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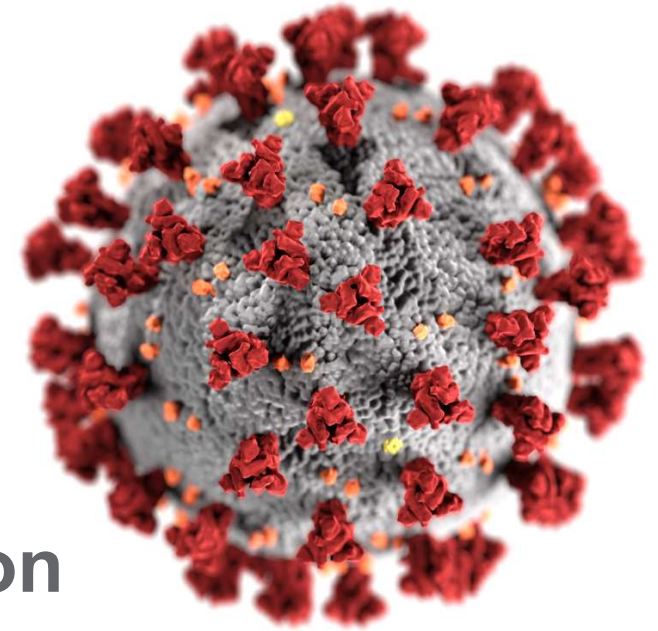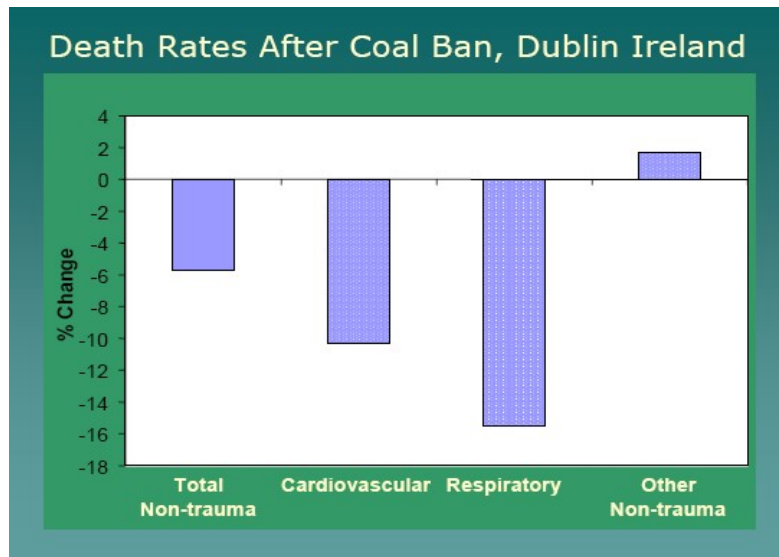
The Covid-19 Natural Experiment

Expected and Unexpected Impacts on Ambient Air Quality in New York

Previous Natural Experiments

Death Rates After Coal Ban, Dublin Ireland

Expected: After a ban on coal use for home heating went into effect in 1990 in Dublin, Ireland, mortality from respiratory disease declined 17%. (Goodman et al)

Expected: During the Atlanta Olympic Games, reduced vehicle traffic reduced air pollution and Medicaid ER visits and hospitalizations for asthma dropped by 42%. (JAMA)
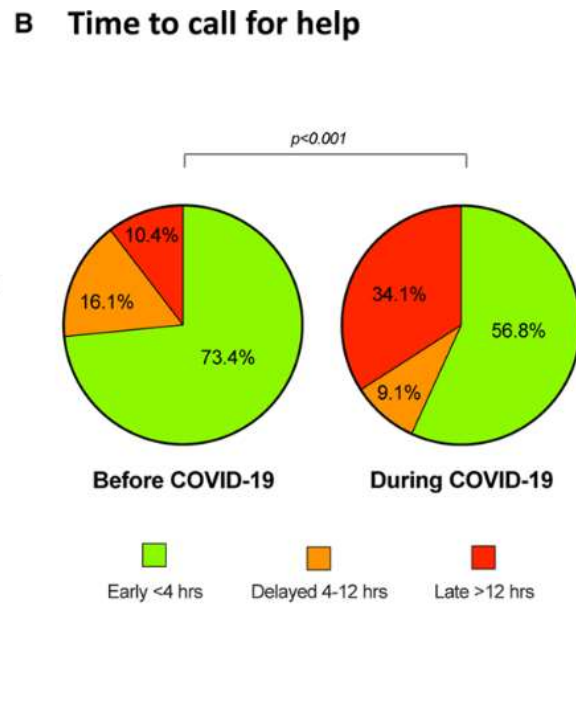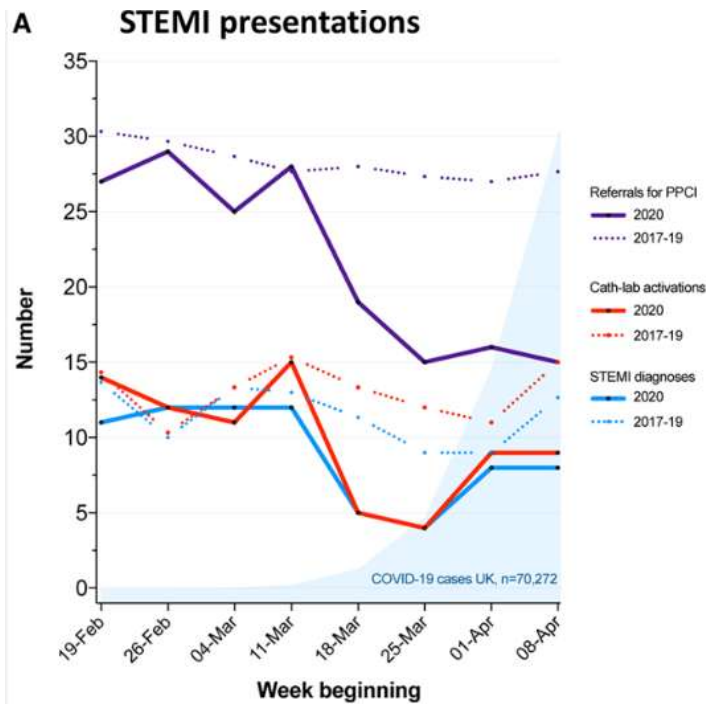
Expected: During a year long strike at a Steel Mill in Utah in 1987, 2/3 fewer children were hospitalized for lung ailments. (Pope)

