Analysis of performance improvements and bias associated with the use of human mobility data in COVID-19 case prediction models

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Objective

COVID-19 case predictions were used to inform policy decisions during the pandemic. Prior research has shown that human mobility data can improve COVID-19 case predictions, but the impact is unclear - there is a need to understand when and how mobility data helps or hurts predictions at a more local, regional level. The objectives are:

1. Quantifying the impact of mobility data on COVID-19 case predictions
2. Assess potential sampling biases
3. Compare across different data sources, models and training methodologies

Methods

Compare performance of COVID-19 case prediction models at the county level (US) trained with and without mobility data. Evaluate improvements across:

- Mobility Data Sources: SAFEGRAPH, Google Maps, Descartes Labs
- Predictive Models: Linear Regression, ARIMA(X)
- Training Approaches: Long Training (LTW) and Short Training Window (STW) [Shown in **Fig 1**]
- Prediction lookaheads: 1, 7,14,21,28
- County socio-economic and demographic characteristics: Age, Income, Race and Urban-Rural Classification

Mobility improvements were evaluated using *correlation improvement (ci)* with respect to the baseline, computed as:

$$CI = pcorr\_Mobility - pcorr\_Baseline$$

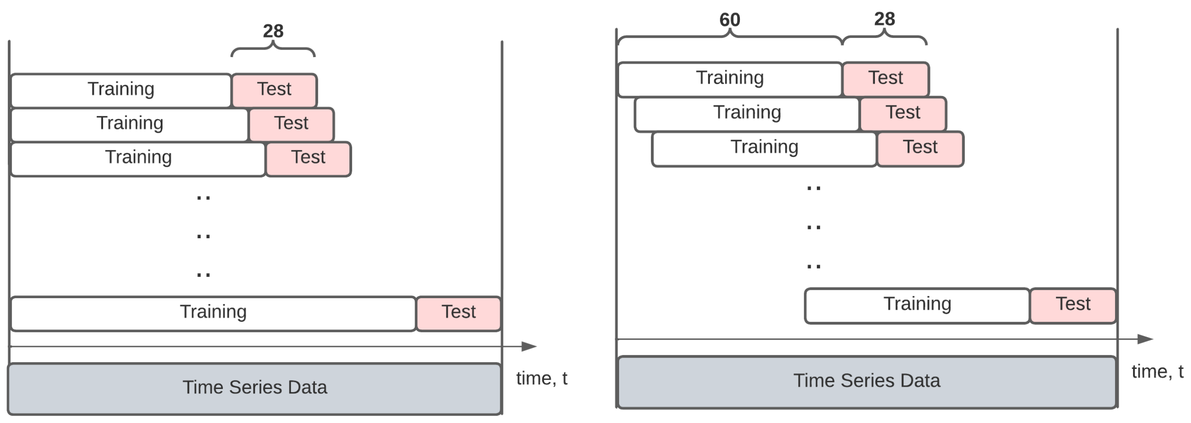

FIG 1: LTW (left) and STW (right) Training Approaches

Results

- Mobility data improved COVID-19 case predictions for up to **60%** of counties.
- For counties with improvements, median correlation increases were modest with **ci ≤ 0.13 for 50% of counties,** and with **ci~0.3** for the upper quartile.
- Counties with higher percentages of minority groups had lower improvements (potential sampling bias):
  - Higher Black, Hispanic, non-White percentages
  - Lower income and more rural areas
- Improvements slightly higher for Apple and SafeGraph mobility data [**Table 1**]
- Longer-term predictions showed larger improvements [**Fig 2**]
- Linear regression had larger improvements than time series
- STW training showed better performance improvements

Dataset	Average proportion of counties improved	Average correlation improvement
Apple	0.38	0.034
Descartes	0.43	0.024
Google	0.54	0.013
SafeGraph Grocery Stores	0.42	0.018
SafeGraph Religious Org	0.45	0.023
SafeGraph Restaurants	0.43	0.024
SafeGraph Schools	0.43	0.021
SafeGraph Inflows	0.42	0.027
SafeGraph Intraflows	0.47	0.027
SafeGraph Outflows	0.44	0.029

TABLE 1: Average percentage of counties with improved COVID-19 predictions from adding different mobility datasets across models and approaches and average median correlation improvement over baseline.

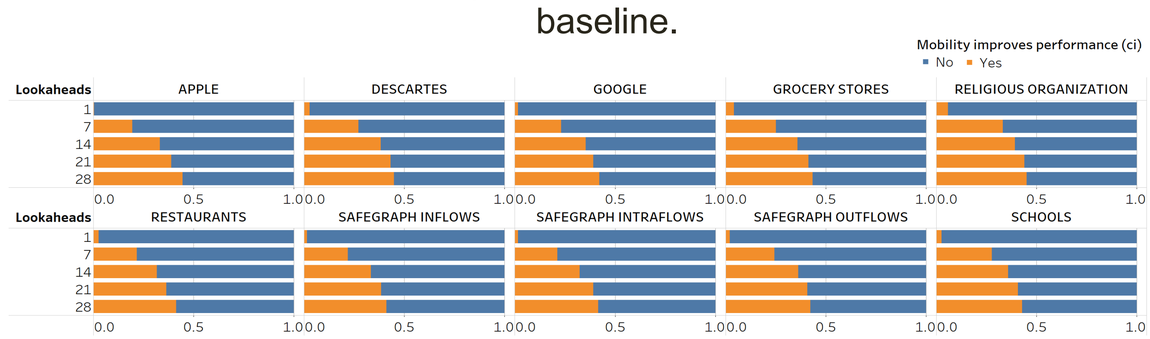

FIG 2: Percentage of counties for which adding mobility data to the COVID-19 case prediction model improves the prediction. Results are for the **STW approach for ARIMA**.

Broader Impact

- Provide data-driven guidance to policymakers on the limitations of costly mobility data for COVID-19 prediction at the county level
- Identify groups that see less benefit due to potential sampling bias in mobility data sources
- Sheds light on need to proactively address algorithmic bias to avoid exacerbating health disparities
- Approach to evaluate bias implications can extend to other AI tools supporting health policy

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CAREER: Data-driven Models of Human Mobility and Resilience for Decision Making

Award ID#: 1750102