North Carolina COVID-19 Mobility and Health Impacts Study

Proposal to the NC Policy Collaboratory, June 2020

UNC-CH Research Partners: Highway Safety Research Center (HSRC), Cecil G. Sheps Center for Health Services Research (Sheps), Gillings School of Global Public Health* (Gillings), Howard W Odum Institute for Research in Social Science (Odum)

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Motivation: Analyses of the interrelationships amongst public health policies, mobility changes, and the transmission and impacts of COVID-19 are needed to inform policy decisions in North Carolina, specifically if there is resurgence of infections due to cyclical outbreaks throughout the year. Such research studies will also support the development of expertise, provide foundational research, and build data infrastructure at UNC-CH for mobility studies involving future respiratory and other infectious disease pandemics.

Research Questions: Overall, we are interested in COVID-19 transmission (spatial and/or behavioral correlates), mobility-related impacts of COVID-related public health policies, and health-related impacts of COVID-related mobility changes in North Carolina. In this quick turn-around study, we will focus on some of the following research questions, as outlined in the proposed tasks. At a minimum, we will seek to answer major research questions about mobility and the spread of COVID-19. Some questions, such as other health impacts or specific demographic trends, will only be explored if time allows at the discretion of the PI. However, we list all possible research questions here to illustrate continued research topics.

1. Did shelter-in-place policies, emergency declarations, and general news and events (local and nationwide) reduce movement within North Carolina, and did this slow the spread of COVID-19? Further, were there differences in mobility between urban and rural counties and how did these trends vary through time?
2. How has re-opening changed mobility patterns, as compared to the COVID-19 Shelter-in-Place period?
    a. As compared to the corresponding period in 2019.
3. Assuming mobility patterns have shifted, has this had a measurable impact on COVID-19 transmission patterns?
    a. Are there differences across the state (e.g. rural versus urban)?
    b. Depending on the health data we are able to acquire, we hope to look at the following patterns:
        i. Across other types of communities (e.g. communities of color, lower income communities, age groups, etc.)?
        ii. Across occupational groups?
        iii. Within transportation safety, focus on transit workers, first responders, (pursue potential data sources from occupational injury epidemiologists at SPH), and other, for example postal services workers.
4. How does North Carolina compare to neighboring states in terms of mobility, sheltering in place, and COVID-19 transmission?
    a. Have there been "spill over" effects from states that have relaxed physical distancing measures sooner?
5. How has COVID-19 impacted the transportation safety sector?

    a. Crashes, crash fatalities, high speed crashes, vulnerable road users, driver education specifically teen drivers, professional driver training, etc.
6. Are there other health impacts related to transportation safety and COVID-19 that are currently going unmeasured, such as potential untreated health conditions due to healthcare avoidance behaviors and hospital resource limitations?
7. What recommendations can State, or local municipalities implement to reduce the spread of COVID-19 while minimizing other safety and transportation impacts?

Guiding Hypotheses:

1. Mobility and health data from recent months (January through late summer, early fall), in comparison to past years (January through December 2019), will show measurable trend changes in traffic and movement corresponding to one or more declarations of emergency, shelter-in-place decrees, university/school closures, and other pandemic-related events including, but not limited to number of positive COVID-19 cases, number of deaths, and hospitalization rates.
2. These trends can be measured at the county level and will vary from county to county as different local governments enacted different policies at different times.

Outline of Proposed Tasks:

Task 1: Data Identification and Acquisition

Task 2: Literature Review and Synthesis of on-going and Recently Completed Synergetic Studies

Task 3: Base Analyses for COVID-19 Mobility and Health Impacts

Task 4: Expanded Analyses COVID-19 Mobility and Health Impacts

Task 5: Study of the Effect of COVID-19 on Young Drivers and Implications for Policy

Task 6: Analysis of Effects of COVID-19 on Transportation Safety Sector

Task 7: Data Management and Storage

Task 8: Data visualization and Prototype Dashboard

Task 9: Website Design and External Communication

Task 10: Final Reporting

Task 1: Data Identification and Acquisition
Researchers/Staff: Randa Radwan (lead), Mark Holmes (co-lead)
Time Frame: (May 4 - July 31)

Mobility Data: The HSRC team will collect and analyze mobility data at two levels: Primary and Secondary. Tertiary data will be considered based on availability and potential impact on the rest of the states. To date, our current mobility data inventory is shown in Table 1.