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Covid-19 Natural Experiment (Not like Previous Examples)

A — STEMI presentations

Referrals for PPCI
— 2020
···· 2017-19

Cath-lab activations
— 2020
-·-· 2017-19

STEMI diagnoses
— 2020
-·-· 2017-19

COVID-19 cases UK, n=70,272

B — Time to call for help

p<0.001

Before COVID-19: 10.4%, 16.1%, 73.4%

During COVID-19: 34.1%, 9.1%, 56.8%

Early <4 hrs (green)   Delayed 4-12 hrs (orange)   Late >12 hrs (red)

Expected: Severe heart attacks decreased during the shutdown

Unexpected: Delays in treatment led to worse in-hospital outcomes.

Doctors are expecting a wave of new cardiac patients after Covid-19 fears have passed

Simon J. Wilson. Circulation: Cardiovascular Interventions. Effect of the COVID-19 Pandemic on ST-Segment–Elevation Myocardial Infarction Presentations and In-Hospital Outcomes, Volume: 13, Issue: 7, DOI: (10.1161/CIRCINTERVENTIONS.120.009438)

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Covid-19 Natural Experiment (Not like Previous Examples)

Unexpected: Poor pre-Covid air quality increases severity of health impact

PM$_{2.5}$: 1 µg/m^3 increase leads to a 11% Covid-19 death rate
98% of US population (Wu et al)

HAPS: increased exposure linked to 9% increase in mortality
National data (Petroni et al)

NO$_2$: 4.6 ppb increase in NO$_2$ leads to an 11% increase in mortality
National data (Liang et al)

NO$_2$: 8.7 ppb increase in NO$_2$ leads to a 35-60% increase in mortality
LA County data (Lipsitt et al)

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Covid -19 Natural Experiment

Katherine Bourzac/CE&EN

Expected: Haze was reduced and views improved

Unexpected: Global Lightning Activity Fell by Nearly 8% During Covid-19 Lockdown in 2020: Yakun Liu, MIT (Mar – May 2020 compared to 2018, 2019, 2021) AGU December 2021

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Covid-19 Impacts: Timing in NY

March 7, 2020 – NY Governor State of emergency declared
March 10, 2020 – A containment zone was setup around New Rochelle
March 12, 2020 – Broadway shuts down,
March 12, 2020 – President Trump declares a National emergency
March 15, 2020 – All NYC schools closed
March 20, 2020 – <u>State-wide stay at home order issued</u>

May 15, 2020 – Phase 1 reopening for counties that meet qualifications
June 8, 2020 – NYC meets qualifications for Phase 1 reopening
June 22, 2020 – NYC meets qualifications for Phase 2 reopening
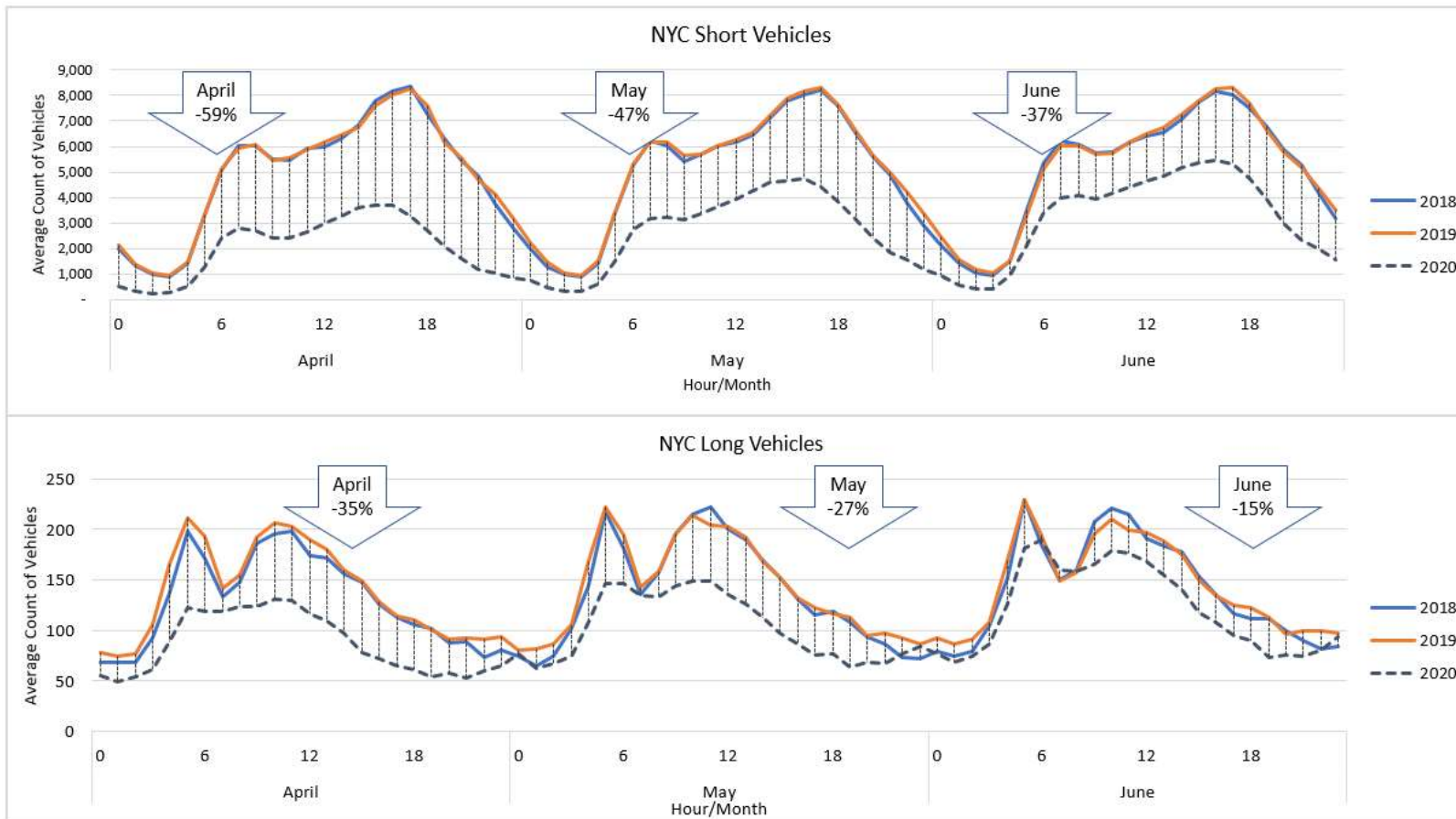August 7, 2020 – Schools allowed to reopen in-person

