COVID-19 Model Projections under different levels of non-pharmaceutical interventions

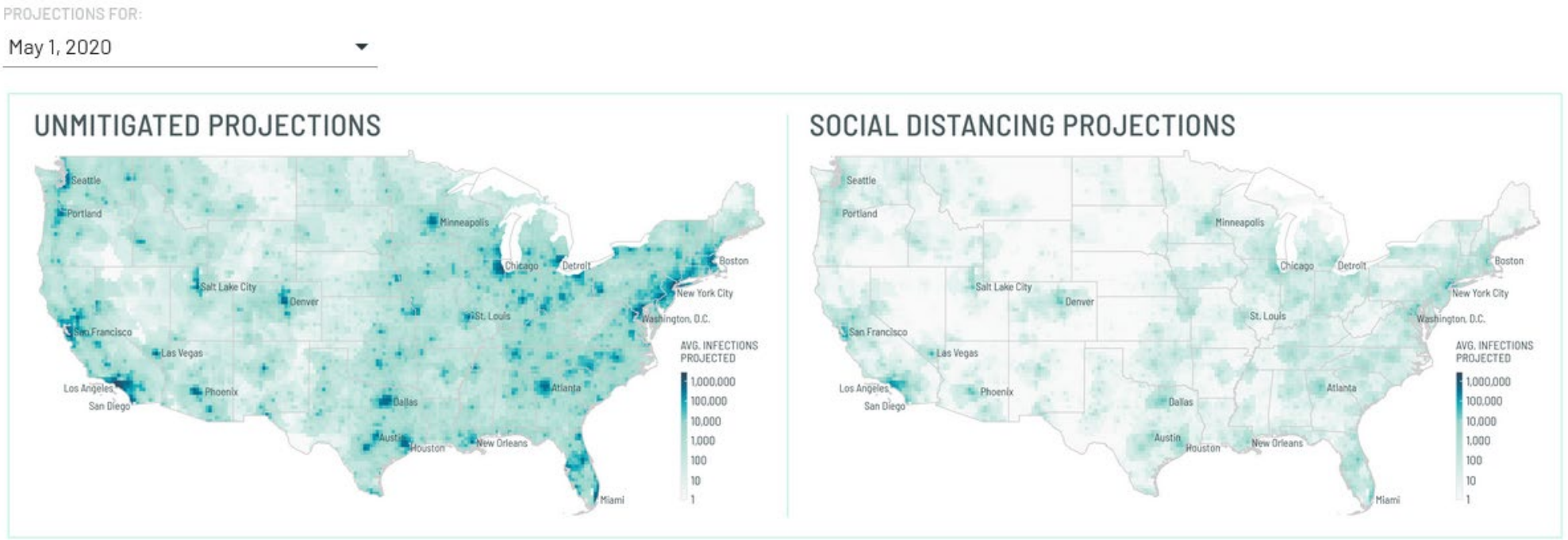
Ira Longini, Ph.D.
Professor of Biostatistics

College of Public Health and Health Professions
College of Medicine
Emerging Pathogens Institute

University of Florida

April 23, 2020

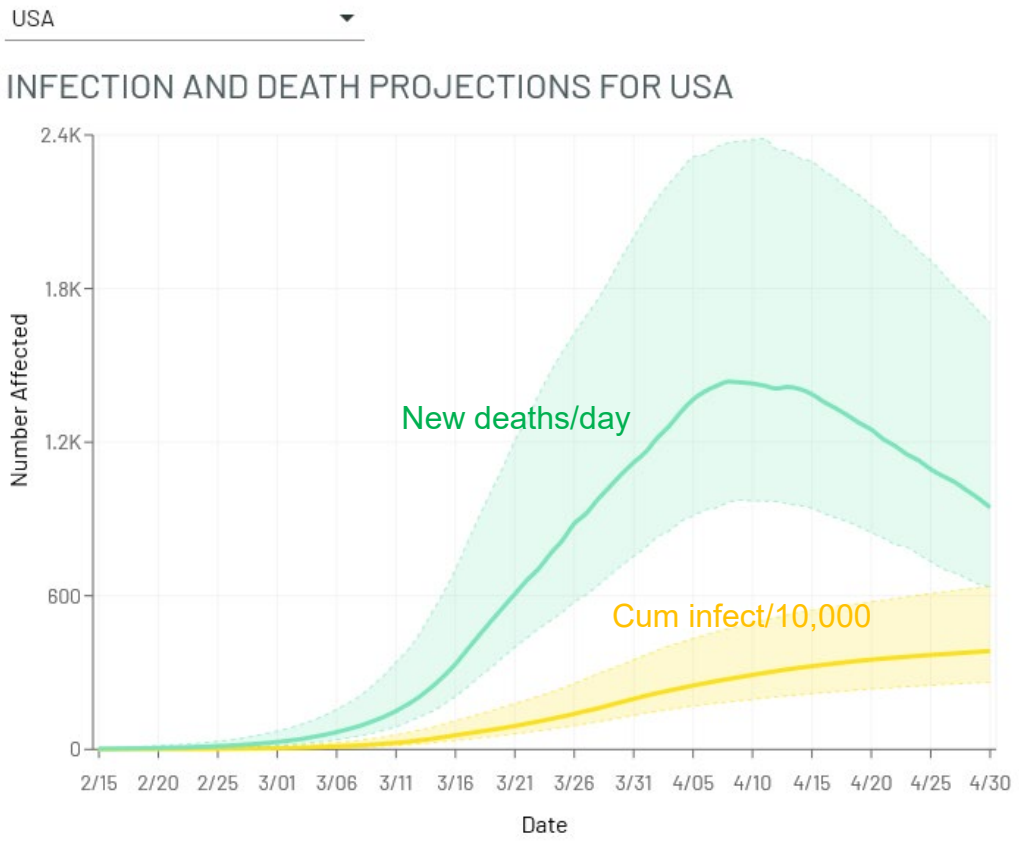
For the entire US



Even with the current level of social distancing and closures, the epidemic will affect virtually the entire US by May 1

