs?
    - Behavioral spillovers: travel/mobility
    - COVID impacts
    - Are spillovers more pronounced on the mobility network or on the Facebook friendship network?

4. Empirical Analysis

4.1 Outcomes

1. **Mobility and Travel:** different outcomes are observable from Facebook at the county and zip code level due to data privacy concerns:
    - **Zip code-level:**
        (a) **Fraction of individuals staying in the same geographical location (1mi x 1mi area) (measured daily). An individual is recorded as staying home if they are in the same (1mi x 1mi) area at the beginning and the end of an 8 hour interval. The measure misses people who leave their neighborhood and return within the interval.**
        (b) **Fraction of individuals leaving the geographical location (1mi x 1mi area) each day (measured daily)**
    - **County-level:**
        (a) **"Stay put" metric: how much of the time are people really staying in their homes? (measured daily) This measure is much more precise than what is available at the zip code level. It reflects the fraction of the day that is spent in a single 600m x 600m geographical area.** Source.

(b) **"Change in movement" metric: "We quantify how much people move around by counting the number of level-16 Bing tiles (600m x 600m) they are seen in within a day. People seen in more tiles are probably moving around more, while people seen in fewer are probably moving around less. Each day we take all the eligible people in a given region and compute the number of distinct tiles they were seen in." (measured daily).** Source.

(c) Colocation data: Data marks counts of people from county pairs (A,B) who are observed 5 minutes in the same place. It counts this as a share relative to all possible meetings. (Measured weekly). This gives a county-by-county transition matrix that is symmetric. (We do not observe where the meeting takes place).

- Timing: We are interested in mobility outcomes for Thanksgiving week. Baseline observations are based on Facebook data availability. When possible, we will include mobility measures from other holidays in 2020.

2. Covid 19:

(a) Case rates/hospitalization/deaths:

- **Zip: available from local public health departments for the 13 states in the Phase I experiment.**
- County: available from local public health departments, nation-wide. Available for download from the New York Times.

(b) Symptoms:

- Facebook COVID-19 symptoms survey. Source.

- Timing: Daily data during the 1 month following Thanksgiving. We began collecting baseline COVID data at the zip code level on November 11.

3. Intended behaviors and beliefs:

- The data all come from Facebook's "Brand Lift" tool. In each zip code of the Phase 1 study, a hold-out sample is randomly selected in target zips to not receive the ad. We can compare treated and control responses within zip.
- Questions:
  (a) Ad recall
  (b) Mask intentions
  (c) Thanksgiving travel intentions
  (d) How much should people try to stay home?

Our primary outcomes are in bold. We are most likely to be able to detect changes on mobility given the study design. Therefore, mobility is our primary outcome. We are also extremely interested in impacts on Covid-19 rates and symptoms. However, detecting impacts on Covid-19 is significantly more demanding from a statistical power perspective given that it is relatively rare at the weekly time horizon. We view the intended behaviors and beliefs outcomes as secondary.

Additional outcomes, data pending:

1. Mobility data from Safegraph (zip code level).
2. MGH COVID-19 symptom tracking app data.
3. Stay put, Change in movement, co-location at the zip code level.
4. Dynata survey data on plans to travel for Thanksgiving, sampled from Nov. 13-24

4.2 Regression Analysis

Direct Impacts (Phase 1):

1. Analysis using Zip-level randomization (Covid cases and mobility outcomes):
   (a) Direct impacts (pooled): $Y_{zt} = \alpha_t + \gamma_c + \beta Treat_{zt} + \delta Y_{z0} + \varepsilon_{zt}$
      - Y_{z0} is a baseline measure of the outcome.
      - γ_c denotes either:
        – Indicator for High Intensity county
        – County fixed effects. For counties with homogenous treatment assignment across zips, pool them into a larger "county unit" to be able to add FEs without losing observations.

   (b) Direct impacts (disaggregated): $Y_{zt} = \alpha_t + \beta_1 Treat_{zt} + \beta_2 1(HighIntensity)_{ct} + \beta_3 Treat_{zt} 1(HighIntens$
   $\delta Y_{z0} + \varepsilon_{zt}$
      - β_2 is a measure of spillovers, related to the geographic network.

   (c) Distributional direct impacts: Quantile regression.
      - Repeat the exercises, above, with quantile regressions. Motivation, right tail (super-spreader) and left tail (sneaky) interactions.

2. Analysis using County-level randomization (Covid symptoms and mobility outcomes):
   (a) Direct impacts: $Y_{ct} = \alpha_t + \beta 1(HighIntensity)_{ct} + \delta Y_{c0} + \varepsilon_{zt}$
   (b) Distributional direct impacts: Quantile regression.

3. Analysis using Individual-level randomization ("Brand Lift" outcomes)
   - We will obtain from FB: Control mean, Treatment mean, number of observations. With this we will need to construct standard errors.
   - 2 methods for inference, using binary outcomes:
     – Construct t-tests on equality of treatment and control
     – Conduct permutation tests
   - We will also be able to test if the individual response is different in Urban versus Rural. FB will give us means in T and C and number of observations separately for Urban vs. rural.

Direct Impacts (Phase 2):

4. Analysis using County-level randomization (Covid symptoms and cases, mobility outcomes):

   (a) Direct impacts: $Y_{ct} = \alpha_t + \alpha_s + \beta 1(Treated)_{ct} + \delta Y_{c0} + \varepsilon_{zt}$
      - α_s are state fixed effects due to stratification.

   (b) Distributional direct impacts: Quantile regression.