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Covid-19 Shutdown: Impact on Upstate Traffic
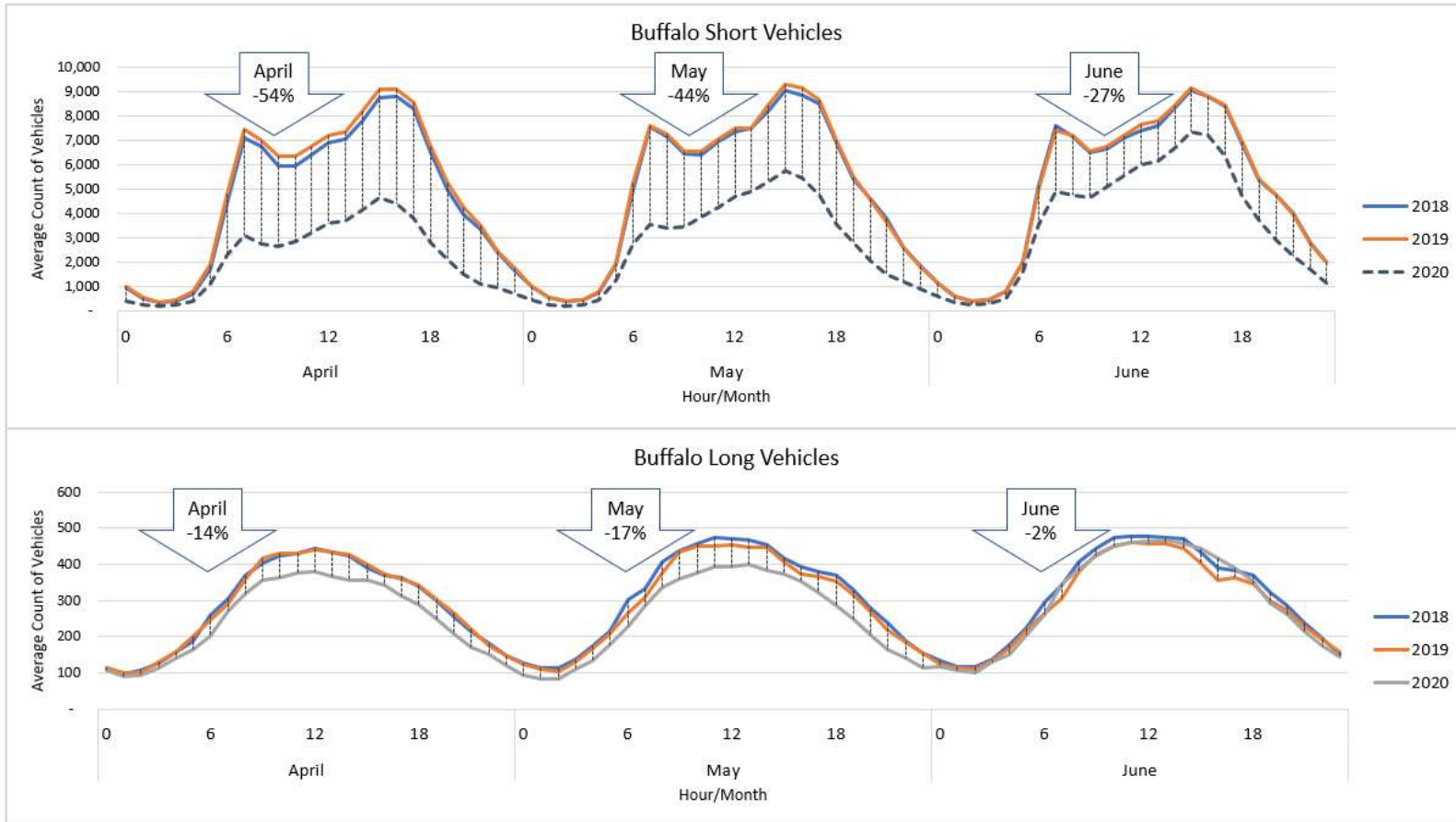
Monthly Diurnal Plots Buffalo, NY