https://covid19.gleamproject.org/#team

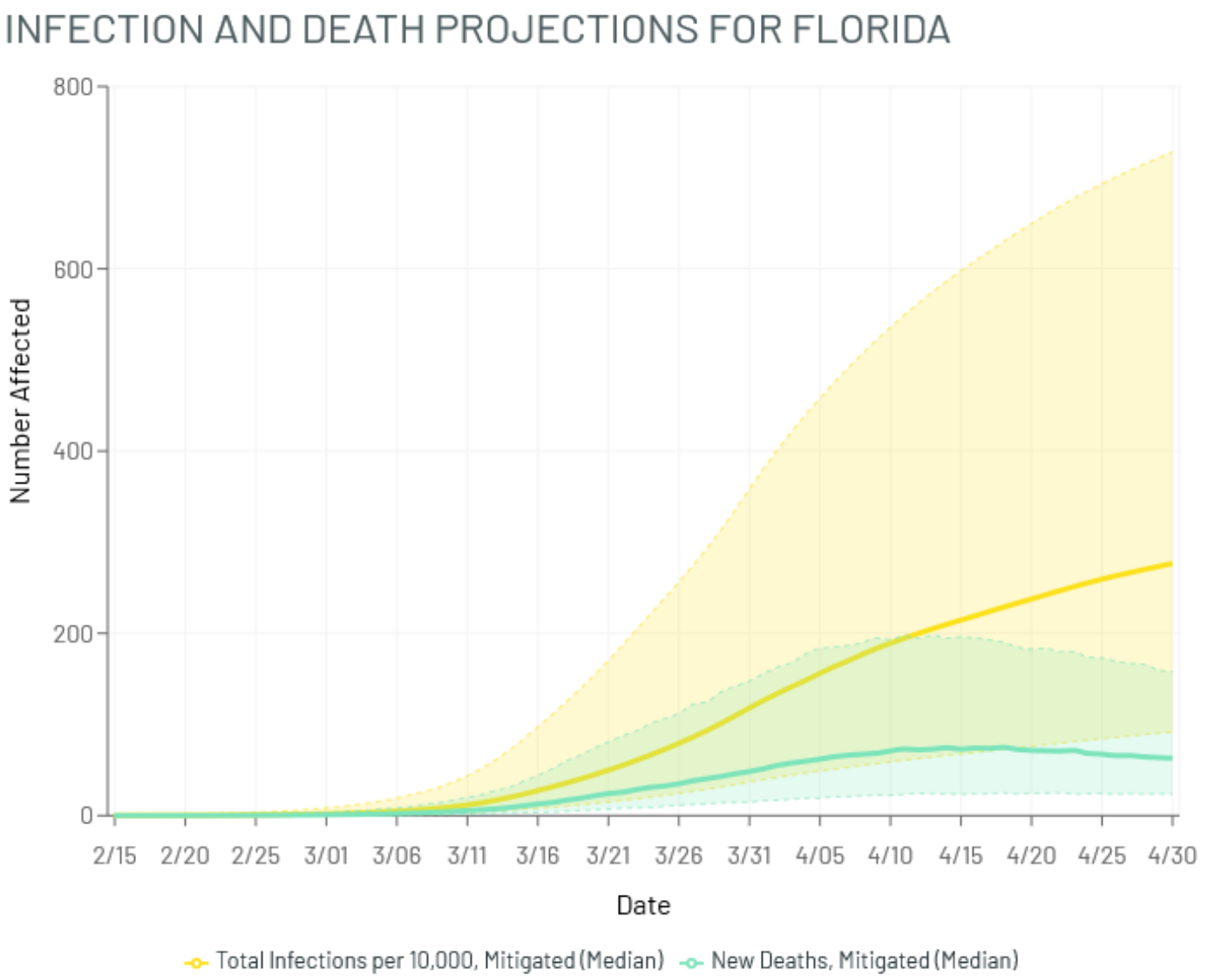
Cumulative infections and incidence of deaths with current mitigation



USA	UNMITIGATED SCENARIO	STAY-AT-HOME POLICY
Total Deaths	544,900 [373,911 - 1,117,467]	51,559 [34,688 - 86,696]
Cumulative Infection Attack Rate	55.1% [43.5% - 77.7%]	3.8% [2.6% - 6.3%]

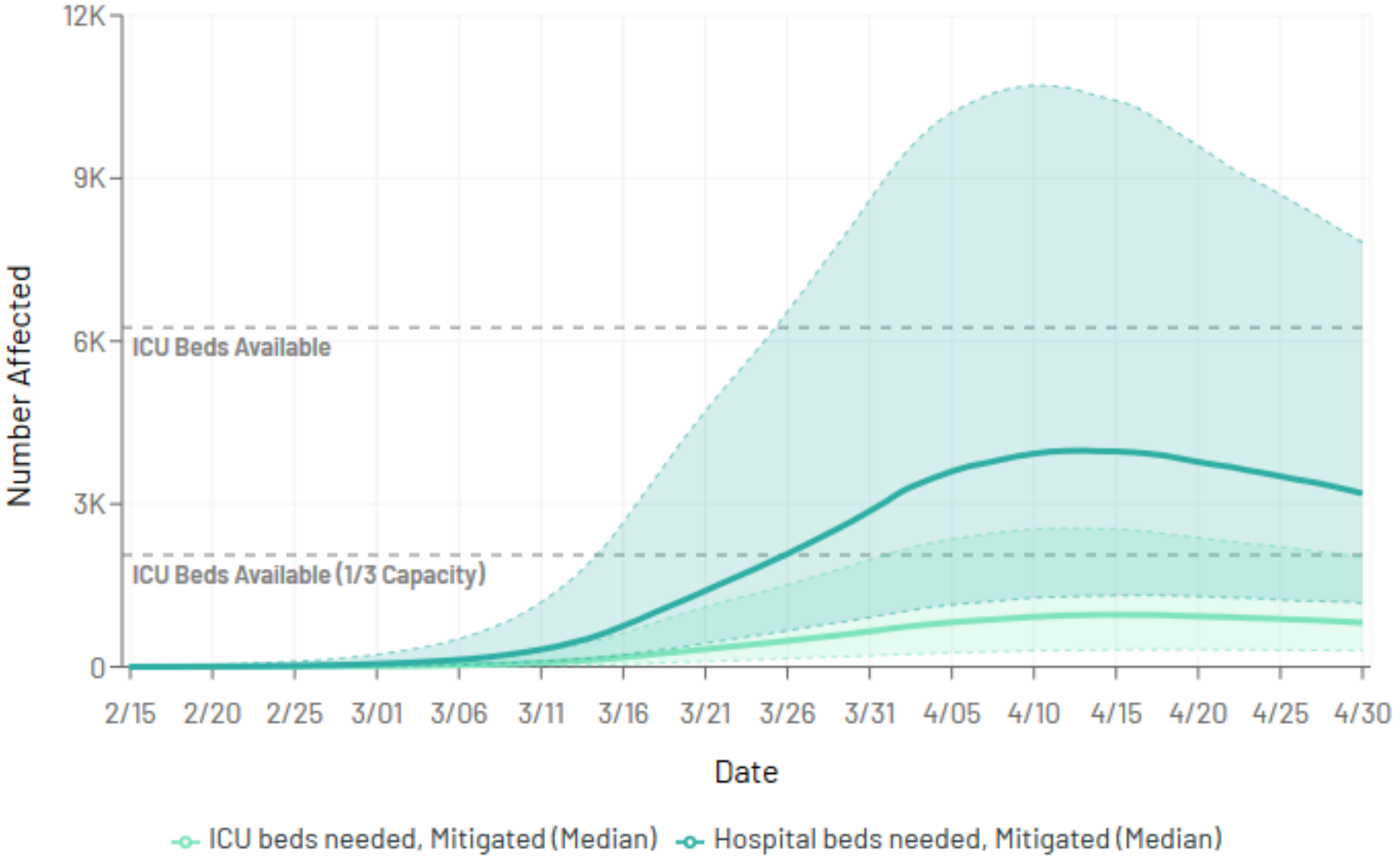
- Model points to the days around April 8, 2020 as the peak time for deaths in the US
- Based on the last projections, a total of about 52,000 COVID-19 deaths are currently projected through April 30, 2020.
- We project that about 4% of the population will have been infected by April 20, 2020

