Meteorological and Behavioral Correlates of COVID-19 Transmissibility Across the United States

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Background

Respiratory viruses (i.e. SARS–CoV–2) primarily transmit through the air.

Instantaneous reproduction number (R_t): Expected infections by one individual at a given time and a measure of transmissibility.

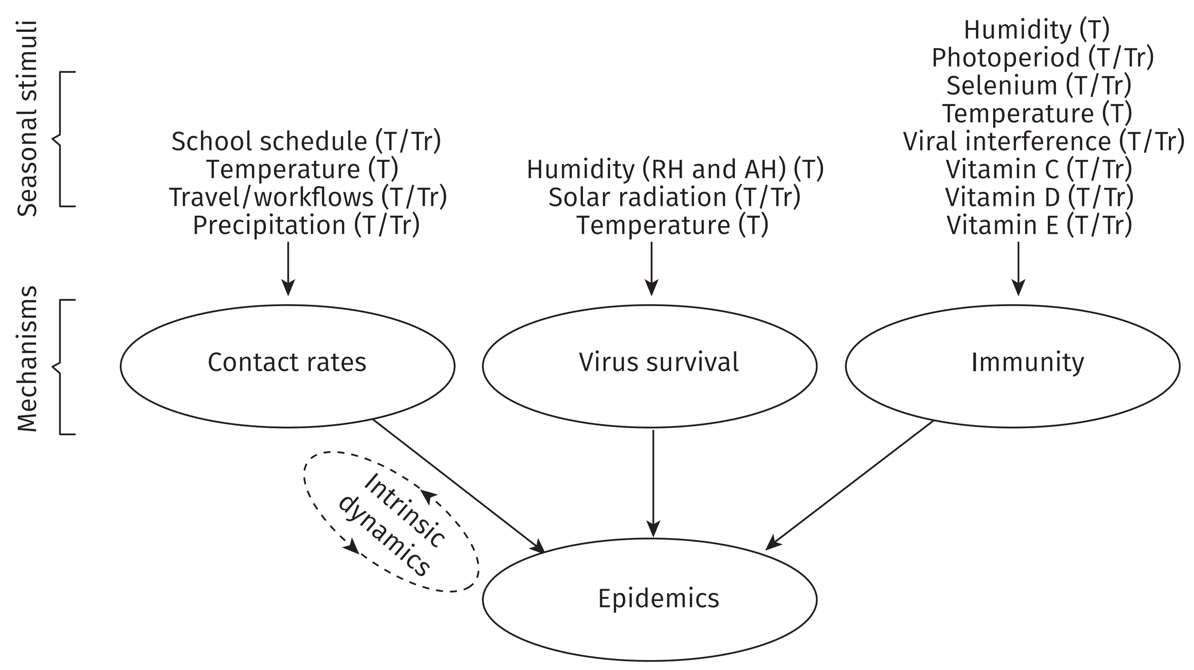


Figure 1. Factors mediating influenza epidemics [1]