Table 1. Data Matrix

Name	Importance	Type	Scope	Time Range	Time Scale	Unit	Comments
Teralytics	Primary	Origin-Destination	Daily O/D dataset for all published Zip Codes in NC	Jan-Dec 2019, Jan-April 2020	Daily (w/ peak hour)	Trips	Three trip purposes (home, work, other)
NCDOT ATR	Primary	Traffic Counts	All State-owned highways	Jan-Mar 2018, Jan-Mar 2019, Jan-Mar 2020	Hourly and daily	Vehicles	Will need to be allocated to counties; can request for updates past March 2020
Streetlight	Secondary	VMT	All counties in NC	Mar-Apr 2020, Jan 2020	Daily	Vehicle miles of travel	Jan 2020 used as baseline; will be updated periodically
Waze	Secondary	Traffic Incidents	All counties in NC	.	.	.	.
GoTriangle	Tertiary	Transit Activity	All routes in Research Triangle operated by GoTriangle	March 2020	Daily	Alightings (tickets)	May need to request more if needed

Data Use Agreements have been established for both Teralytics and Waze data. The Teralytics data is based on cell tower data pings and estimates the location of devices between cell towers, detects movement versus stationary devices, and identifies routes and modes of transit. The Teralytics data is currently available only through April 23, 2020. As such, the team will need to identify another data vendor with similar daily attributes for data starting in late April. Cuebiq data, which is based on GPS signals from cell phone devices and has been used by the New York Times, 538, University of Oxford, UNICEF, George Washington University, and ISI Foundation, will be pursued. A line item in the budget called “Data Acquisition” has been allocated for acquiring this data.

Health Data:
The Sheps team will extract and clean health data from the North Carolina Electronic Disease Surveillance System (NC EDSS) and the North Carolina Disease Event Tracking and Epidemiologic Collection Tool (NC DETECT). These two datasets are owned by the NC Division of Public Health (DPH). The Sheps team will work with the NC DPH to get an amendment to their existing Data Use Agreement to ensure authorization for use on this project.

1. NC EDSS records of COVID-19 contain (among other elements) the date of the test results, whether the test was positive, residence ZIP, age, and sex.

2. NC DETECT data for emergency department visits has records with respiratory symptoms, symptoms of influenza-like illness, and other symptoms that are consistent with reasonably suspecting COVID-19. Fields include patient age, sex, race/ethnicity, residence ZIP, and hospital.

The Sheps team will consider Medicaid claims data:

3. Medicaid data contain claims by Medicaid beneficiaries and are shared with the Sheps Center under special arrangements. Data use for each project is subject to approval of the Division of Health Benefits (DHB) following existing, well-established protocols. Per a June 5 email from the Department, "The impact of COVID-19 on the Medicaid program and our beneficiaries is a top priority of the Department. " Thus, we expect that DHB will review the data request favorably. We expect that data sharing will be accelerated so that claims will be available within 60 days (e.g. a March 31 claim will be sent to Sheps on May 31). Data contain medical encounters (e.g. hospitalizations, ED visits, physician visits) for the 1.3 million North Carolinians covered by Medicaid.

The following data sources will also be considered and pursued:

1. Crash data and counts of other morbidity/mortality outcomes of interest (e.g. traffic fatalities)
2. Pedestrian/bicycle data
3. GIS layers for study areas
4. US Census data
5. NC social determinants of health (https://nc.maps.arcgis.com/apps/MapSeries/index.html?appid=def612b7025b44eaa1e0d7af43f4702b)

The research team will be seeking IRB approval, as needed, for use of above data.

Task 2: Literature Review and Synthesis of On-going and Recently Completed Synergetic Studies

Researchers/Staff: Arrianna Marie Planey (lead), Randa Radwan (co-lead)

Time Frame: (July 1 - November 30)

The main objective is to inform proposed analyses and provide input to 1-2 pages updates to the Policy Collaboratory beginning at the middle of August. The focus will be on peer reviewed literature, on-going state, national, and international studies involving the intersection of mobility and COVID health impacts, and studies applying spatial analysis to mobility data.