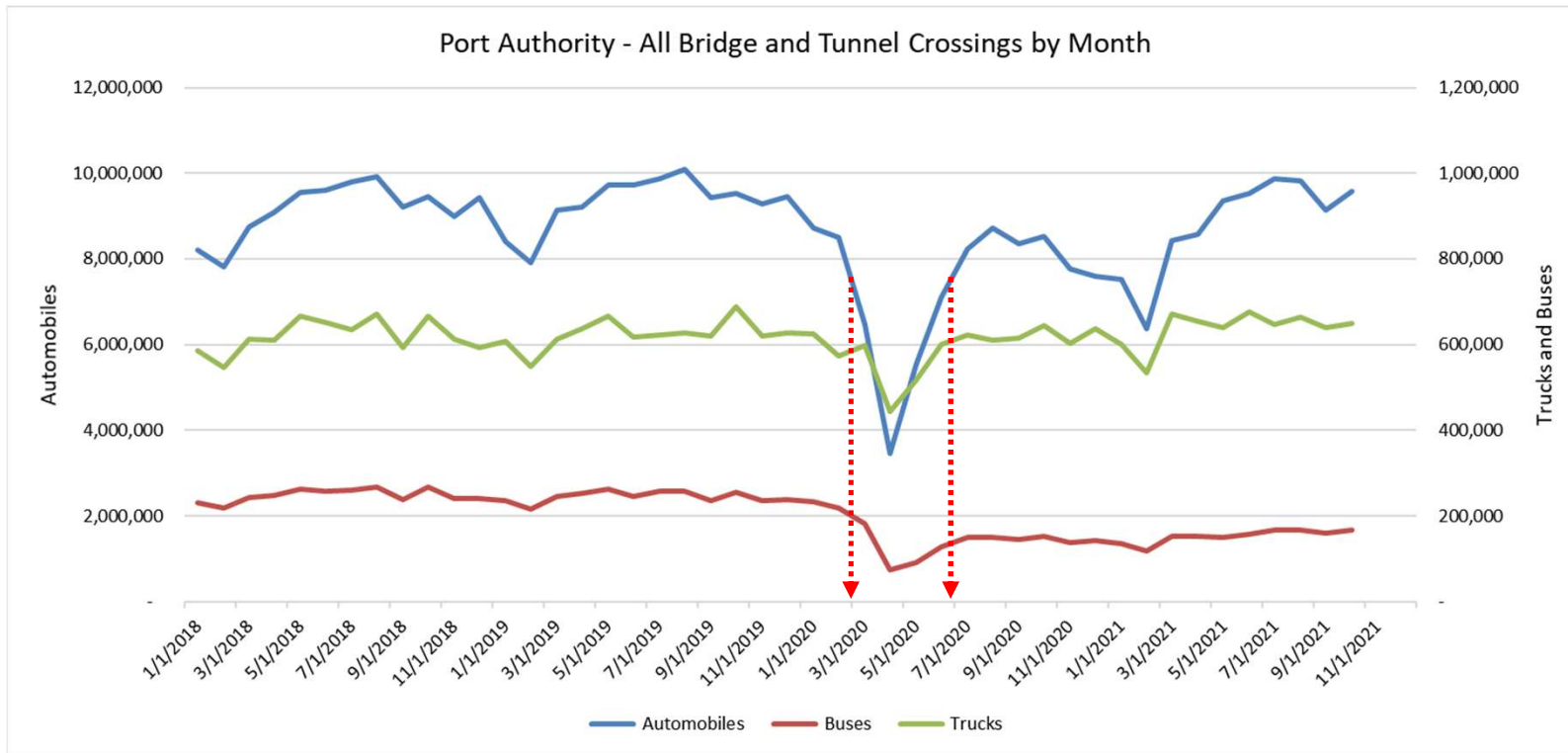I-90 close to the Near Road Air Monitor

No Tolls in this road segment

Covid-19 Shutdown: Impact on NYC Traffic

NYC

Lower portion of I-87 Toll Road

Covid-19 Shutdown: Impact on NYC Traffic

Port Authority - All Bridge and Tunnel Crossings by Month

The decrease in NYC Bridge and Tunnel crossings lasted 3 - 4 months

Bus traffic has not fully returned

NYC Bridge and Tunnel crossings back to pre-pandemic levels

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Covid-19: Human Behavior

<u>Unexpected</u>: Speeds and reckless behavior increased, In NYC - The average number of speeding citations issued went from 10,800 in early February to 24,800 in April

In many cities - Traffic fatalities dropped ½ as much as the reduction in traffic

<u>Unexpected</u>: NYC subway ridership has only recovered from a low of 8% to < 50%.

Affluent neighborhood ridership is lagging behind working class/EJ areas

Current usage: 11% to 74% depending on the station

A car crash in Brooklyn from late March LEV RADIN/PACIFIC PRESS/SHUTTERSTOCK

Trend
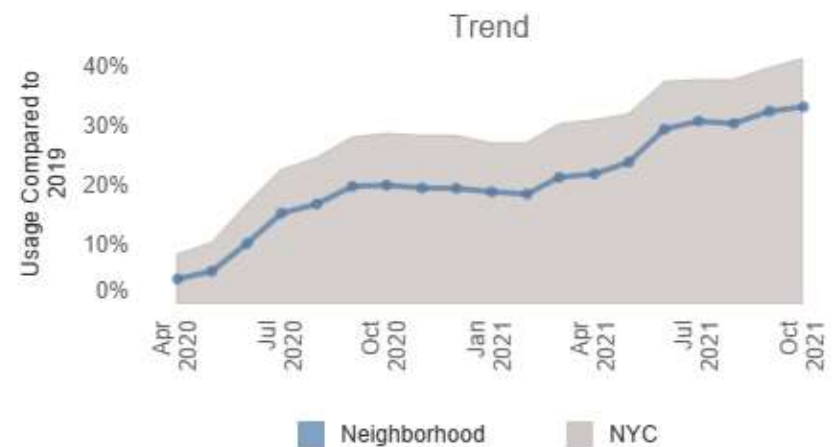
Covid Shutdown: Impact on Mobile Source Pollutants

Decrease in 2020 compared to average of 2018 and 2019 March 20 - June 20 (2018, 2019 and 2020)						
	NO	NO2	CO	BC	PM-2.5	UFP
Near Road Sites	37%	34%	16%	28%	22%	22%
Neighborhood Scale Sites	32%	31%	12%	18%	9%	31%

Expected: Near Road sites show greater decreases in mobile source pollutants

Unexpected: Some sites had smaller decreases for some pollutants than other similar sites. The Rochester NCore site had a 12% decrease in BC but a 53% increase in DC (DC = UV – BC)

Unexpected: Neighborhood UFP decreased more than Near Road UFP

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Covid-19: Unexpected Human Behavior

