An evaluation of Earth Observation as a potential tool to forecast and manage resources during the Covid-19 pandemic

SGAC Space Medicine & Life Sciences Project Group − Team Novidien

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C-19 pandemic

Team Novidien

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- Dr Peter Ward, MD, Health Informatician
- Dr Saran Shantikumar, Public Health England, Lead MPH Warwick
- Dr Zhen Cahilog, MD, SGAC SMLS Research co-lead
- Akash Karri, Engineering and Pre-med, ML expert
- Lauren Church, Masters Space Physiology, Medical Student
- Bruno Pavletic, SGAC SMLS, ESA intern
- Eleanor Frost, Masters Medical Physics
- Devjoy Dev, SGAC SMLS Vice-lead

Additional affiliations:

Can Earth Observation data be used to forecast the number of C-19 cases in an area?
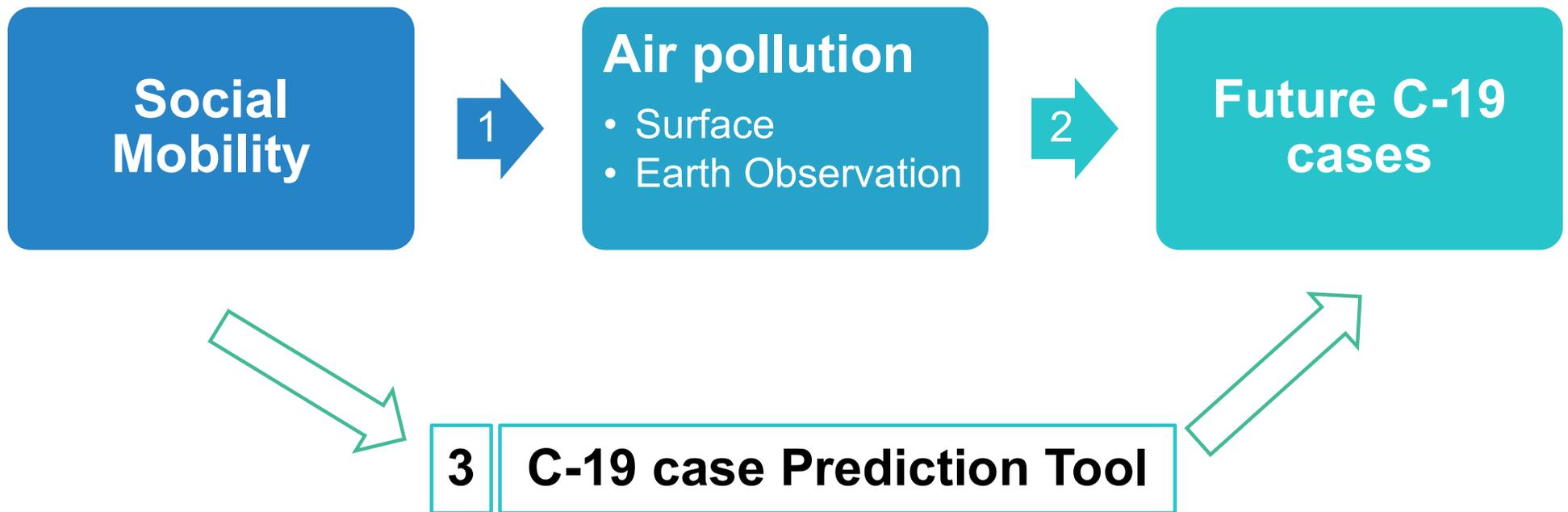
Social Mobility