Task 3: Base Analyses for COVID-19 Mobility and Health Impacts

Researchers/Staff: Wes Kumfer (lead), Katie Harmon (co-lead)

Time Frame: (June 15 - August 31)

The objective of this task is to address the following research questions:

1. Have shelter-in-place policies, emergency declarations, and general news and events (local and nationwide) reduced movement within the North Carolina, and is this slowing the spread of COVID-19?
2. What are the differences in mobility between urban and rural counties and how do these trends vary through time?

We plan to consider three primary data sources (two mobility sets and one health set) and at least one secondary source of mobility data. We will also plan to consider a timeline of formal and informal policy measures/declarations to test inflection points.

1. **Primary datasets**
   a. Mobility and travel data
      i. *ZIP code-level origin-destination data (trips):* Teralytics
      ii. *County-level traffic data quantified by annual average daily traffic (AADT)* – NCDOT Automatic Traffic Recorder (ATR) stations
   b. Health data: *TBD, based on fields that the Sheps team is able to collect* (see Task 1)
   c. Timelines of COVID-19 closures and executive orders related events
      i. Time and date of government-issued stay-at-home orders (both national, NC-specific, and county/city specific)
      ii. Time and date of North Carolina Executive Orders (restaurant closures, social distancing directives, university, and school closures, etc.)
2. **Secondary datasets**
   a. Mobility and travel data: We plan to use at least one of the two following datasets
      i. *County-level vehicle miles of travel (VMT):* StreetLight
      ii. *Traffic incident data:* Waze.

The analysis approach in this base analysis will involve the comparison of descriptive statistics for different counties in North Carolina. Limited time series analysis will be conducted to determine the trends for both mobility and health data. One of the possible approaches to conduct the time series analysis is JointPoint Regression, a time series regression tool that has been used in cancer surveillance studies. This task will also conduct an analysis of policy declarations as stimuli for any identified trend changes.

Task 4: Expanded Analyses for COVID Mobility and Health Impacts
Researchers/Staff: Michael Kosorok (lead), Raghavan Srinivasan (co-lead)
Time Frame: (July 1 - November 15)
This Task will build on the results from Task 3 and provide further insight toward our research questions. The expanded analyses will explicitly consider the inter-relationships between the trends in the different data sets including health and mobility data. Using acquired primary, secondary, and tertiary mobility datasets, this task will explore more robust statistical methodologies including different types of multivariate analyses, Bayesian models, and possibly simultaneous equation models to account for confounding variables and to properly program time lags and intervention points. As part of the precision health AI technology at Gillings, causally-based analysis approaches will also be considered. Such approaches can help identify contextually-dependent optimal policies. In addition, more robust spatial methodologies for identifying areas within the State with the highest risk will be considered (simple example: https://storymaps.arcgis.com/stories/4a38c9e3c7bf4b8eafac7d4f17688711), otherwise the spatial component can used for visualization (See Task 8).

Task 5: Study of the Effect of COVID-19 on Young Drivers and Implications for Policy
Researchers/Staff: Natalie O'Brien (lead)
Time Frame: (July 1 - December 31)
Motor vehicle crashes are the leading cause of death for teenagers in the United States. The only countermeasure proven to address this problem is graduated driver licensing (GDL). GDL is a three-stage system that aims to flatten the learning curve by placing progressively fewer restrictions on novice drivers as they gain practical driving experience. The initial stage requires an extended period of supervised practice, usually lasting 6-12 months. The second stage allows unsupervised driving but prohibits driving in high-risk conditions such as

carrying multiple teenage passengers and driving at nighttime. The pandemic has resulted in many problems for young drivers including fewer opportunities for practice and delays in licensing process.