For the State of Florida

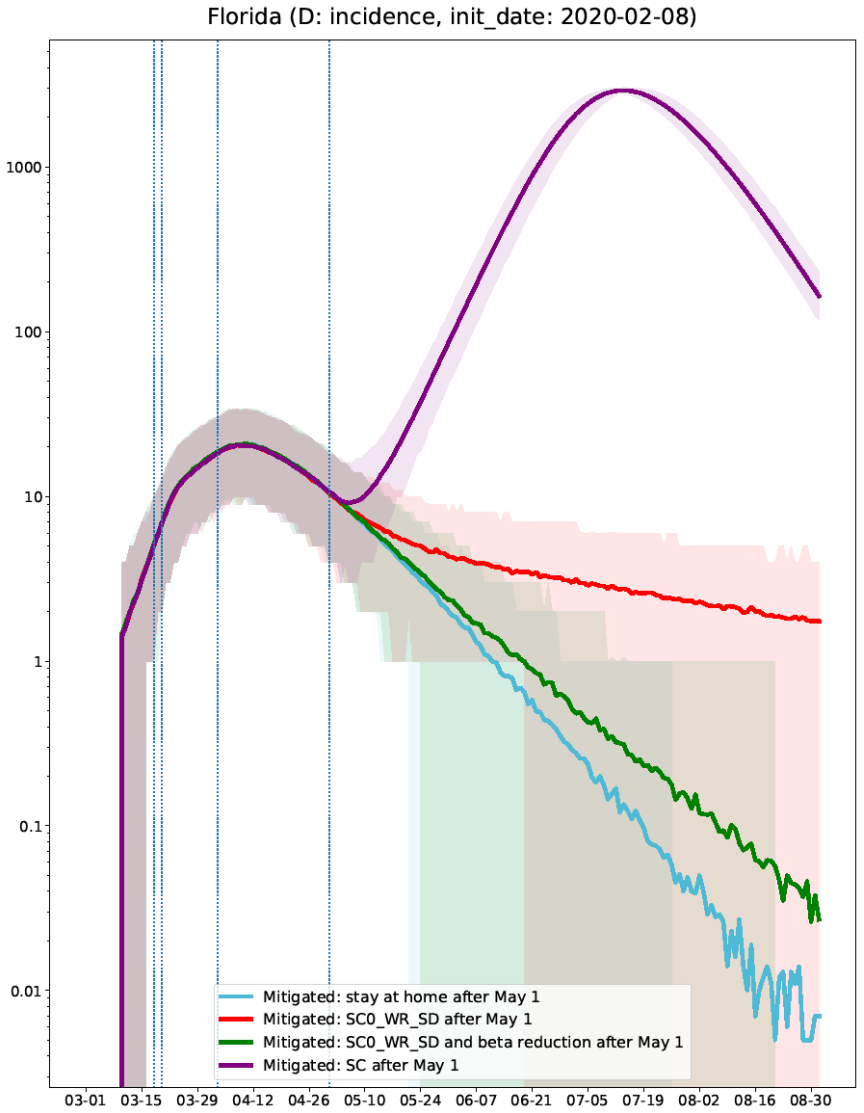


- Around April 14, 2020 as the peak time for deaths
- We project that about 2.8% of the population will have been infected by April 20, 2020
- Thus, lifting mitigation will result in large epidemic

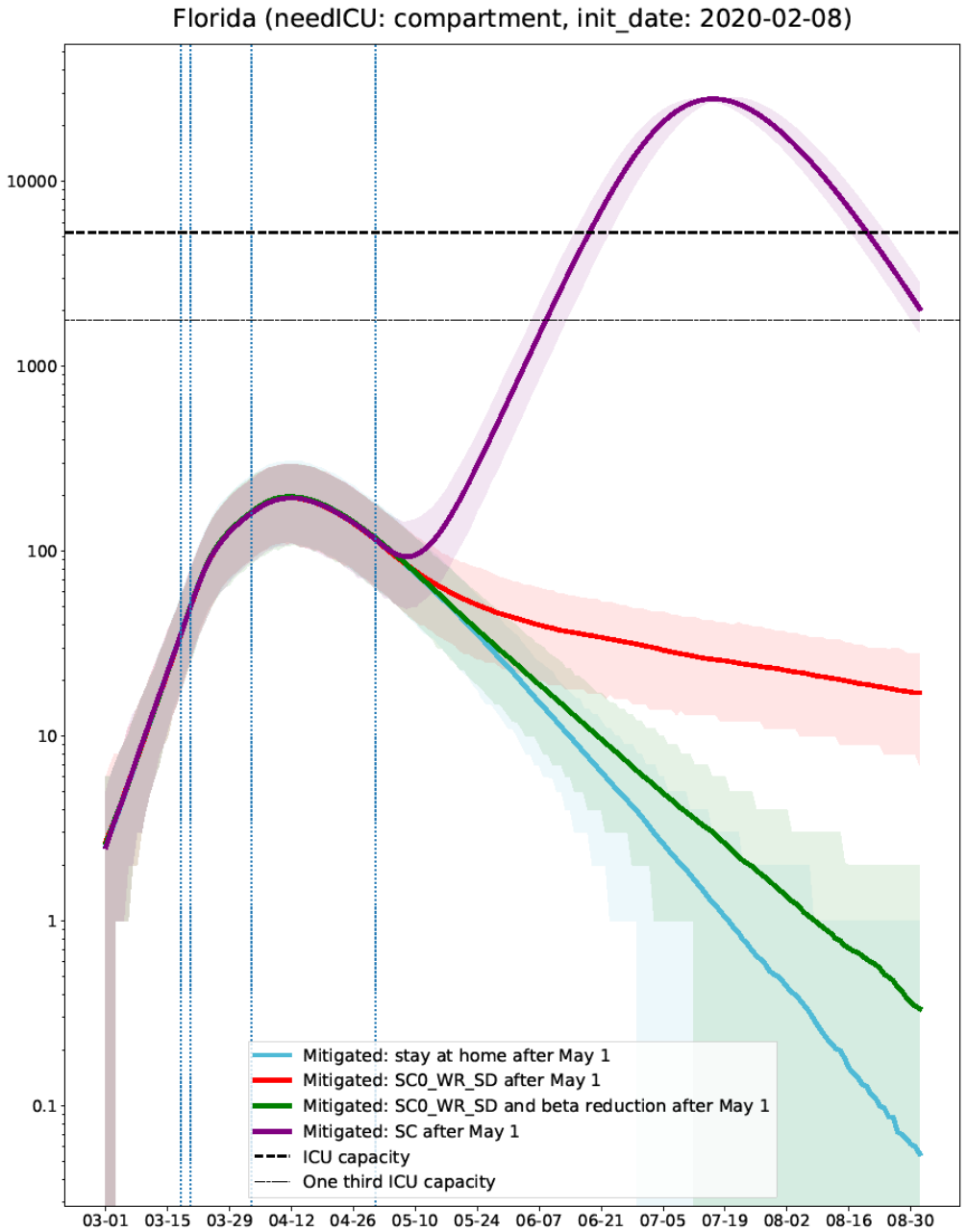
ICU AND HOSPITAL BED PROJECTIONS FOR FLORIDA