1

Air pollution
- Surface
- Earth Observation

Future C-19 cases

3 C-19 case Prediction Tool
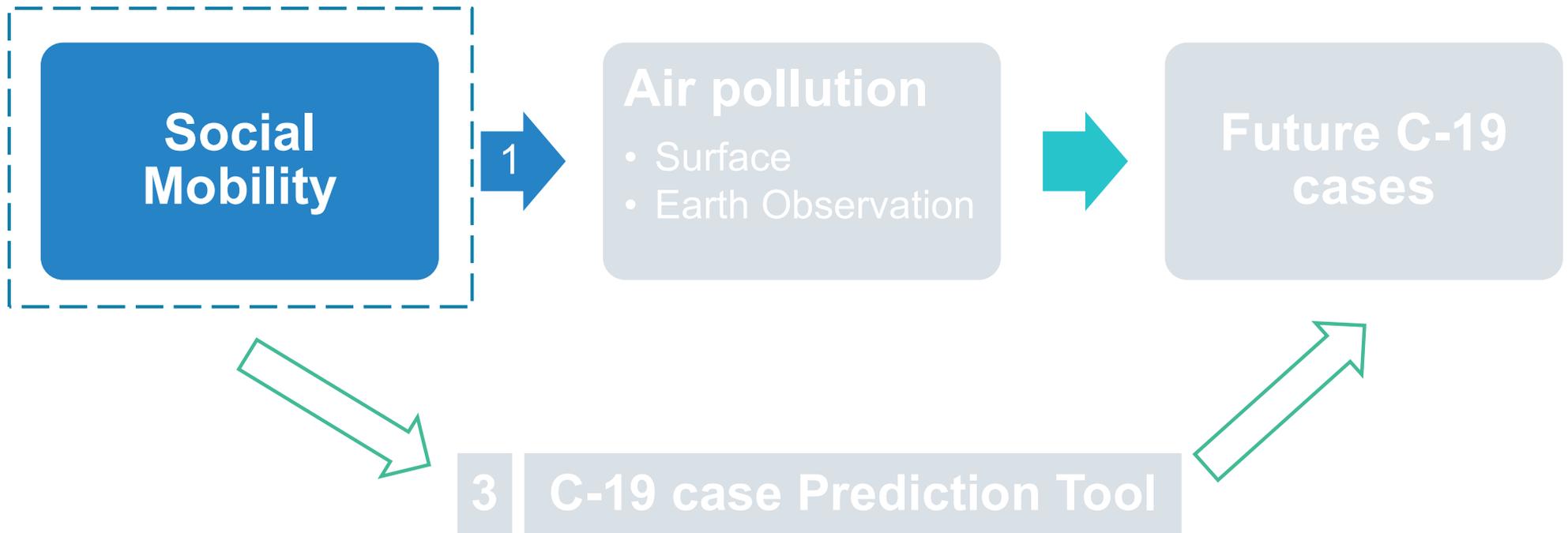
Social distancing minimizes C-19 transmission

Figure 2
COVID-19 impact and care actions
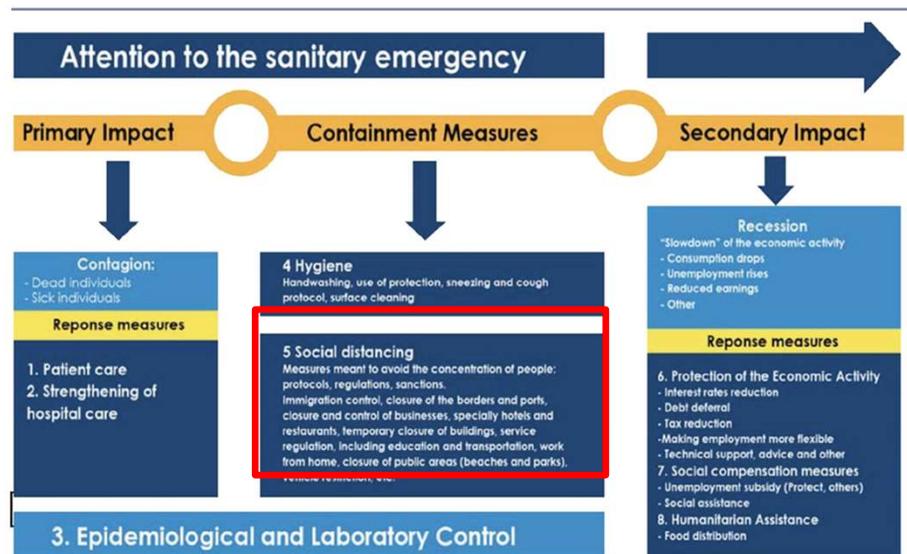
UN/DESA Policy Brief #85: Impact of COVID-19: perspective from Voluntary National Reviews

- **Part of the public health solution for C-19**
- Lockdown and uplift timelines geographically different
- Public health guidance different across borders
- Public and workplace adherence measures variable

Mobile phone mobility data indirectly measures social mobility
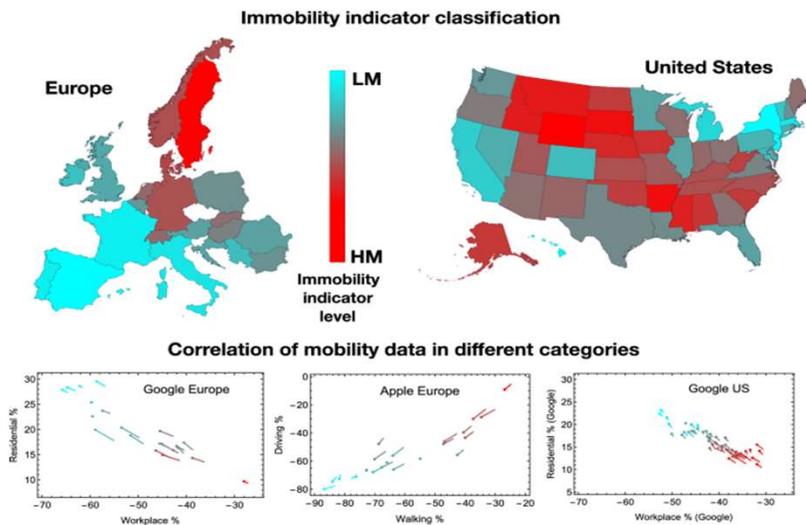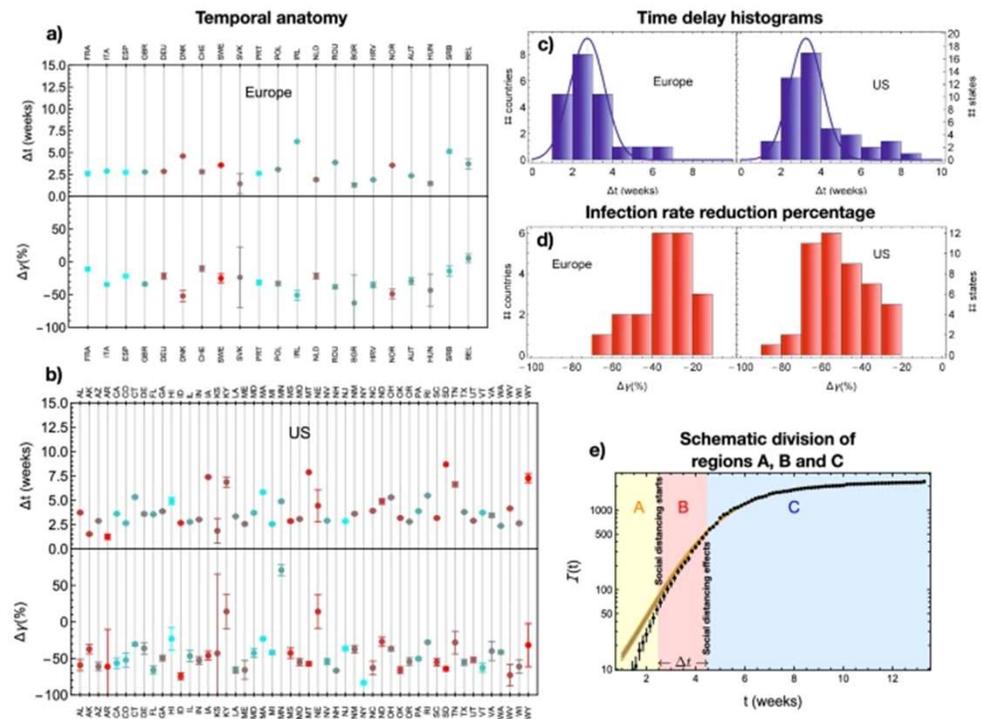
Our analysis → Google social mobility data good indirect measure

Home

Retail

Grocery

Parks

Transit

Workplace

- London – primary case study: Google Mobility data for London Feb 2020 to June 2020

- Same trend across European capitals

Social mobility vs Air pollution (surface)

Figure 1 Effect of lockdown on surface PM$_{2.5}$ concentrations

- Observed by surface pollution stations

- Social mobility limitations (Lockdowns) = decrease in air pollution across regions