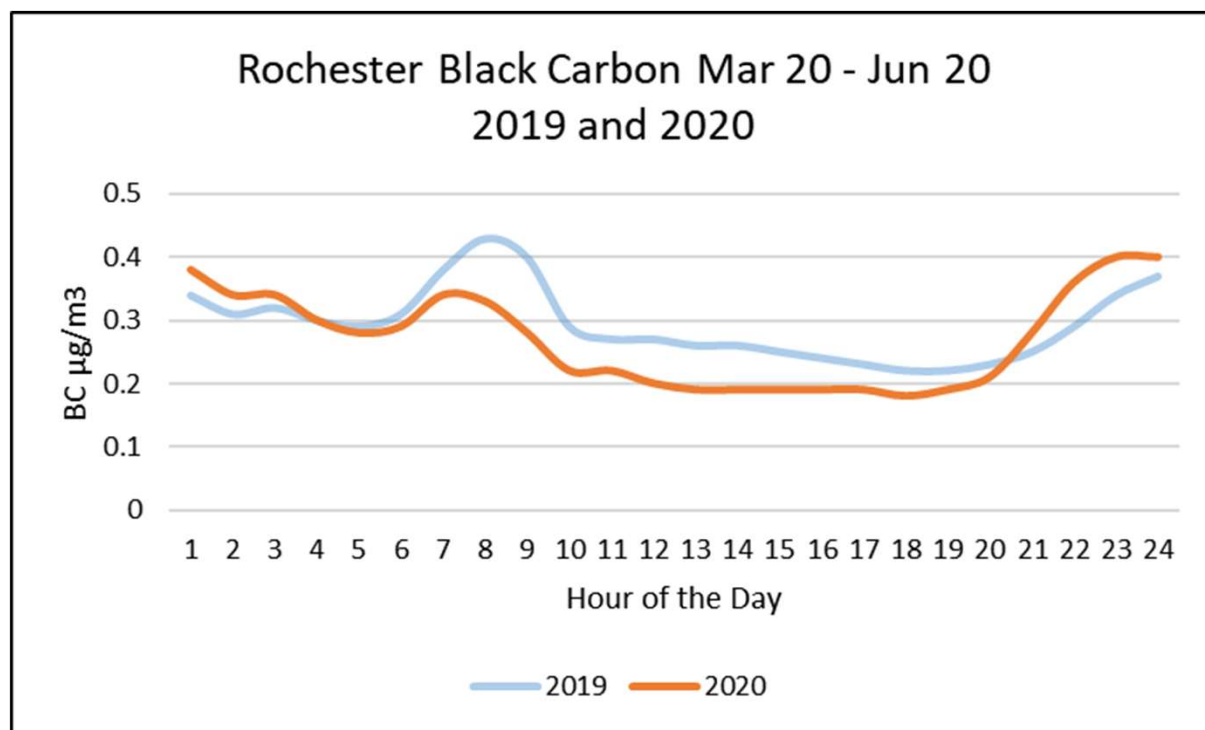Rochester Black Carbon Mar 20 - Jun 20 2019
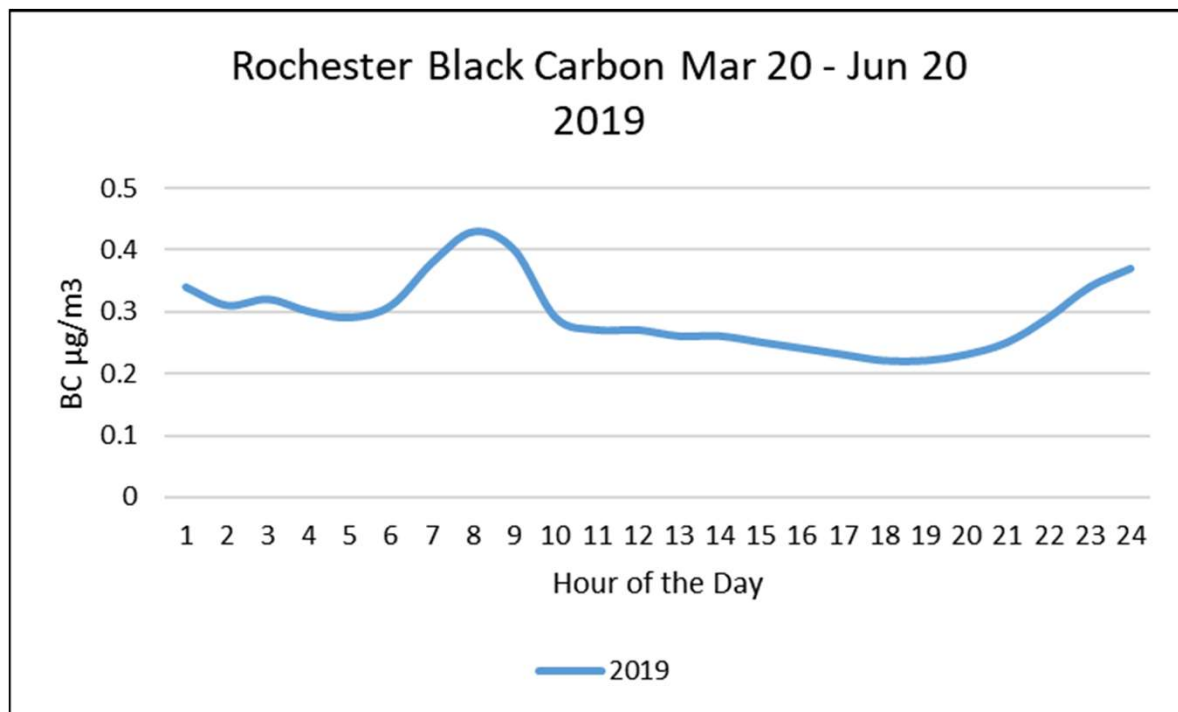
Rochester NCore Site

In 2019:
BC has a peak in the morning during rush hour and a smaller evening peak due to recreational wood burning

Covid-19: Unexpected Changes in BC (NCore)