Indirect impacts (Phase 1 and Phase 2 variation):

5. Indirect zip code-level impacts

   - Sample-frame = Phase 1 states, but spillovers can come from both phase 1 and phase 2 treatments.
   - We only have detailed facebook network information (SCI) at the zip code level (no colocation data).

   (a) $Y_{zt} = \alpha + \beta_{SCI,T} ExpPhase1 Treat_z^{SCI} + \beta_{SCI,HI} ExpPhase1 HighInt_z^{SCI} + \delta_{SCI} ExpPhase2 Treat_z^{SCI} + \gamma_{SCI,1} ExpPhase1 Sample_z^{SCI} + \gamma_{SCI,2} ExpPhase2 Sample_z^{SCI} + \lambda Y_0 \varepsilon_{zt}$

   - Notation:
     - SCI is the Facebook friend network, Mobility is the Facebook colocation mobility network.
     - *Phase*1 denotes the first treatment phase. Phase2 denotes the second treatment phase.
     - *Treat* denotes whether a connected zip is treated (for Phase 1 and Phase 2).
     - *HighInt* denotes whether a connected zip is in a High Intenstiy county.
     - All non-phase 1 and phase 2 zips are marked non-treated
     - We will measure exposure (*Exp*) in 2 different ways:
       (a) Share of network connections exposed
       (b) Number of network connections exposed

6. Indirect county-level impacts:

   - Sample-frame = All states (Phase 1 and Phase 2 states, and non-intervened states), but need to control for relevant exposure

   (a) $Y_{ct} = \alpha + \beta_{SCI} ExpPhase1 Treat_c^{SCI} + \beta_{Mob} ExpPhase1 Treat_c^{Mobility} + \delta_{SCI} ExpPhase2 Treat^{SCI} + \delta_{Mob} ExpPhase2 Treat_c^{Mobility} + \gamma_{SCI,1} ExpPhase1 Sample^{SCI} + \gamma_{Mob,1} ExpPhase1 Sample_c^{Mobility} + \gamma_{SCI,2} ExpPhase2 Sample_c^{SCI} + \gamma_{Mob,2} ExpPhase2 Sample^{Mobility} + \phi_{SCI} Degree_c^{SCI} + \phi_{Mob} Degree_c^{Mob} + \lambda Y_0 + \varepsilon_t$

   (b) $Y_{ct} = \alpha + \beta_{SCI} ExpPhase1 Treat_c^{SCI} + \delta_{SCI} ExpPhase2 Treat^{SCI} + \gamma_{SCI,1} ExpPhase1 Sample^{SCI} + \gamma_{SCI,2} ExpPhase2 Sample_c^{SCI} + \phi_{SCI} Degree_c^{SCI} + \lambda Y_0 + \varepsilon_t$

   (c) $Y_{ct} = \alpha + \beta_{Mob} ExpPhase1 Treat_c^{Mobility} + \delta_{Mob} ExpPhase2 Treat_c^{Mobility} + \gamma_{Mob,1} ExpPhase1 Sample_c^{Mobilit}$
   $\gamma_{Mob,2} ExpPhase2 Sample^{Mobility} + \phi_{Mob} Degree_c^{Mob} + \lambda Y_0 + \varepsilon_t$

- Notation:
  - SCI is the Facebook friend network, Mobility is the Facebook colocation mobility network.
  - Phase1 denotes the first treatment phase. Phase2 denotes the second treatment phase.
  - Treat denotes whether a connected county is either High Intensity (for Phase 1) or treated (for phase 2)
  - We will measure exposure in 2 different ways:
    * Share of network connections exposed
    * Number of network connections exposed

Supplemental Analysis:

7. Indirect impacts: ("Link-level" Analysis), using nation-wide county co-location data: Construct county-pair level analog to the Indirect county-level regressions, above.
8. Test for presence of any spillovers on the network: reference.
9. Analysis using County-level non-random variation
   - Goal, use untreated states to generate a "pure control"
     - Can be used to measure impacts of the whole campaign.
   - Differences-in-differences regression
     - Not in sample frame
     - Low intensity treatment
     - High intensity treatment
   - Use standard diff in diff setup (log(cases) on county FE + time FE + treatment * FE.
     - Additionally use Synthetic Diff-in-Diff approach: reference.
     - Also Consider non-linear Diff-in-Diff to capture extreme covid growth rates: reference.

4.3 Controls

For all regressions, we will use Machine Learning techniques to select the controls. Potential controls include: Baseline covid rates, Baseline mobility rates, State fixed effects, zip and county-level demographics from the census, distance to major city, distance to state capitol,...

4.4 Inference

For our core analyses at both the county and zip level, we will use heteroskedasticity-robust standard errors, as our randomization is at those levels. We will check for additional statistical robustness following the approaches outlined in Section 5 of the Supplementary Appendix of this paper.

4.5 Heterogeneous Effects

We will explore heterogeneity on the following dimensions:

- Urban vs. rural ZIPs: (this is what we stratified on for the brand lift study.) Caveat: ad targeting is running differently in urban vs. rural, so the "first stage" is likely also different.
- Travel restrictions and local government messaging: are PSAs and policy substitutes or complements? (If substitutes, we get power on the other stuff by dummying them out.)
- COVID rates at origin and destination. Does the campaign discourage travel to/from high covid places?
- Prior infection rates (e.g. infections in April?)
- Red/Blue counties and zips
- Weather: rain or cold weather on Thanksgiving (or weekend more generally)

5. Funding and Human Subjects Review

Facebook is supplying sufficient ad credits to fund the campaign. The IRB at MIT is serving as the primary institution of record and has entered into a reliance agreement with Harvard, Massachusetts General Hospital, and Yale.