Our analysis → Surface Pollution vs Google social mobility data

NITROGEN DIOXIDE

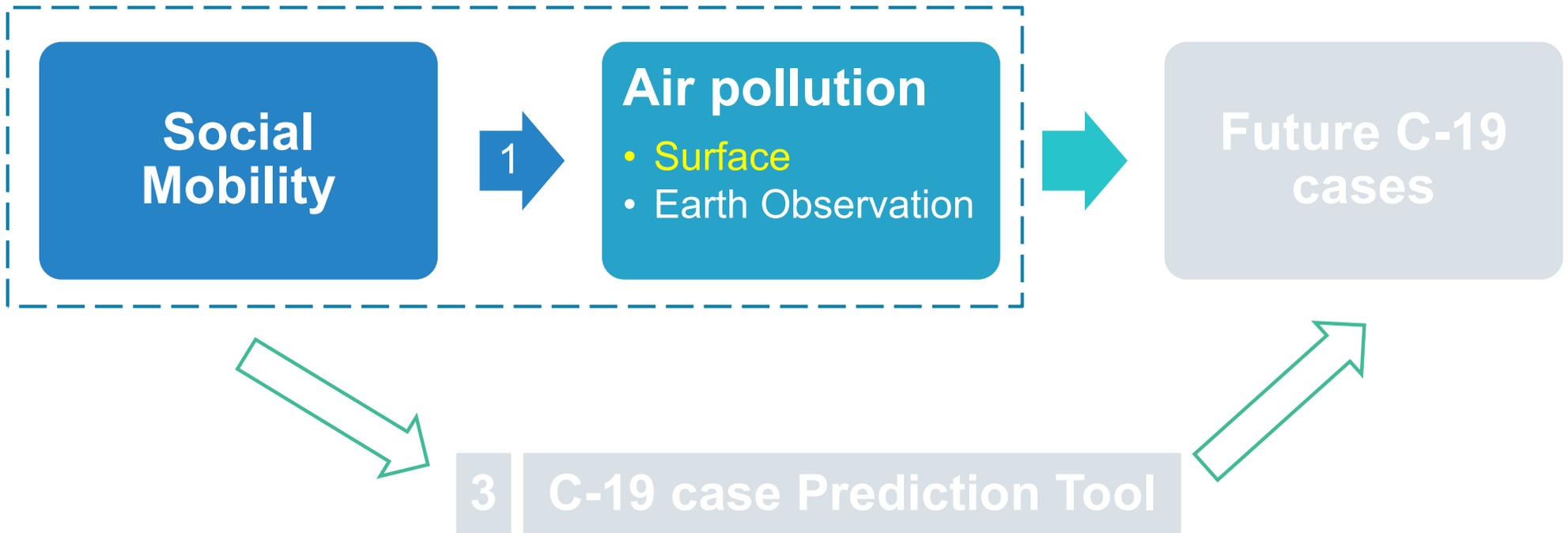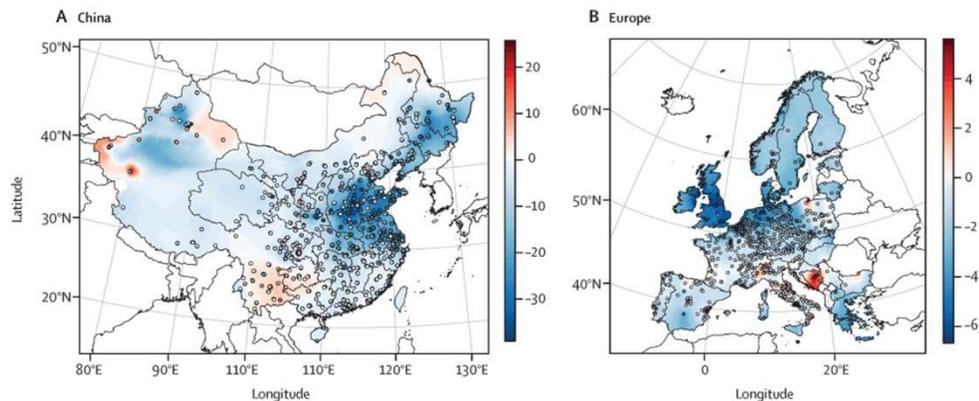| Region	Residential time	Retail and recreation time	Grocery and pharmacy time	Parks time	Transit time	Workplaces time
Amsterdam	-0.03	0.19	0.26	0.16	0.16	-0.03
Ankara	-0.61	0.62	0.41	0.55	0.62	0.64
Athens	-0.06	0.15	0.19	0.18	0.11	0.1
Belfast	-0.37	0.59	0.58	0.33	0.51	0.38
Bratislava	0.19	0	0.08	0.04	-0.05	-0.21
Brussels	0.26	0.01	0.17	-0.01	-0.15	-0.23
Bucharest	-0.51	0.69	0.66	0.61	0.63	0.49
Budapest	-0.08	0.29	0.42	0.23	0.24	0.1
Copenhagen	-0.13	0.3	0.14	0.23	0.26	0.05
Dublin	-0.01	-0.05	0.03	0.16	-0.03	0.0
Edinburgh	-0.17	0.47	0.5	0.41	0.42	0.19
Helsinki	-0.12	0.51	0.45	-0.19	0.42	0.02
Lisbon	-0.31	0.5	0.5	0.49	0.46	0.33
London	0.05	0.15	0.21	0.12	0.06	-0.03
Madrid	-0.44	0.62	0.65	0.51	0.59	0.46
Oslo	-0.05	0.46	0.43	0.25	0.31	0.03
Paris	-0.07	0.27	0.32	0.23	0.23	0.07
Rome	-0.24	0.38	0.43	0.31	0.37	0.26
Sofia	-0.1	0.24	0.28	0.14	0.26	0.13
Tallinn	-0.12	0.32	0.27	0.26	0.27	0.04
Warsaw	0.25	0.03	0.02	-0.11	-0.09	-0.18
Zagreb	-0.21	0.54	0.61	0.09	0.46	0.3

- Residential time causes significant drop in surface NO_2

- Across 22 European capital cities

- Feb 2020 to June 2020 (start of the C-19 pandemic)