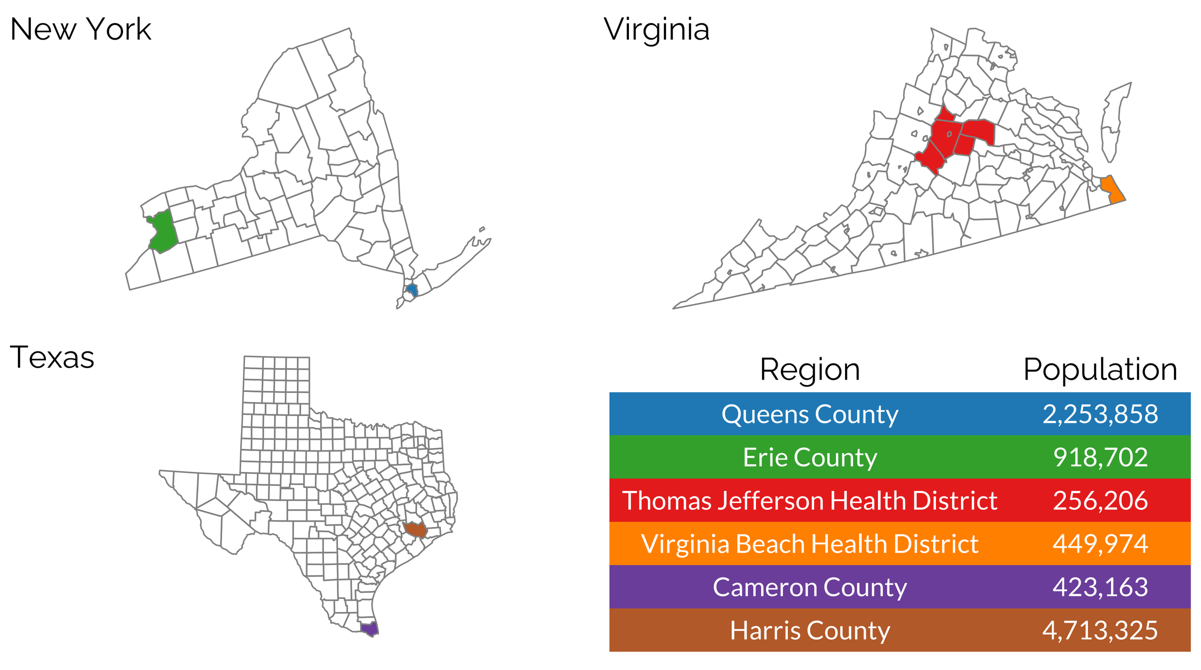
Objective

The purpose of this study is to **quantify** the role of dry bulb temperature (DBT), relative humidity (RH), absolute humidity (AH), and indoor activity (IA) on the instantaneous reproduction number of COVID–19.

We hypothesize that an interaction between indoor activity and said meteorological variables will be strong predictors of SARS-CoV-2 transmissibility.

Methods

- Daily COVID–19 surveillance data – Johns Hopkins Center for Systems Science and Engineering (JHU CSSE) [2]
- Hourly meteorological measurements – National Centers for Environmental Information (NCEI) [3]
  - AH calculated with *humidity* R package [4]
- Weekly relative indoor activity (IA) from a study of cell phone records [5]
- R_t for SARS–CoV–2 computed with the Cori et al. method [6]
  - *EpiEstim* R package
  - Incidence ≈ 7 day rolling average of confirmed cases
  - Parametric serial interval with a sliding window of **7** days
  - $\mu = 4.8$, $\sigma = 2.3$ [7]



Region	Population
Queens County	2,253,858
Erie County	918,702
Thomas Jefferson Health District	256,206
Virginia Beach Health District	449,974
Cameron County	423,163
Harris County	4,713,325

Figure 2. Map of regions studied

Results

Equation 1. Multivariate orthogonal binomial model

$$\bar{R} \approx \text{poly}\left(\frac{\text{DBT} \cdot \ln(\text{RH})}{\text{Indoor Activity}}, 2\right)$$

The purpose of this model is to estimate the effect of interactions between DBT, RH, and IA on reproduction number.

Table 1. Summary of model fit and optimal lag*

State	Region	R^2_{adj}	Lag (weeks)
NY	Queens County	0.52	0
	Erie County	0.60	0
VA	Thomas Jefferson Health District	0.28	−1
	Virginia Beach Health District	0.26	−2
TX	Harris County	0.48	0
	Cameron County	0.037	2

*Lags kept at **0** throughout analysis for consistency.