Effect of different mitigation effects

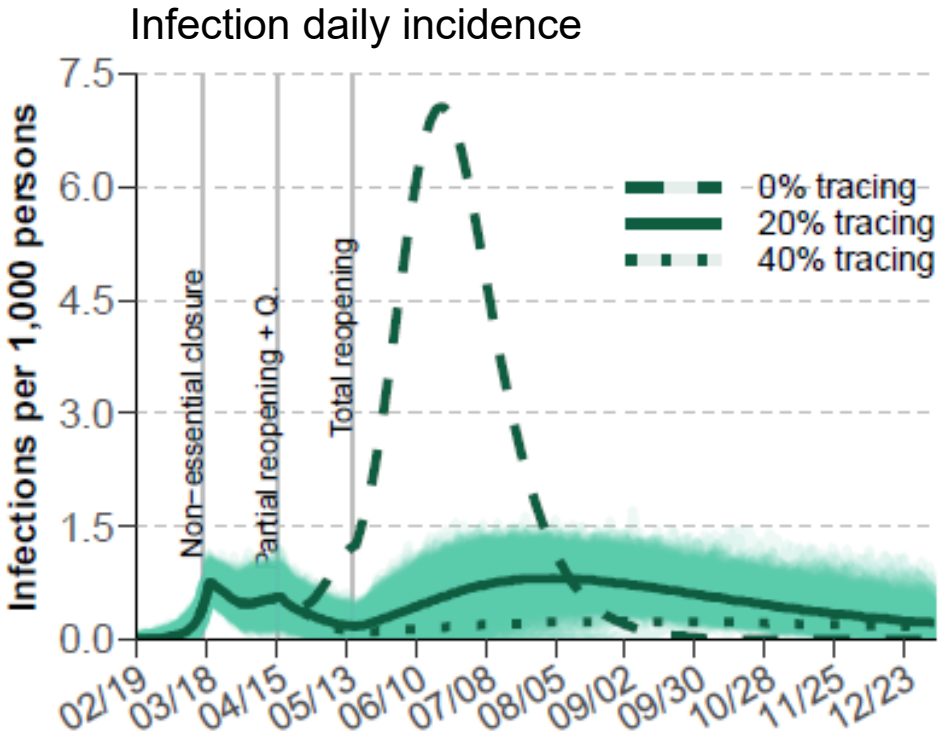


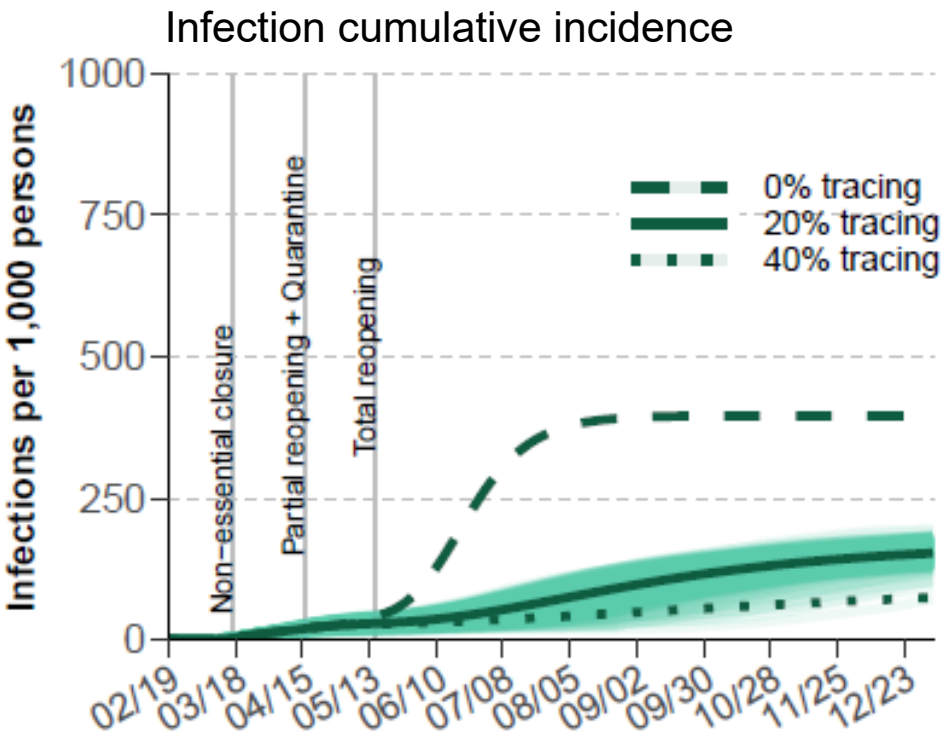
Purple line: Schools closed; everything else goes back to normal on May 1
Red line: Non-essential business open but schools and universities closed, smart working for about 50% of people; restaurant, bars and mass gatherings shut down.
Green line: The same as red + enhanced testing with contact tracing
Blue line: Stay at home order prolonged after May 1st.