- Similar trend with CO

Other surface pollutants and social mobility

Pollutant	Residential time	Retail and recreation time	Grocery and pharmacy time	Parks time	Transit time	Workplaces time
CO						
O_3						
SO_2						
PM2.5						

- Similar trends for surface CO = less CO more time at home

- Not all surface pollutant markers correlate with social mobility in the same way

- Opposite trends for O3, and mixed trends for SO2 and PM2.5

Can Earth Observation data be used to forecast the number of C-19 cases in an area?
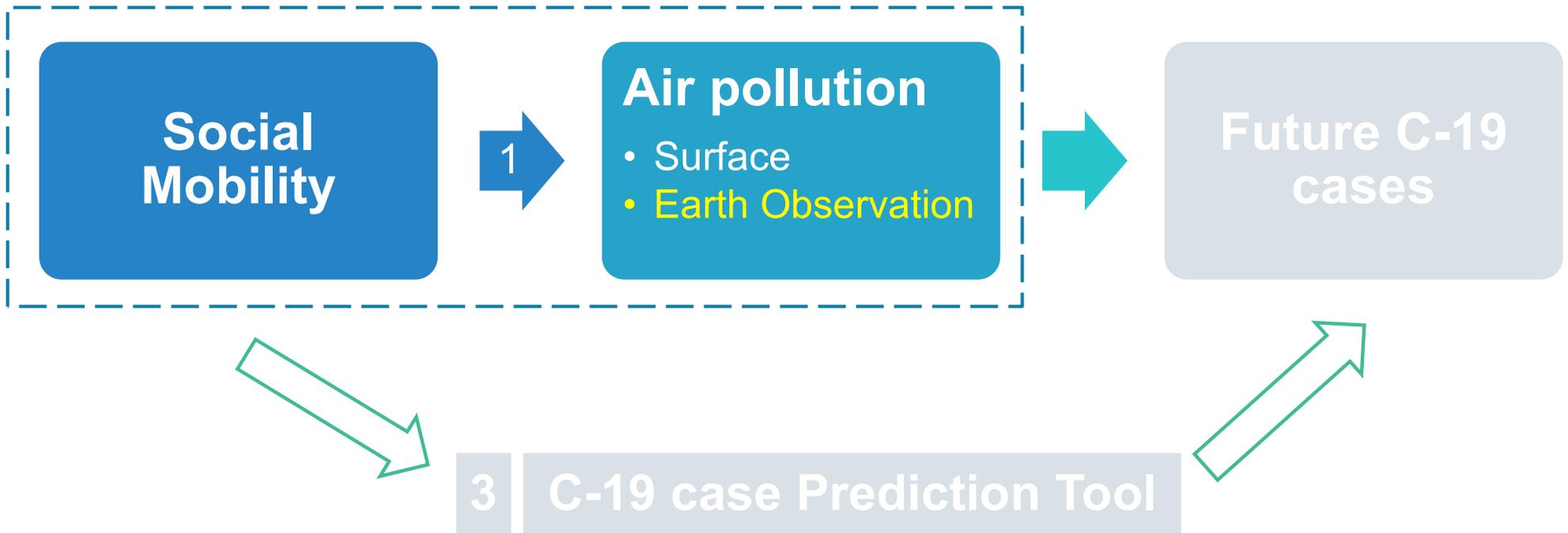
Social Mobility

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Air pollution
- Surface
- Earth Observation

Future C-19 cases

3 **C-19 case Prediction Tool**

Social <u>mobility</u> vs Air pollution (EO)

January 1-20, 2020

February 10-25, 2020

CHINA

Chongqing Wuhan

Hong Kong

Beijing

Lanzhou

CHINA

Shanghai

500 km

Mean Tropospheric NO_2 Density ($\mu mol/m^2$)

0   125   250   375   ≥500
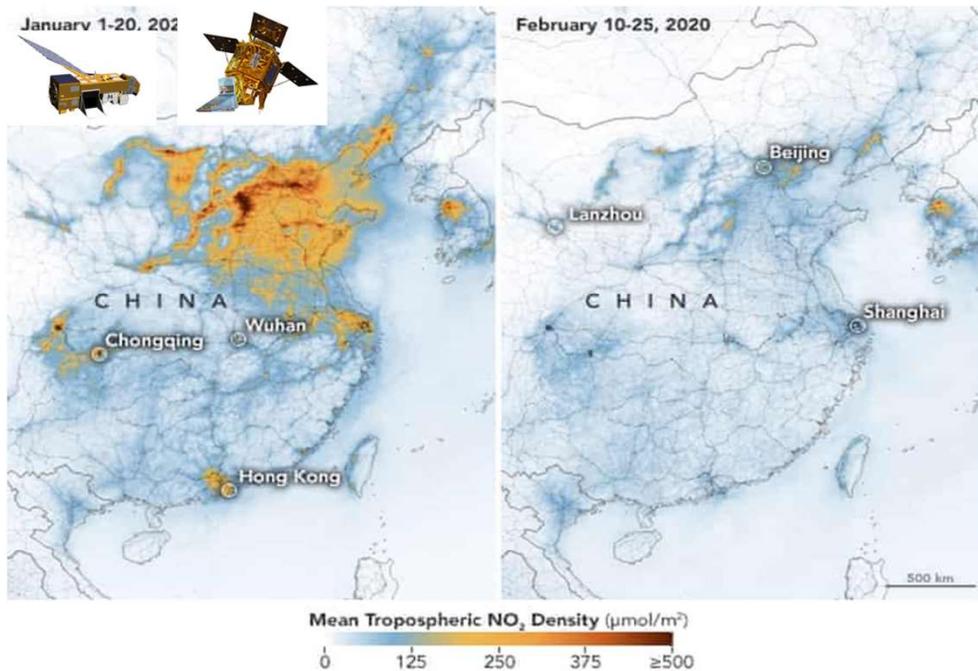
- Social mobility limitations (Lockdowns) = decrease in air pollution across regions

- Observed on satellite Earth Observation (ESA Sentinel-5 and NASA Aura)