Rochester Black Carbon Mar 20 - Jun 20
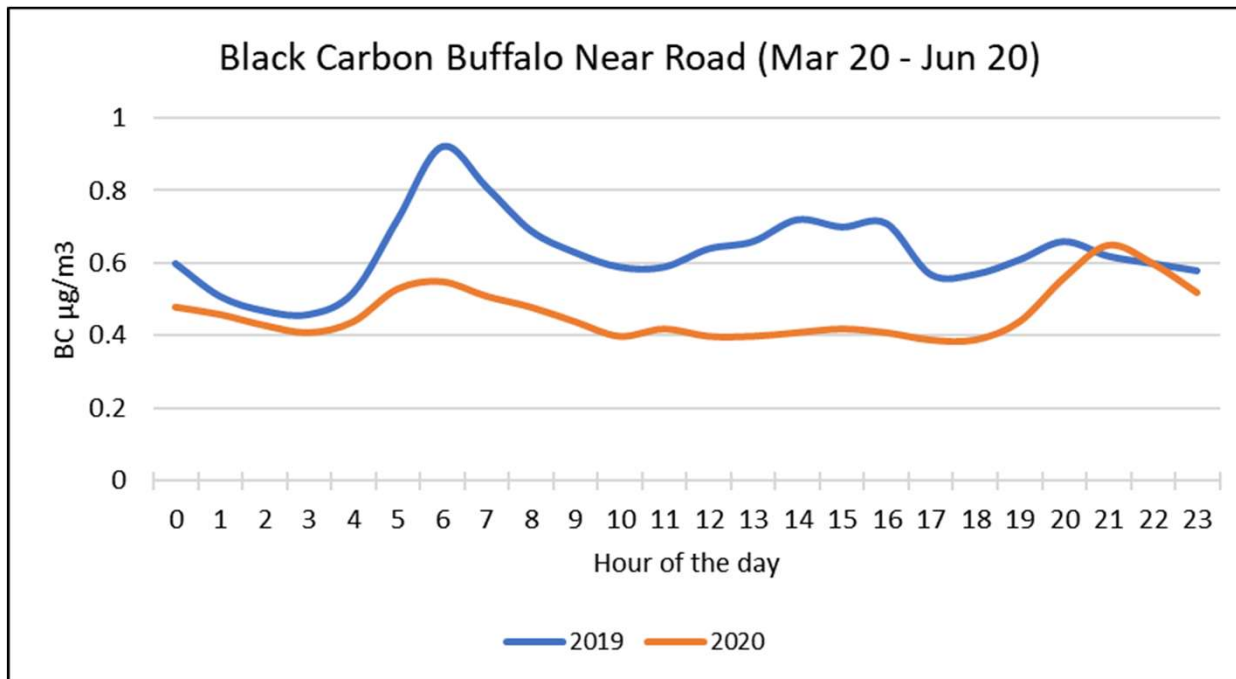2019 and 2020

In 2020:
The morning peak in BC was reduced but the evening peak due to recreational wood burning increased (8:00 pm – 4:00 am)

BC decreased 12%
DC increased 53%

Unexpected: Increases in recreational woodburning limited the overall reduction in BC

Covid-19: Unexpected Changes in BC (Near Road)

Black Carbon Buffalo Near Road (Mar 20 - Jun 20)
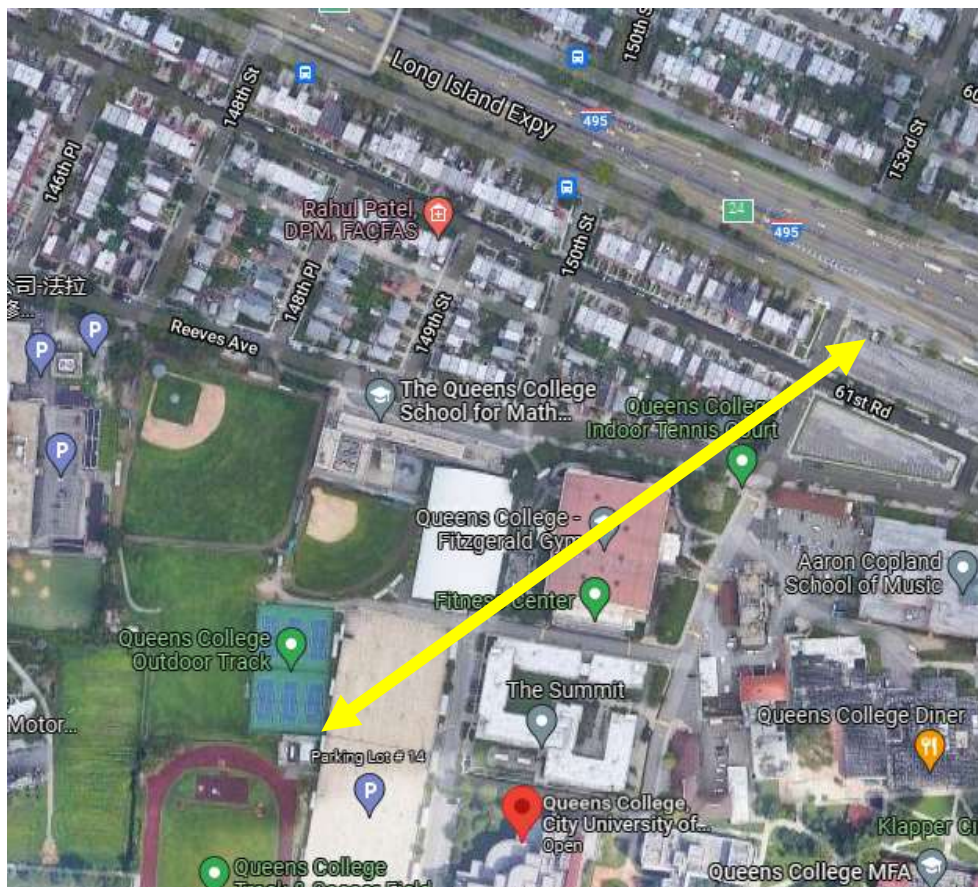

In 2019:
We see a normal traffic influenced diurnal pattern

In 2020:
Even at this near road site, BC increased in the evening hours during the shutdown period

Unexpected: Even at this near road site, recreational woodburning will have to be factored into future PM control strategies

Covid-19: Unexpected UFP Results


The percent decrease is larger at the NCore site but the particle # is higher at the Near Road site

March 20 - June 20 (2018, 2019 and 2020)				
	2018-19	2020	Difference	% Difference
Queens Near Road	29,726	22,397	7,329	-25%
Queens NCore	17,146	11,417	5,729	-33%