Purple line: Schools closed; everything else goes back to normal.
Red line: Non-essential business open but schools and universities closed, smart working for about 50% of people; restaurant, bars and mass gatherings shut down.
Green line: The same as red + enhanced testing with contact tracing
Blue line: Stay at home order prolonged after May 1st.

Boston: Modeling mitigation strategies, second wave





- Staged reopening without testing with contact tracing results in a large second wave
- If 20% or more or more of the contacts of the detected symptomatic individuals are traced and put into quarantine, the epidemic is controlled

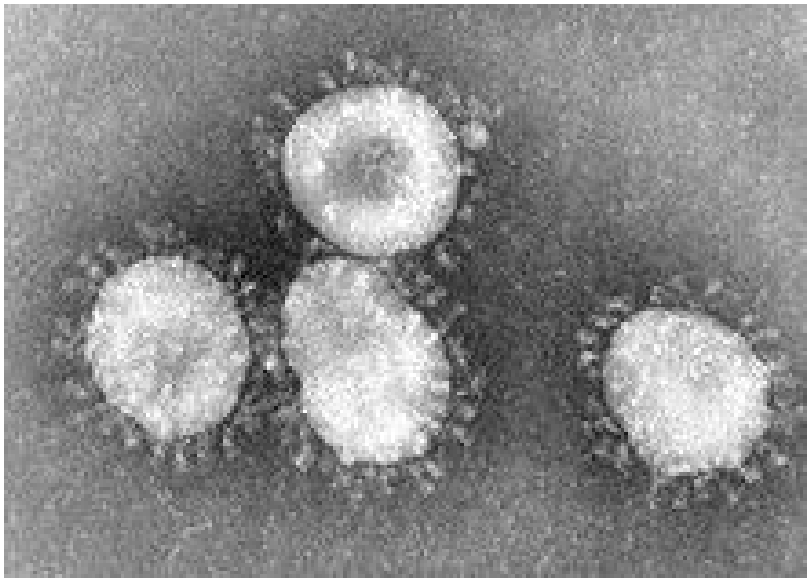
Source: Aleta, et al. Modeling the impact of social distancing, contact tracing and household isolation on second-wave scenarios of the COVID-19 epidemic. Posted soon.

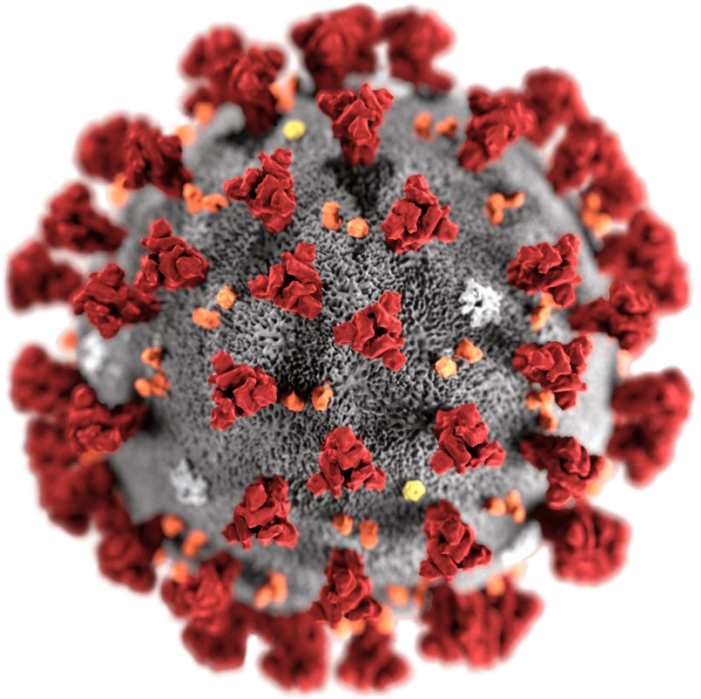
Bottom line

- Return to normal will result in a big epidemic surge, i.e., second wave.
- Epidemic will continue to decline and reach a low endemic level as long as social distancing is in force. However, the infection will not disappear.
- Go slowly with easing social distancing and watch trajectory of epidemic.
- Large testing, contact tracing, treatment preparation is necessary to lift social distancing.
  - Some level of social distancing must stay in place

Thank you

Severe acute respiratory syndrome coronavirus 2 = SARS CoV-2

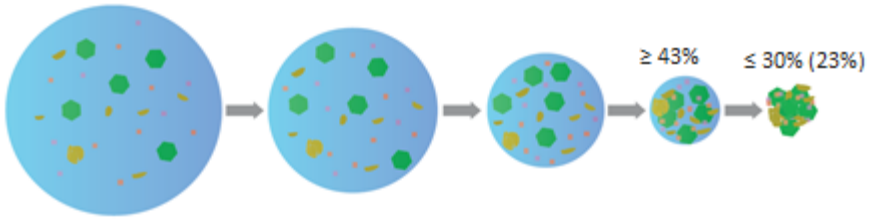




SARS CoV-2 causes COVID-19

Droplets from coughs and sneezes

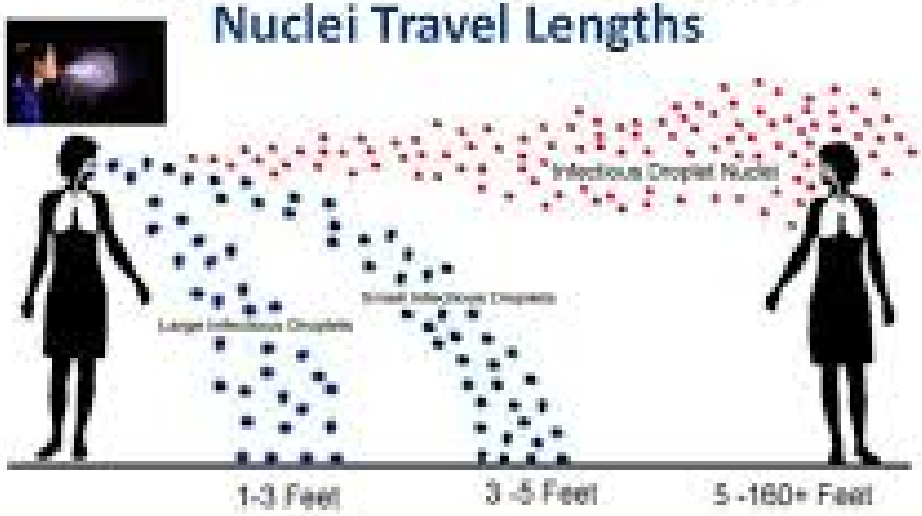
How Airborne Droplet Nuclei are created



Evaporation of a liquid droplet (left) to a droplet nucleus (right). As the liquid evaporates, the nonevaporative content concentrates until a droplet nucleus is obtained.