- Focus – Wuhan, China

Social mobility vs Air pollution (regional variation)
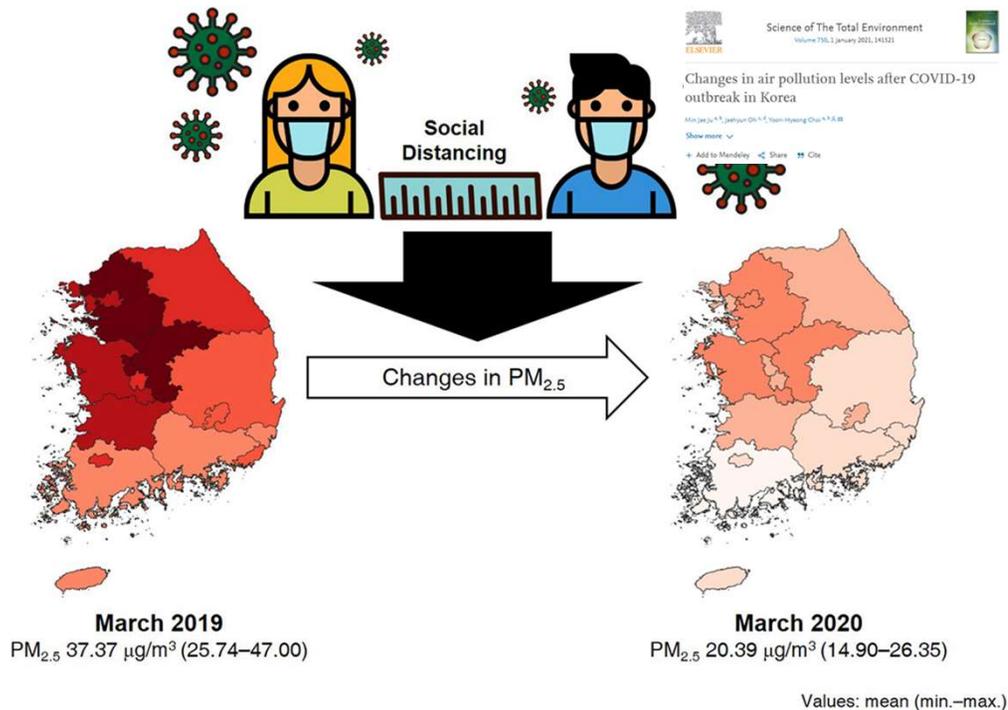
Social Distancing

Changes in PM$_{2.5}$

Science of The Total Environment
Volume 750, 1 January 2021, 141521

Changes in air pollution levels after COVID-19 outbreak in Korea

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March 2019
PM$_{2.5}$ 37.37 μg/m^3 (25.74–47.00)

March 2020
PM$_{2.5}$ 20.39 μg/m^3 (14.90–26.35)

Values: mean (min.–max.)

- Social mobility limitations (Lockdowns) = decrease in air pollution across regions

- Observed across different regions – map of Korea last year in March 2020

Our analysis → EO Pollution and Google social mobility data in Europe

EO pollutants that were lower with more time at home? NO₂ and SO₂

EO pollutants that increased with more time at home? PM2.5, Total PM, UV

NITROGEN DIOXIDE

| Region	Residential time	Retail and recreation time	Grocery and pharmacy time	Parks time	Transit time	Workplaces time
Amsterdam	0	0.11	0.11	-0.01	0.09	-0.01
Athens	0.11	-0.12	-0.03	0.18	-0.09	-0.1
Belgrade	0.06	-0.03	0.01	-0.05	0.01	-0.04
Berlin	-0.22	0.3	0.25	0.01	0.27	0.23
Bratislava	-0.22	0.31	0.14	0	0.29	0.19
Brussels	0.26	-0.18	0.01	-0.28	-0.24	-0.12
Bucharest	-0.03	0.08	0.09	0.02	0.05	0.06
Budapest	-0.2	0.28	0.27	0.12	0.2	0.17
Copenhagen	-0.36	0.26	0.19	0.09	0.34	0.35
Helsinki	0.03	0.04	0.05	0.28	0	-0.14
Lisbon	0.14	-0.04	-0.04	-0.02	-0.09	-0.14
Ljubljana	-0.03	0.18	0.26	0.08	0.05	0.01
Luxembourg	0.23	-0.03	0.18	-0.3	-0.12	-0.17
Madrid	-0.4	0.46	0.51	0.43	0.47	0.42
Oslo	-0.15	0.19	0.05	0.35	0.15	0.03
Paris	0.22	0.05	0.09	-0.02	-0.1	-0.18
Prague	0.21	-0.23	-0.13	-0.26	-0.24	-0.24
Rome	-0.11	0.22	0.26	0.19	0.19	0.16
Sofia	0.18	-0.15	-0.07	-0.11	-0.16	-0.18
Stockholm	-0.06	0.18	0.16	0.44	0.16	-0.11
Valletta	0.16	-0.1	-0.15	-0.02	-0.16	-0.16
Vienna	0.06	-0.01	-0.02	0.05	-0.03	-0.09
Warsaw	0.17	0.06	0.11	-0.03	-0.04	-0.15
Zagreb	-0.07	0.25	0.3	0.2	0.18	0.16
Zurich	0.38	-0.25	0.05	0.13	-0.33	-0.13