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Covid-19: Unexpected Changes in Ozone
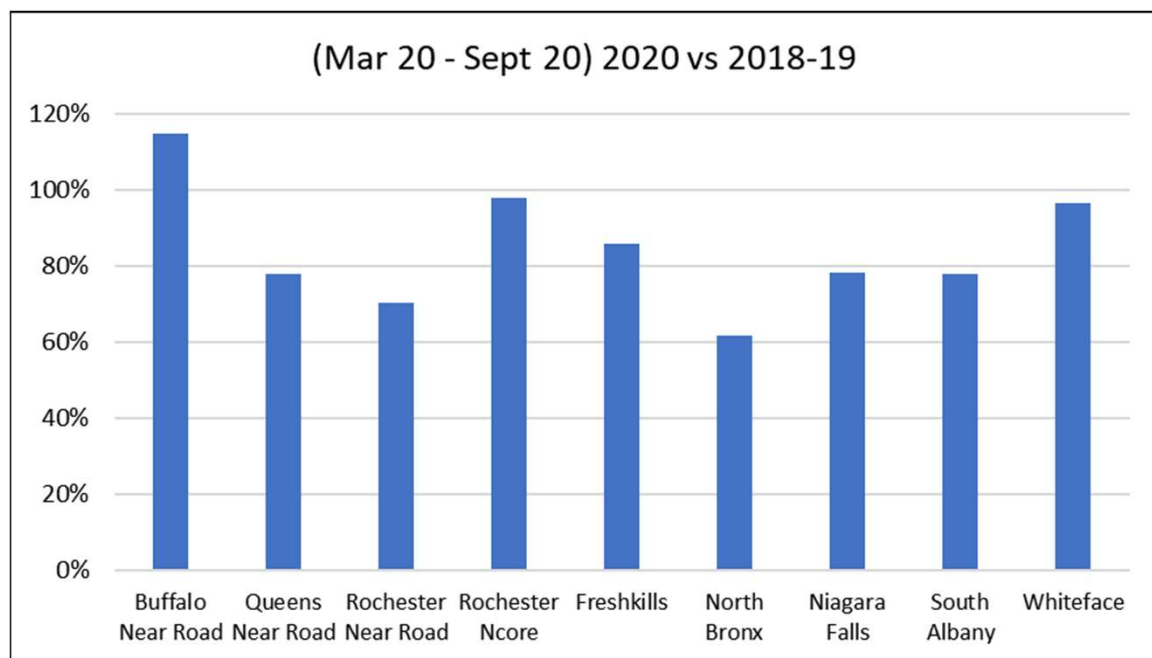

Ozone (24-Hr): Mar 20 - Jun 20, 2020 vs 2018 & 2019
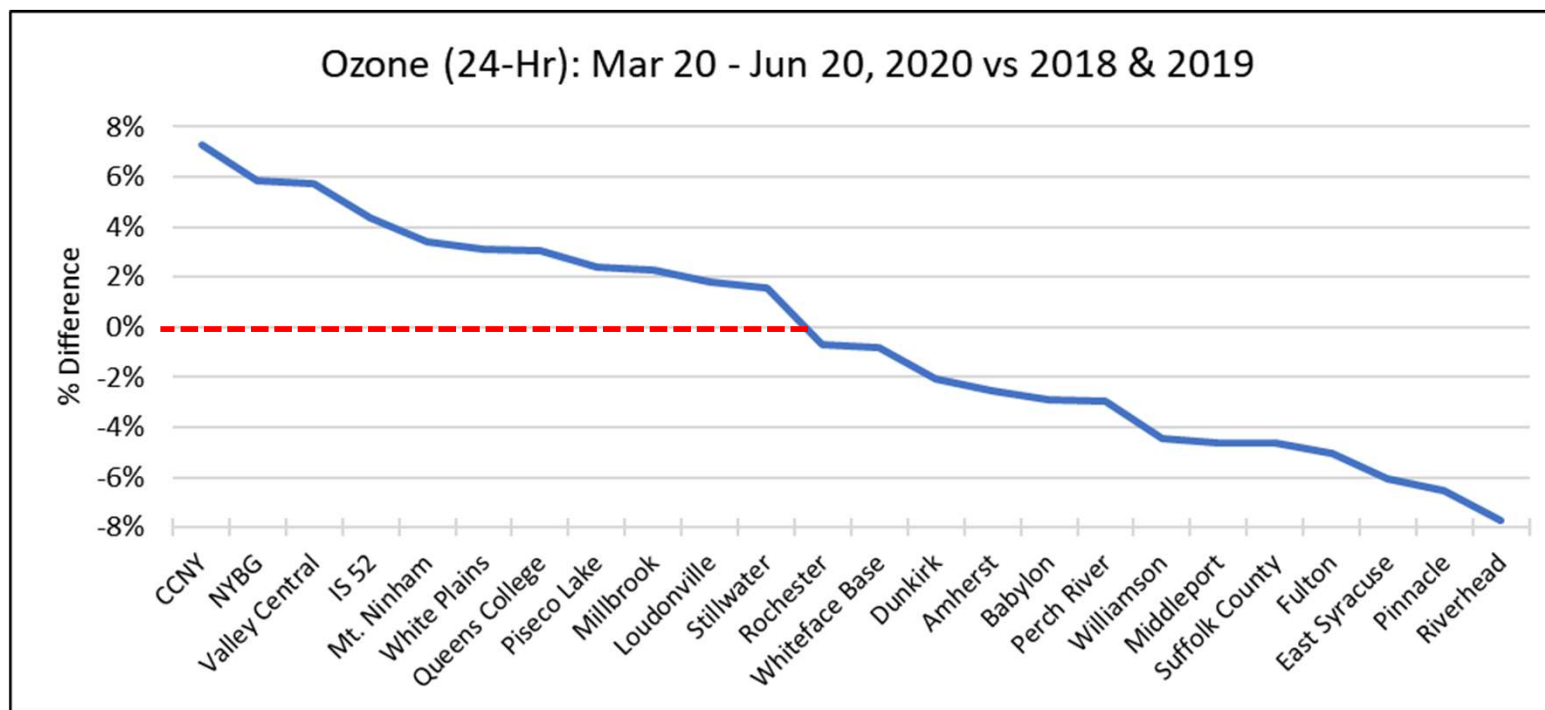
Ozone > in NOx source regions