Five bills have been introduced in the North Carolina General Assembly to loosen restrictions currently in place for new drivers. This task will compile data to inform these policy decisions as they would dramatically impact young drivers' safety in the coming years. The following activities will be performed:

1. Compare the number of teens who obtain a learner permit in North Carolina from January 1 to June 30, 2020 with historical averages.
2. Work with the NC Department of Public Instruction to obtain information about the number of teens who enroll and complete driver education classes during that same period.
3. Conduct telephone interviews with 300 new teen drivers and their parents in North Carolina to obtain information about young driver behavior. Interviews will focus on the amount and characteristics of driving practice, the extent of loss in income and/or employment due to COVID-19, and how families have adapted given the restraints posed by the coronavirus. A goal would be to uncover important factors that predict driving practices and licensing decisions.
4. Use preliminary 2020 NC crash data to assess the initial effects of the virus on young driver crash rates. Specifically, we will examine the characteristics of the crashes and compare them with those of pre-COVID crashes during the same period in previous years.

Task 6: Analysis of Effects of COVID-19 on Transportation Safety Sector

Researchers/Staff: Raghavan Srinivasan (lead), Wes Kumfer (co-lead), Katie Harmon (co-lead)

Time Frame: (September 1 - December 31)

The focus of this task would be to examine trends in crashes, crash fatalities, high speed crashes, and vulnerable road users in available data in 2020 as compared with 2019.

Task 7: Data Management and Storage

Researchers/Staff: Jon Crabtree (lead), Raghavan Srinivasan (co-lead)

Time Frame: (July 16-December 31)

This task will provide the data management and storage needs for this effort. Odum Institute at UNC will lead this task. Data will be uploaded to the Odum Institute developed systems by each disciplinary team on the project. Data will be cleaned by the data provider following the guidelines developed by the Odum Institute archives team members. The Odum Institute will evaluate, test, and implement the storage environment needed by the project as information and specifics of the data to be used are discovered in the early phases of the project. One of the objectives is to design and implement data storage to facilitate internal use by HSRC team members sharing data for different types of analysis.

Task 8: Data visualization and prototype dashboard

Researchers/Staff: Jon Crabtree (lead), Randa Radwan (co-lead)

Time Frame: (August 1 - December 31)

One of the important outcomes of this effort is to provide data in a form that can be easily understood by the general public. This task will provide the results of Tasks 3 through 6 in the form of plots, graphs, and charts that can be understood by individuals without a background in scientific research. Multiple tools will be explored for this purpose including explorer tools in Dataverse (available at Odum Institute), Tableau, and different spatial tools for display relevant information in maps.

Task 9: Website Design and external communication
Researchers/Staff: Randa Radwan (lead), Caroline Mozingo (co-lead)
Time Frame: (July 15 - December 31)
The team will develop a content-based website to serve as a focal point for research updates and dissemination of results, as well as linkage to synergetic studies. They will coordinate with Odum staff to develop Dataverse widgets for a prototype data statistics dashboard through such a website. The team will also develop 1 to 2-page flyers, to include infographics/charts, designed to provide study updates to the Collaboratory and NC legislature staff. Coordinate participation in public events, (e.g. stakeholder meetings, convening of academic partners, etc.) to describe the research team's work and share findings.

Task 10: Final Reporting
Researchers/Staff: All
Time Frame: (November 16 - December 31)

Internal Team Communication:
Given the short-turnaround timeframe and different facets of this project, the following internal teams will be formed. As the project is starting up, the teams will meet weekly, early in the week, and report out to the overall team meeting midweek. The meeting will be conducted virtually, via Zoom or Microsoft Teams, as long as researchers are working remotely. Each internal team lead will provide weekly email progress to the PI, Randa Radwan. The PI will synthesize and submit bi-weekly progress emails to the project team and the Collaboratory.

1. Mobility and Spatial Data Team: Wes Kumfer (lead), Tabatha Combs (co-lead), Arrianna Marie Planey, Mike Vann, Raghavan Srinivasan, Randa Radwan
2. COVID Health Outcomes Data Team: Mark Holmes (lead), Randa Radwan, Katie Harmon, Sheps staff
3. Mobility and Heath Literature Review Team: Arrianna Marie Planey (Lead), Randa Radwan, Cheng Ma (graduate student)
4. Base Analyses Team: Wes Kumfer (lead), Katie Harmon, Tab Combs, Raghavan Srinivasan, Randa Radwan, graduate students
5. Extended Analyses Team: Michael Kosorok (Lead), Raghavan Srinivasan (co-lead), Rui Song, , Bo Lan, Mark Holmes, Randa Radwan, graduate students
6. Young Driver Team: Natalie O'Brien (lead), Stephanie Harrell, Arthur Goodwin, Bevan Kirley, Yudan Wang, Kristel Robison
7. Effects of COVID-19 on Transportation Safety Sector: Raghavan Srinivasan (lead), Katie Harmon, Wes Kumfer, Bo Lan, Tabatha Combs, Randa Radwan, graduate students (*Note: this team will start their meetings in September*)
8. Data Management and Visualization: Jon Crabtree (lead), Randa Radwan (co-lead), Raghavan Srinivasan, Wes Kumfer, graduate students, Jonathan Weisenfeld
9. External Reporting and Communications Team: Randa Radwan (lead), Caroline Mozingo (co-lead), Jennifer Palcher-Silliman, Jonathan Weisenfeld, Graham Russell