Airborne viral droplets are coughed, sneezed or expelled by humans. Toilet aerosolization also creates viral droplets.
This illustration shows how the mucus droplets filled with viruses eventually evaporate to create microscopic masses of viruses, salt and protein called Droplet Nuclei. Named and discovered by William F. Wells in 1934, droplet nuclei are the key to understanding airborne infectious disease transmission.

Infectious Droplets & Droplet Nuclei Travel Lengths

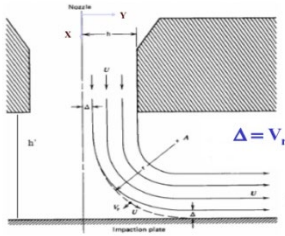


Bioaerosol Samplers:

Bie&Ag

Principle of Collection - Inertial Impaction

Assumptions: the flow velocity is uniform in the jet; the streamlines are arcs of a circle with centers at A



$$V_r = \tau a_r = \frac{\tau U^2}{r}$$

$$\Delta = V_r t = \frac{\tau U^2}{r}\left(\frac{2\pi r}{4U}\right) = \frac{\pi}{2}\tau U$$

$$E_I = \frac{\Delta}{h} = \frac{\pi\tau U}{2h} = \frac{\pi}{2}\mathrm{Stk}$$

40

Bioaerosol Samplers:

Bie&Ag

Principle of Collection - Inertial Impaction

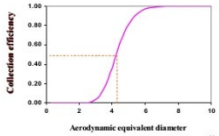
Stk. to characterize inertial impaction:

$$\mathrm{Stk} = \frac{\tau V}{D_j/2} = \frac{\rho_p d_p^2 V C_c}{9\eta D_j}$$

$$d_{50}\sqrt{C_c} = \sqrt{\frac{9\eta D_j \mathrm{Stk}_{50}}{\rho_p V}}$$

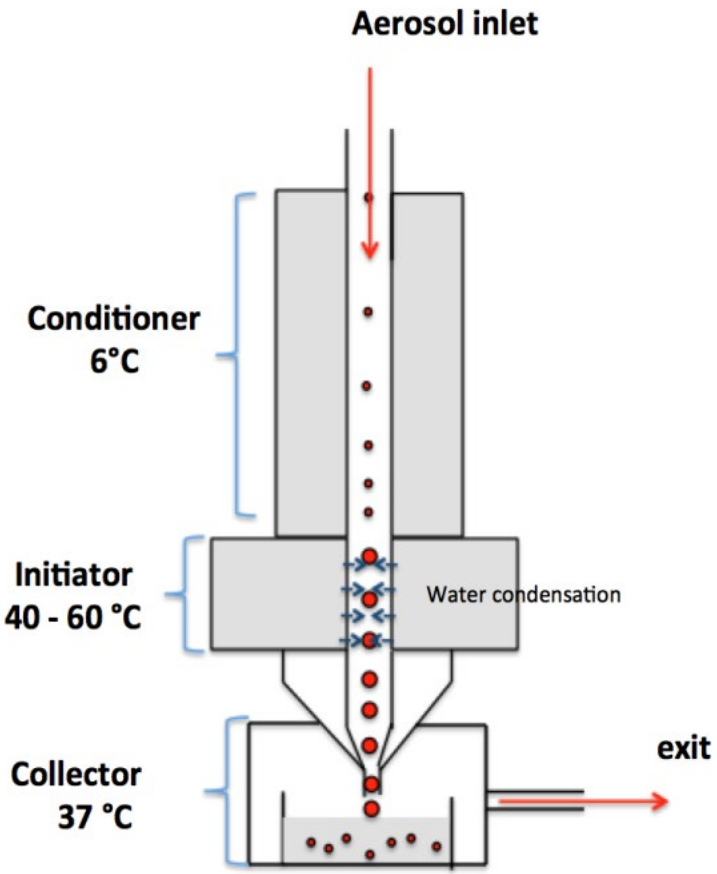
The characterization dimension :

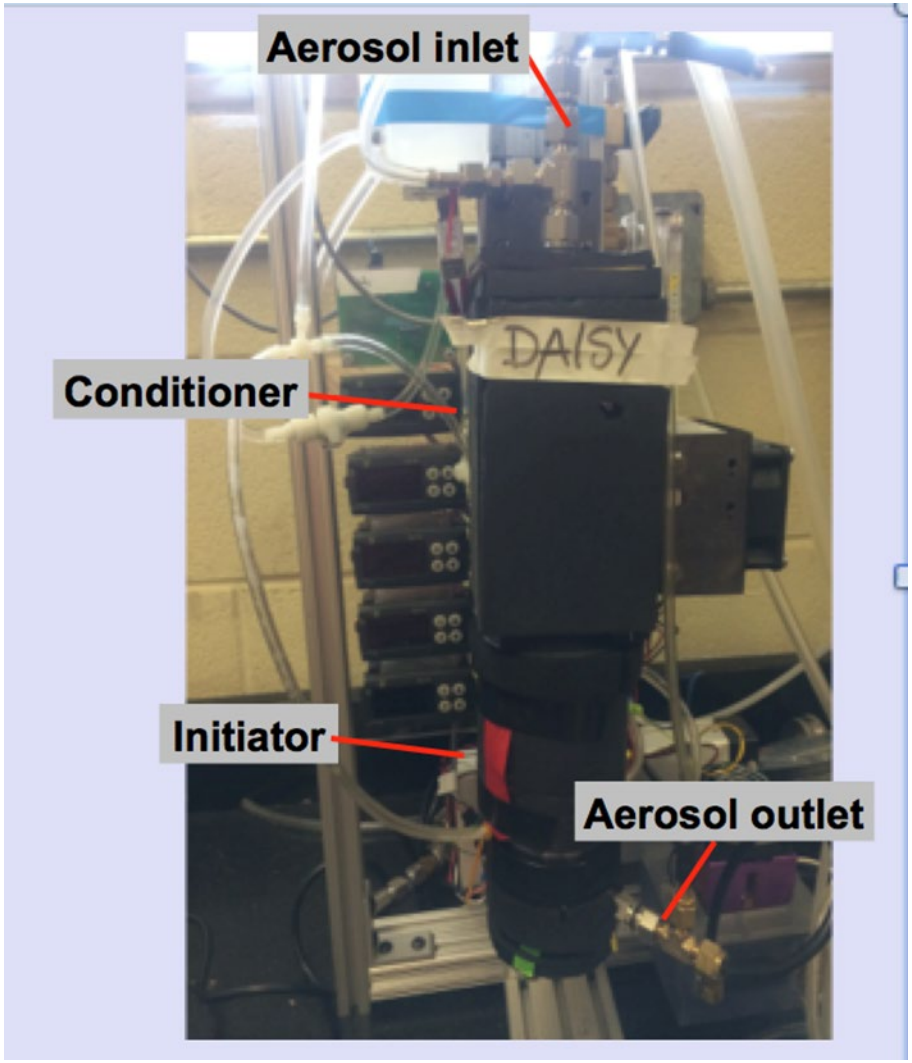
- **the radius of the nozzle jet = $D_j/2$ for a circular jet**
- **the jet half-width = W/2 for a rectangular jet**