Ozone < in NOx limited regions

Unexpected: The natural experiment shows where Ozone is NOx limited

Covid Shutdown: Impact on Formaldehyde (DNPH)

(Mar 20 - Sept 20) 2020 vs 2018-19

	Average
Buffalo Near Road	15%
Queens Near Road	-22%
Rochester Near Road	-30%
Rochester NCore	-2%
Staten Island	-14%
North Bronx	-38%
Niagara Falls	-22%
South Albany	-22%
Whiteface Mt	-3%
Overall	-16%

Near Road sites include monitoring for Carbonyls
Formaldehyde decreased at all sites except one

Covid Shutdown: Impact on Air Toxics (TO-15)

VOCs (24-Hr): Mar 20 - Jun 20, 2020 vs 2018 & 2019
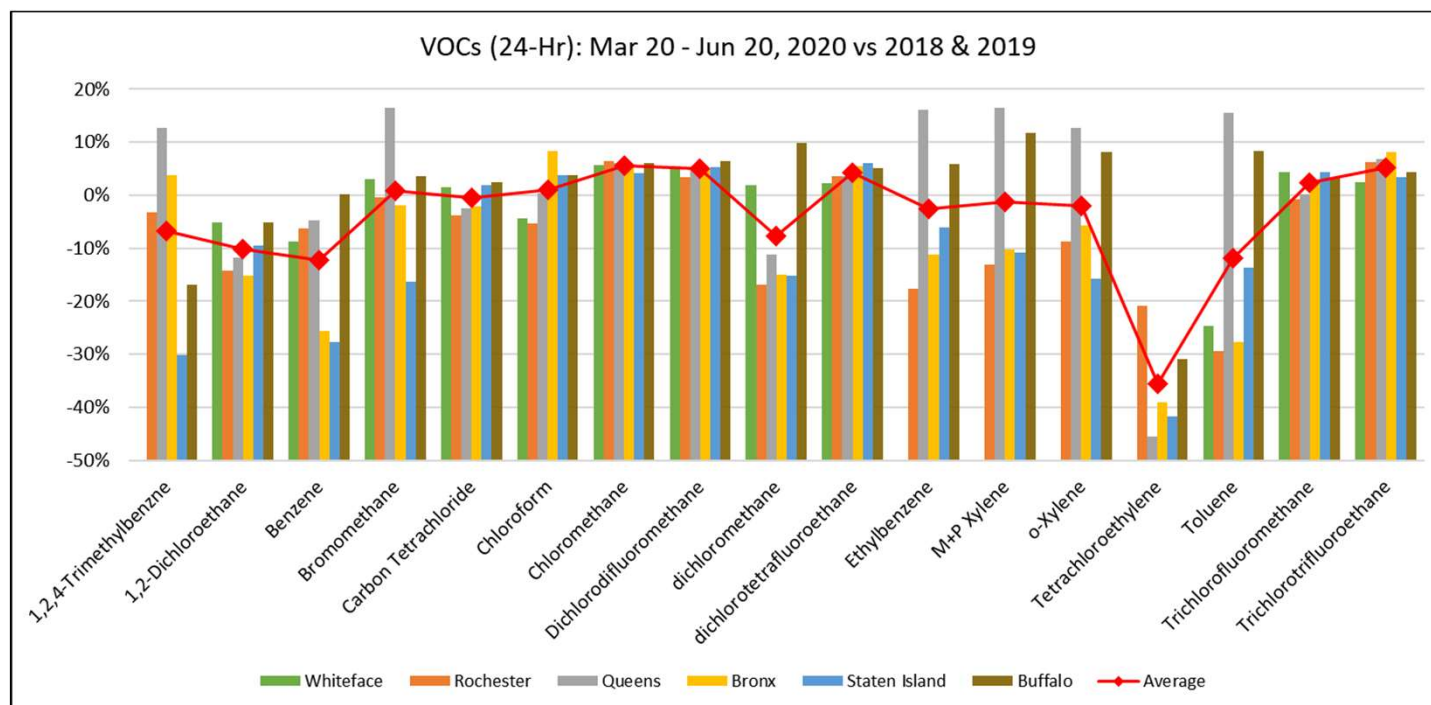
	Average
1,2,4-Trimethylbenzne	-7%
1,2-Dichloroethane	-10%
Benzene	-12%
Bromomethane	1%
Carbon Tetrachloride	0%
Chloroform	1%
Chloromethane	6%
Dichlorodifluoromethane	5%
dichloromethane	-8%
dichlorotetrafluoroethane	4%
Ethylbenzene	-3%
M+P Xylene	-1%
o-Xylene	-2%
Tetrachloroethylene	-36%
Toluene	-12%
Trichlorofluoromethane	2%
Trichlorotrifluoroethane	5%

Unexpected: The VOC that dropped the most is associated with dry cleaning

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Covid Shutdown: Impact on PM-2.5 Components

% Difference in 2020 compared to average of 2018 and 2019 March 20 - June 20 (2018, 2019 and 2020)						
	Ammonium	Nitrate	Sulfate	Sulfur	Elemental Carbon	Organic Carbon
Buffalo Urban	-27%	-36%	-10%	-10%	17%	27%
Rochester Urban NCore	-31%	-32%	-12%	-13%	8%	3%
Pinnacle Rural NCore	-30%	-12%	-10%	-9%	1%	-5%
Whiteface Mt. Rural	19%	-9%	24%	20%	12%	9%

Unexpected: The Adirondacks experienced a surge in camping and day hikes as visitors wanted to be outdoors but in uncrowded areas

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Conclusions

The correlations between changes in air quality and health outcomes during the Covid-19 shutdown are complicated by the state of the health care system and the pollutant levels prior to the shutdown.

Near road sites had the largest reductions in mobile source air pollutants

Covid-19 shutdowns reduced car traffic more than truck traffic but the reductions were temporary

Reductions in the use of public transit (bus and subway) seem to be more persistent, these could hamper emission reduction strategies in the future

People at home still create emissions

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Thank You

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