PM 2.5

| Region	Residential time	Retail and recreation time	Grocery and pharmacy time	Parks time	Transit time	Workplaces time
Amsterdam	0.53	-0.51	-0.49	0.15	-0.54	-0.49
Athens	0.32	-0.31	-0.24	-0.24	-0.33	-0.1
Belgrade	0.35	-0.34	-0.33	-0.28	-0.36	-0.33
Berlin	0.55	-0.55	-0.38	0.04	-0.59	-0.57
Bratislava	0.43	-0.35	-0.26	0.01	-0.4	-0.39
Brussels	0.52	-0.55	-0.54	-0.24	-0.57	-0.52
Bucharest	0.25	-0.24	-0.24	-0.21	-0.26	-0.24
Budapest	0.48	-0.41	-0.39	-0.41	-0.47	-0.47
Copenhagen	0.41	-0.42	-0.33	0.35	-0.51	-0.45
Helsinki	0.15	-0.36	-0.31	0.11	-0.29	-0.15
Lisbon	0.22	-0.23	-0.26	-0.27	-0.24	-0.26
Ljubljana	0.42	-0.42	-0.38	-0.31	-0.4	-0.37
Luxembourg	0.57	-0.58	-0.55	-0.42	-0.58	-0.56
Madrid	0.39	-0.48	-0.45	-0.52	-0.49	-0.41
Oslo	0.54	-0.51	-0.02	0.32	-0.55	-0.59
Paris	0.51	-0.57	-0.58	-0.55	-0.56	-0.5
Prague	0.37	-0.46	-0.39	-0.41	-0.44	-0.41
Rome	0.4	-0.42	-0.42	-0.47	-0.45	-0.41
Sofia	0.33	-0.29	-0.34	-0.3	-0.35	-0.36
Stockholm	0.41	-0.41	-0.36	0.16	-0.44	-0.42
Valletta	0.29	-0.25	-0.25	-0.31	-0.27	-0.22
Vienna	0.46	-0.41	-0.42	-0.17	-0.46	-0.47
Warsaw	0.24	-0.1	-0.11	0.05	-0.23	-0.21
Zagreb	0.51	-0.54	-0.56	-0.27	-0.58	-0.56
Zurich	0.45	-0.51	-0.21	0.13	-0.5	-0.45
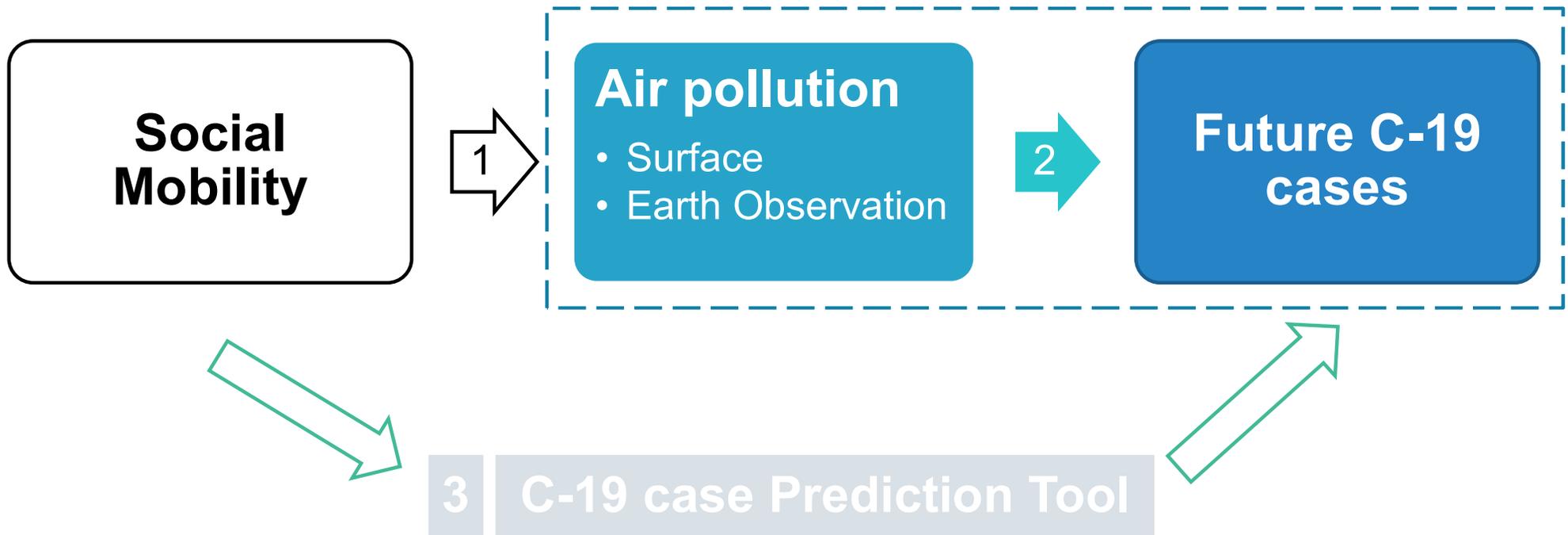
Novid analysis: Surface air pollution vs C-19 cases with differential lag times
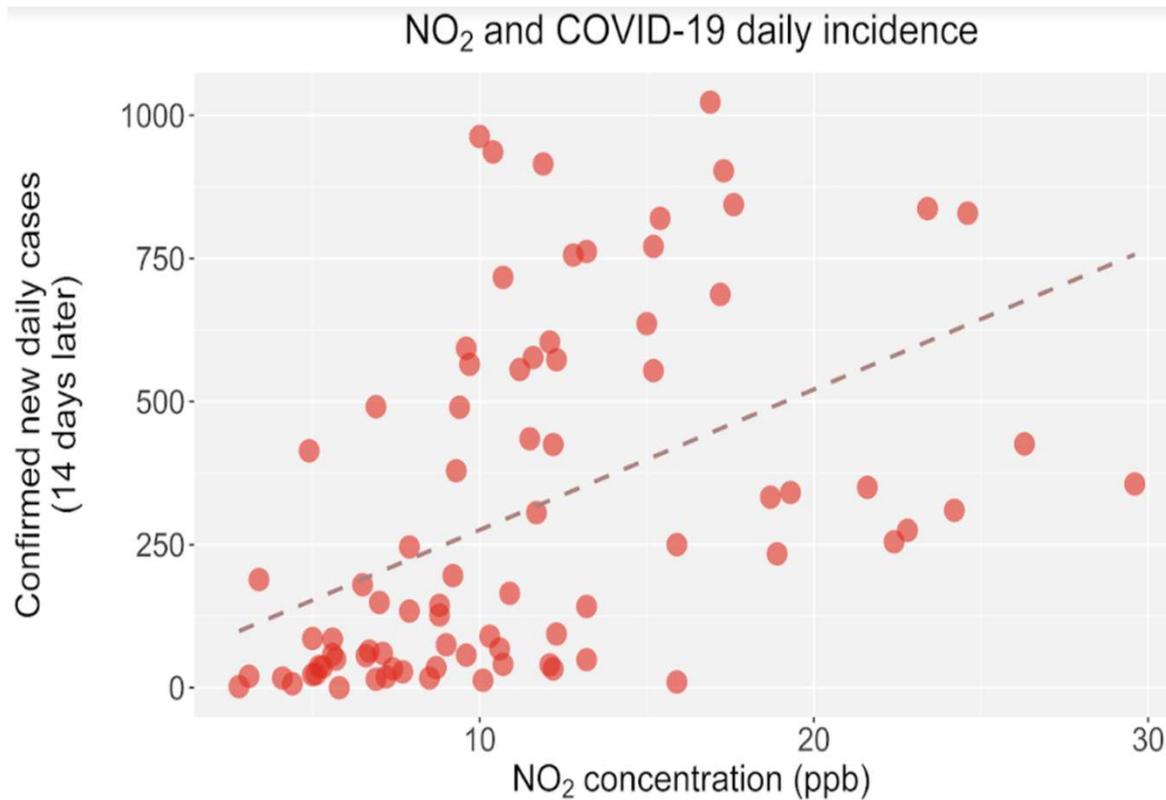
London, UK
Nitrogen dioxide
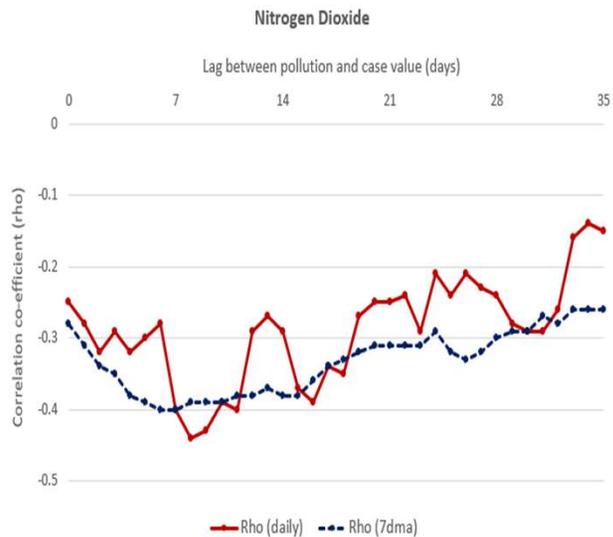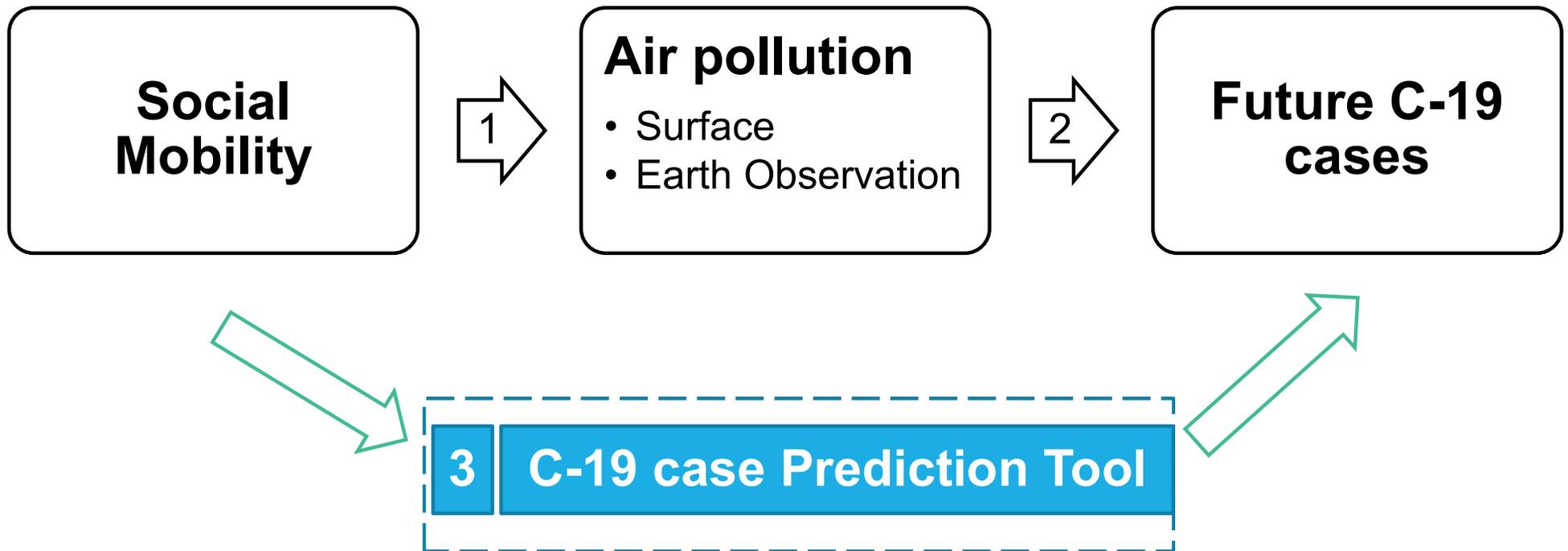
Budapest, HU
Nitrogen dioxide
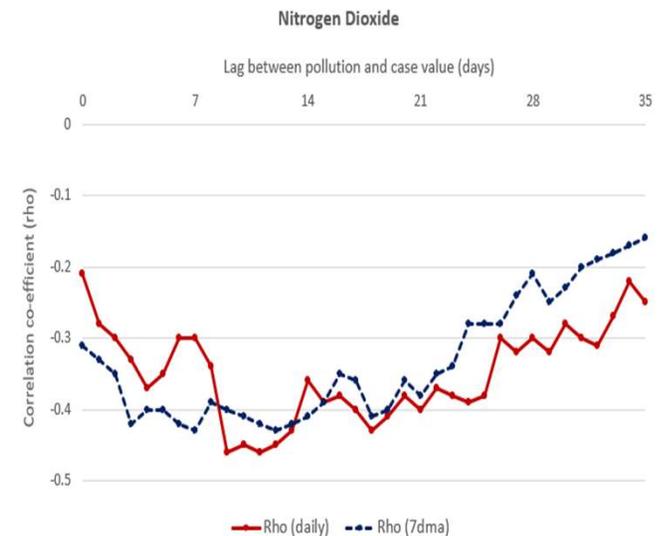
What is the best lag time (C-19 incubation time)? 14 days lag time (rho=0.59)