Deliverables and Outcomes:
- Detailed work plans to be developed by the task leads:
  - for Tasks 1, 2, 5, and 7- to be provided to the PI by July 10.
  - for Task 3, Base Analyses, to be provided to the PI by July 1.
  - for Task 6, Effects of COVID-19 on transportation safety sector, to be provided to the PI by August 1.

  - for Task 4, Expanded Analyses, to be provided to the PI by August 7.
  - for Task 8, Data visualization and prototype dashboard, to be provided to the PI by August 7th.
  - The PI will synthesize the work plans and report out to the Collaboratory.
- Bi-weekly or monthly reports to include summary descriptive statistics, as decided by research project staff in discussions with Collaboratory.
- Final report

Project Outcome:

- The team proposes one or two white papers for the North Carolina General Assembly highlighting the interrelationships amongst public health policies, mobility changes, and the transmission and impacts of COVID-19.
- The team will also publish one or more abstracts or manuscripts related to the research study, as well as, produce slide decks describing results.

Limitations:

1. The mobility data already identified by the team lacks specific data for pedestrians and bicyclists. While the mobility data we have identified will show some changes in how people move, we cannot entirely rule out contact from people walking or biking in close proximity.
2. We will only be able to make conclusions based on the resolution and time span of our data.
3. The health data will consist only of laboratory-confirmed COVID-19 cases (and clinician-suspected if available). Patients with asymptomatic or mild infections may not seek medical treatment and testing and will not be included in our case count.
4. It is important that are other factors that we may not be able to control for or model in our analyses.

Follow-up Research Studies:

1. Future research can build upon this work to investigate traffic safety changes.
2. Future research can also build upon this work to investigate policy elasticities

Budget:

Title:	The Collaboratory State Funds	YEAR 1 TOTAL					
Institution:	The University of North Carolina at Chapel Hill (UNC-CH)						
Department:	Highway Safety Research Center (HSRC)	Start:	End:	# of mos:			
Project Period:	5/4/20-12/31/20	5/4/2020	12/31/2020	7.9			
Personnel	Title/Project Role	Hours	% of Time	P Months	Salary	Fringe	Total Cost
Radwan, Randa	HSRC Director, HSRC	353.00	25.70%	2.04	39,140	10,802	49,941
Vann, Michael	HSRC Social/Clinical Research Asst	328.00	23.88%	1.89	6,950	2,722	9,673
Palcher-Silliman, Jennifer	HSRC Public Communication Specialist	50.00	3.64%	0.29	1,407	502	1,909
Mozingo, Caroline	HSRC Sr. Mgr of Comm, Outreach & Ed	100.00	7.28%	0.58	4,782	1,492	6,274
Lan, Bo	HSRC Research Engineer	303.00	22.06%	1.75	14,215	4,453	18,668
Srinivasan, Raghavan	HSRC Sr. Transportation Research Engineer	289.00	21.04%	1.67	22,429	6,453	28,882
Harmon, Katherine	HSRC Research Associate	121.00	8.81%	0.70	4,341	1,446	5,787
Weisenfeld, Jonathon	HSRC Design Services Manager	200.00	14.56%	1.15	6,772	2,290	9,063
Russell,Graham	HSRC Designer	20.00	1.46%	0.12	546	196	742
Kumfer, Wesley	HSRC Research Associate	285.00	20.75%	1.64	9,438	3,211	12,648
Combs, Tabitha	HSRC Research Associate	121.00	8.81%	0.70	4,472	402	4,874
TBH - Program Manager	HSRC Program Manager	433.00	31.53%	2.50	15,056	5,056	20,112
Grad Assistant #1 @ $17/hr	HSRC Graduate Assistant #1	606.75	44.18%	3.50	10,573	2,128	12,700
Grad Assistant #2 @ $17/hr	HSRC Graduate Assistant #2	606.75	44.18%	3.50	10,573	2,128	12,700
Grad Assistant #3 @ $17/hr	HSRC Graduate Assistant #3_from NCA&T	606.75	44.18%	3.50	10,573	2,128	12,700
Grad Assistant #4 @ $17/hr	HSRC Graduate Assistant #4_from NCA&T	606.75	44.18%	3.50	10,573	2,128	12,700
Goodwin, Arthur	HSRC Senior Research Associate	174.00	12.67%	1.00	9,858	2,979	12,837
O'Brien, Natalie	HSRC Research Associate	434.00	31.60%	2.50	18,547	5,927	24,474
Kirley, Bevan	HSRC Social Behavior Research Associate	174.00	12.67%	1.00	7,870	2,484	10,354
Robison,Kristel	HSRC Research Associate	86.00	6.26%	0.50	2,970	999	3,970
Harrell, Stephanie	HSRC Social/Clinical Research Asst	434.00	31.60%	2.50	10,318	3,881	14,200
Wang, Yudan	HSRC Research Associate_NC A&T	174.00	12.67%	1.00	8,017	2,886	10,903
Holmes, Mark	SHEPS Center Director	113.00	8.23%	0.65	13,160	3,615	16,775
Planey, Arianna	SHEPS Research Associate	182.00	13.25%	1.05	8,072	2,559	10,631
TBH - Programmer	SHEPS Programmer	282.00	20.53%	1.63	15,286	4,656	19,942
TBH-System Administrator	SHEPS System Administrator	113.00	8.23%	0.65	6,125	1,866	7,991
RESEARCH ASSISTANT @ $17/hr	SHEPS Research Assistant	563.00	40.99%	3.25	9,810	4,146	13,956
Song, Rui	Gillings SPH Associate Professor_NC State	111.03	8.08%	0.64	10,720	3,280	14,000
Kosorok, Michael	Gillings SPH Professor-Biostatistics	104.00	7.57%	0.60	23,194	6,082	29,276
Grad Assistant @12.50	Gillings SPH Graduate Assistant_Biostatistics	1,040.00	75.73%	6.00	13,325	3,216	16,541
Subtotal Salaries (without support staff applied)		**9,014.03**	**656.34%**	**52.00**	**329,114**	**96,111**	**425,225**
Lytle, Richard	HSRC Applications Analyst	559	40.74%	3.23	20,325	6,750	27,075
Subtotal Salaries (for support staff)		**559.47**	**40.74%**	**3.23**	**20,325**	**6,750**	**27,075**
TOTAL LABOR AND FRINGE, HEALTH COSTS		**9,573.50**	**697.08%**	**55.23**	**349,439**	**102,861**	**452,300**
OTHER DIRECT COSTS							
HSRC Project Supplies/Photocopies							535
SHEPS Tuition and Fees							6,321
Gillings SPH Biostats Fee							1,851
Data Acquisition							300,000
HSRC Telephone Survey							50,000
HSRC Equipment							5,810
SHEPS IT Fee ($3,571/FTE)							2,151
ODUM managed storage and backup costs $6,000							6,000
ODUM Research Data Information Systems Labor Costs @ 103.42 per hour							82,736
ODUM Archive Labor Costs @ 104.49 per hour							20,898
TOTAL OTHER DIRECT COSTS							**476,302**
TOTAL LABOR, FRINGE, HEALTH, AND OTHER DIRECT COSTS							**928,602**
F&A Base					TDC		928,602
UNC-CH Facilities & Administrative Costs (F&A)					Indirect Cost	0.00%	0
TOTAL ESTIMATED COSTS (Slight Rounding Factor)							**928,602**
Summary by UNC-CH Department							
HSRC							**379,533**
Sheps Center							**77,767**
Gillings SPH							**61,668**
ODUM Institute							**109,634**
Data Acquisition							**300,000**
Total							**928,602**