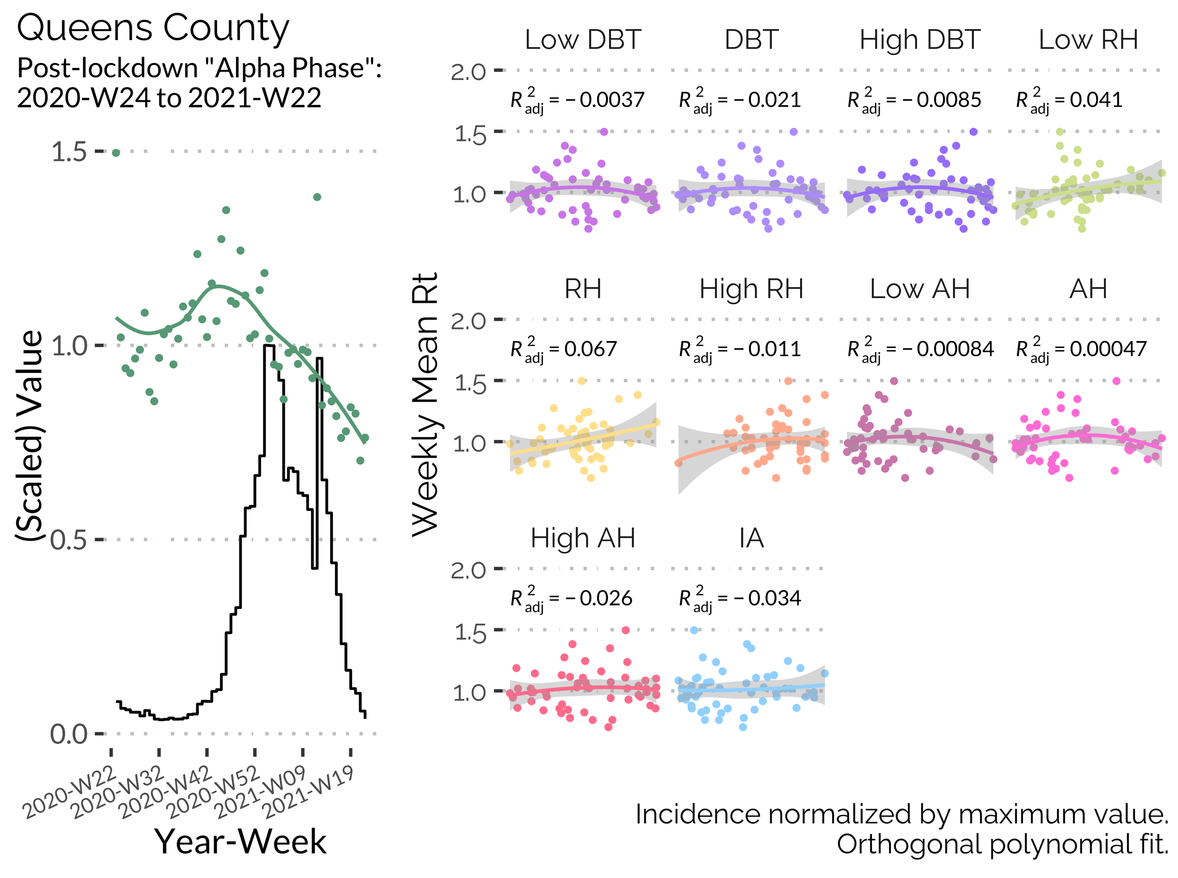
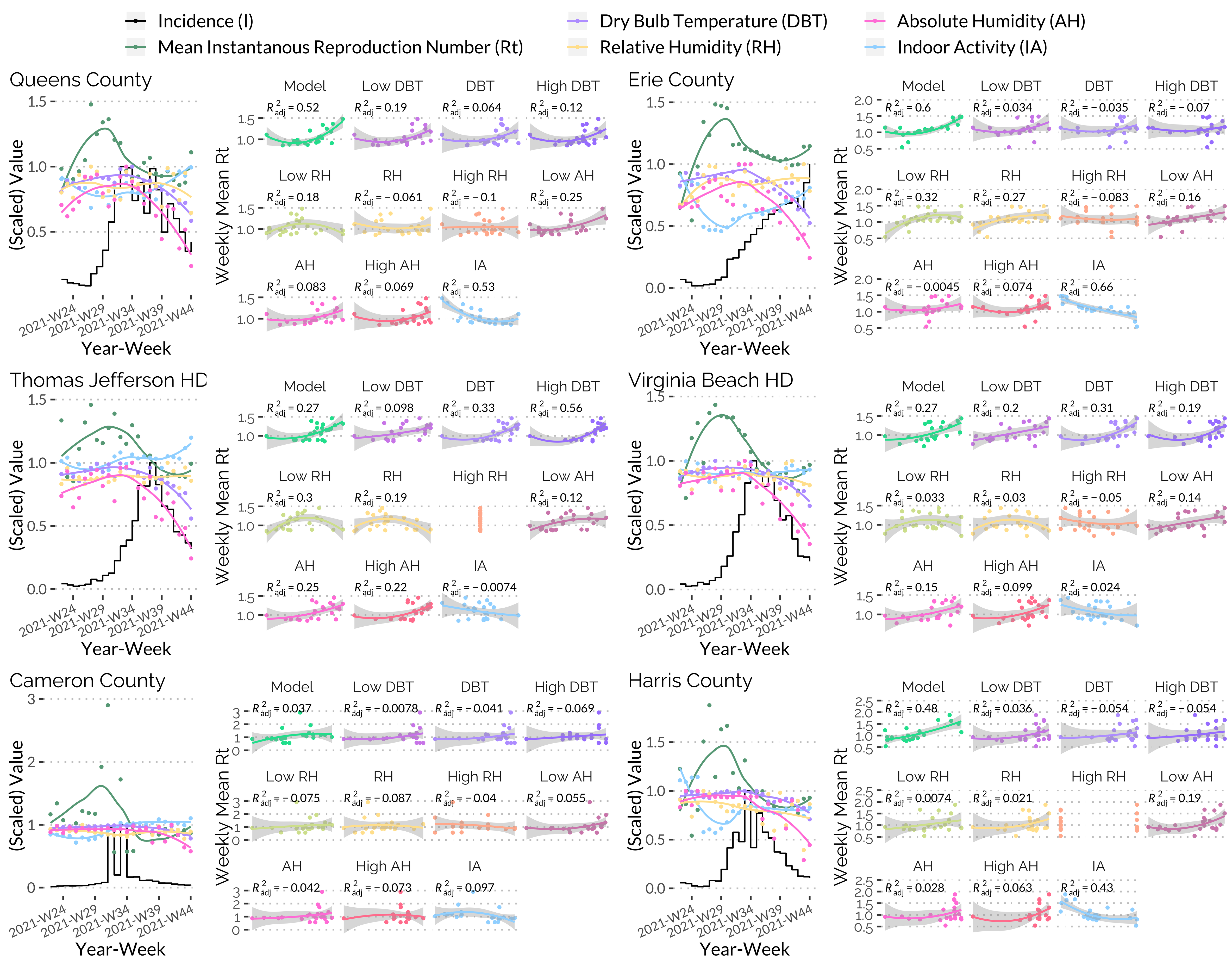