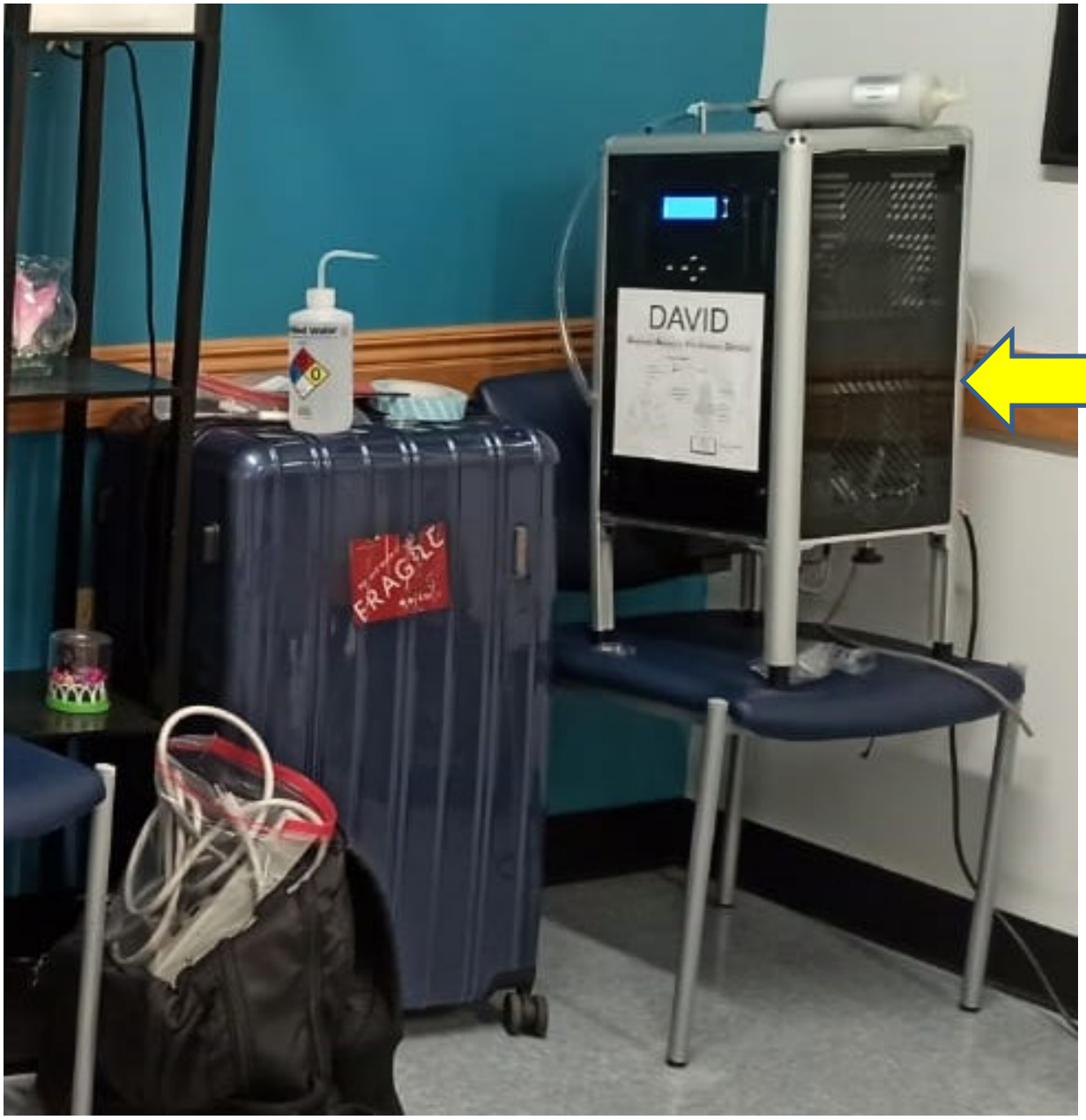
41

Air Sampler for Virus Aerosols that Operates via a Water Condensation Process





Prototype of a highly efficient (effective) air sampler developed at UF that works well for collecting virus aerosols and maintaining the viability of the collected virus particles.