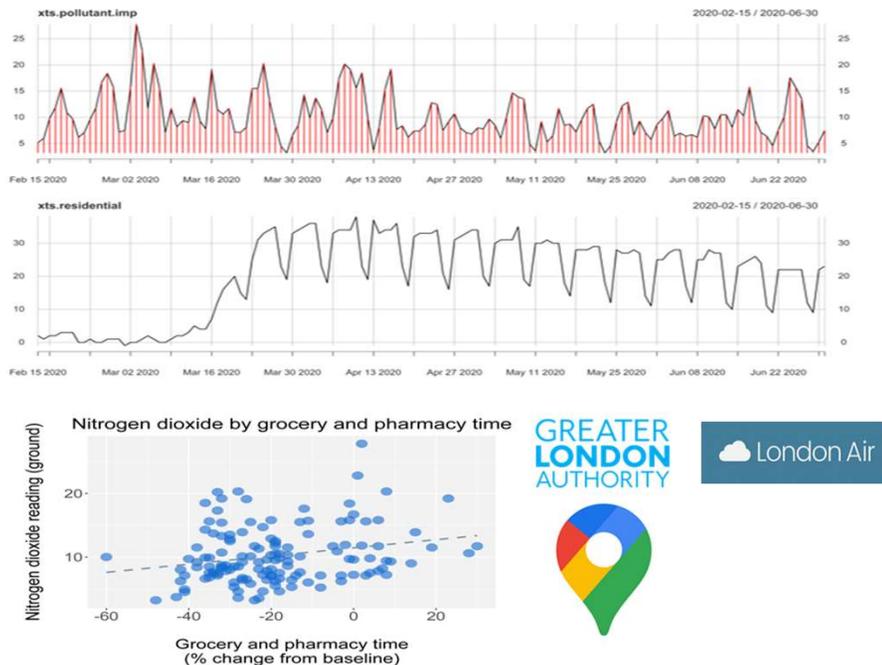# Novid analysis: Air pollution vs C-19 cases with differential lag times