Figure 3. COVID–19 "Alpha Phase" in Queens County

Key Findings

- Significant U-shaped relationship with weekly mean R_t during the "Delta Phase" ⟶ T, RH, and IA are good predictors
- *Weak* & *non-significant* associations during the "Alpha Phase"
- Latitudinal trend ⟶ stronger further from equator
- Population differences ⟶ stronger in larger populations



Incidence, DBT, RH, and AH normalized by maximum value. Orthogonal binomial fit.

Figure 4. Results by county

Assumptions & Limitations

Table 2. Shapiro-Wilk test of normality for R_t

State	Region	p-value
NY	Queens County	0.0061
	Erie County	0.0831
VA	Thomas Jefferson Health District	0.0578
	Virginia Beach Health District	0.0845
TX	Harris County	0.140
	Cameron County	0.0001

- Weekly mean R_t is *mostly* normally distributed ($p > 0.05$).
- Heteroskedasticity observed in regression model
- Inconsistencies present in incidence data

Conclusions

DBT, RH, and indoor activity are significant drivers of SARS-CoV-2 transmission in the **near-absence** of preventative measures.

- Inform predictions of future COVID-19 outbreaks
- Guide public policy planning in affected communities

Future Directions

- Fit model to more counties across the US
- Analyze the Omicron wave
- Control for lags in symptom onset and reporting
- Incorporate demographic parameters (age, risk factors, etc.)

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