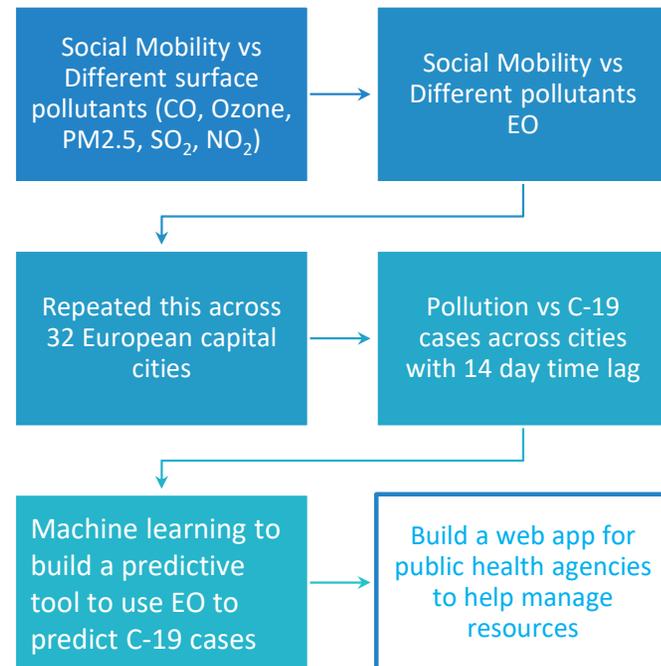

NO$_2$ and COVID-19 daily incidence

Novid analysis: Social <u>mobility vs</u> Air pollution (surface)

Primary case study – Surface NO2 in London

Additional analysis to build a 'forecasting tool'

Social Mobility vs Different surface pollutants (CO, Ozone, PM2.5, SO_2, NO_2) → Social Mobility vs Different pollutants EO

Repeated this across 32 European capital cities → Pollution vs C-19 cases across cities with 14 day time lag

Machine learning to build a predictive tool to use EO to predict C-19 cases → Build a web app for public health agencies to help manage resources

EO to predict C-19 – developing a 'C-19 forecasting tool'

Overall Absolute Differences
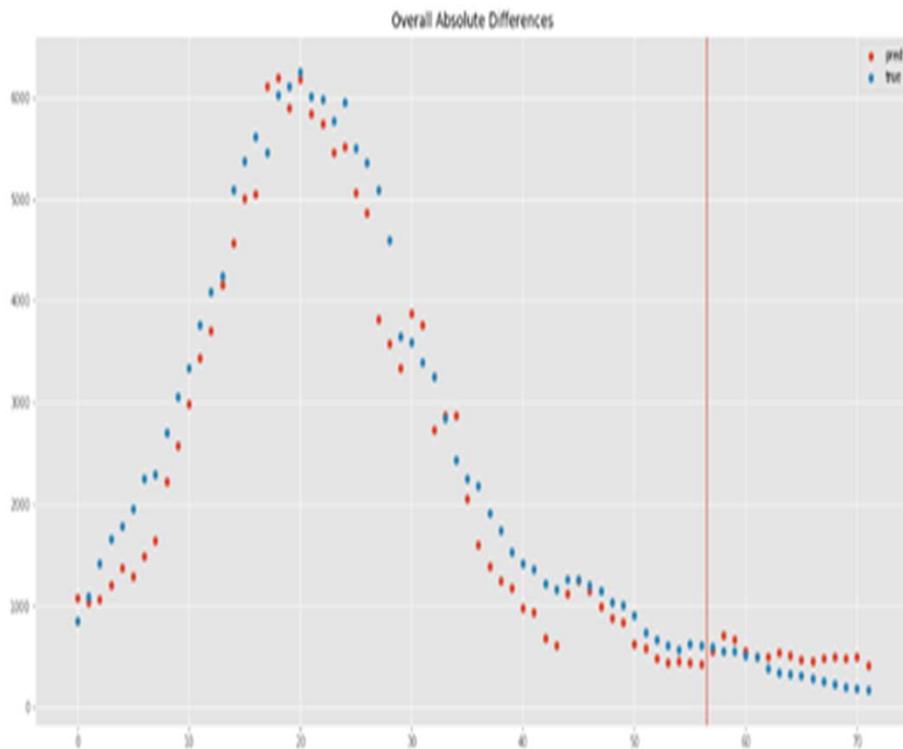
→ Put all the information together in a ML Model

→ 14 day lag time

→ Trained the model with the data that we gathered

→ **Model predicts Air pollution (NO2) T+0 and C-19 cases T+14days**

→ **Limitations – vaccination drive, new variants incubation time etc.**