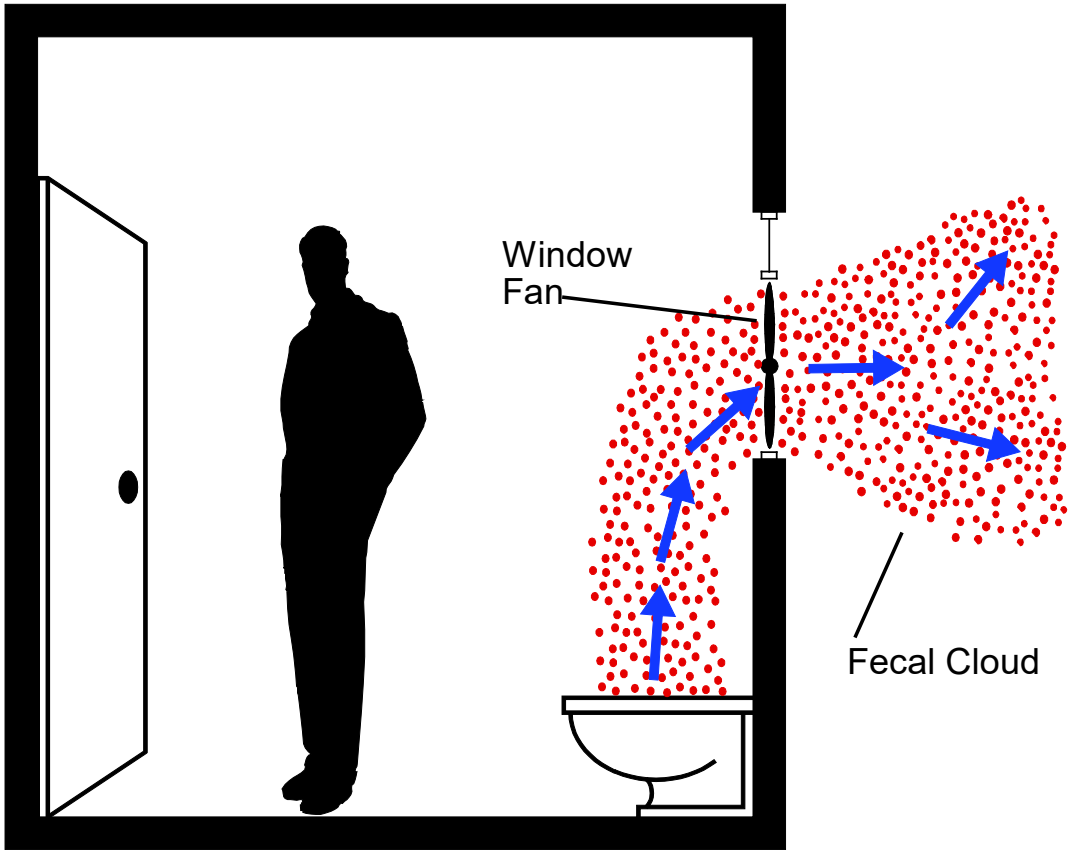


Air sampler (Air sampling in process at a medical clinic).

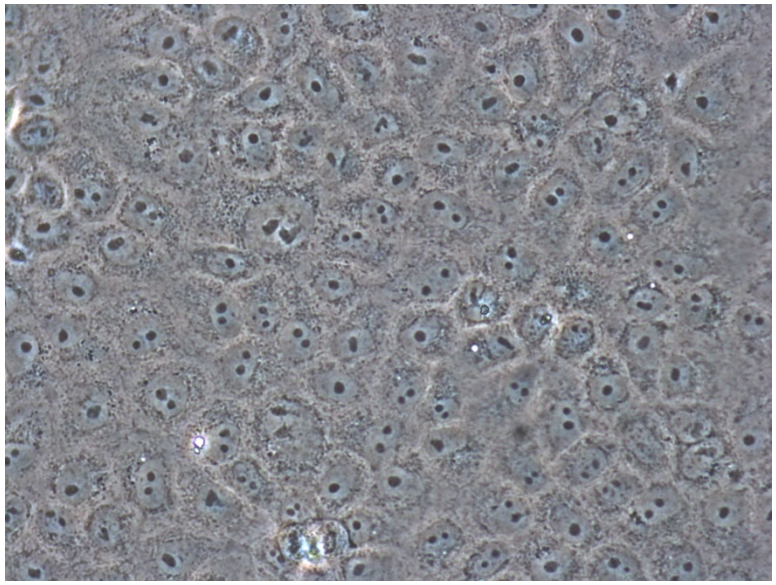
BioSpot-VIVAS™ bioaerosol sampler

Airborne SARS Transmission at Amoy Gardens Apartments 03.19-20.2003

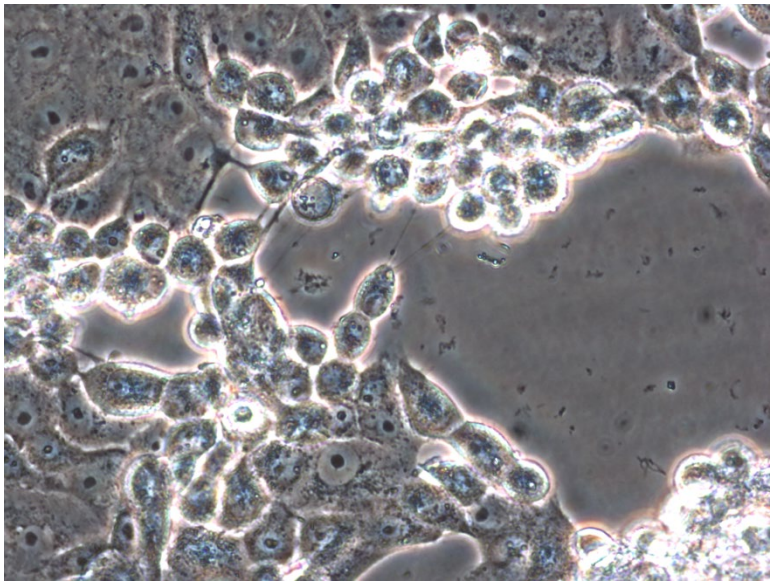
Wang Kaixi was infected by airborne SARS viruses that he breathed in at the Prince of Wales Hospital.
Since SARS produced diarrhea in the majority of patients, he flushed his toilet water likely heavily laced with his SARS thereby aerosolizing his SARS viruses into the most toxic Fecal Cloud ever recorded. His window fan blew his SARS Fecal Cloud(s) outdoors where the wind and rising air currents spread them on to his unsuspecting Amoy Gardens neighbors.



Isolation of coronavirus in cell cultures



Non-infected cells



Coronavirus-infected cells

Workers wearing powered air- purifying respirators (PAPR)

SARS CoV-2 in air sample

Severe acute respiratory syndrome coronavirus 2 isolate SARS-CoV-2/ENV/USA/UF-3/2020, complete genome

GenBank: MT324684.1

FASTA Graphics

Go to:

```
LOCUS       MT324684               29889 bp    RNA     linear   VRL 13-APR-2020
DEFINITION  Severe acute respiratory syndrome coronavirus 2 isolate
            SARS-CoV-2/ENV/USA/UF-3/2020, complete genome.
ACCESSION   MT324684
VERSION     MT324684.1
KEYWORDS    .
SOURCE      Severe acute respiratory syndrome coronavirus 2 (SARS-CoV2)
  ORGANISM  Severe acute respiratory syndrome coronavirus 2
            Viruses; Riboviria; Nidovirales; Cornidovirineae; Coronaviridae;
            Orthocoronavirinae; Betacoronavirus; Sarbecovirus.
REFERENCE   1  (bases 1 to 29889)
  AUTHORS   Shankar,S.N., Wu,C.-Y., Clugston,J.R., Elbadry,M.A., Morris,J.G.
            Jr. and Lednicky,J.A.
  TITLE     Genomic sequence of SARS CoV-2 in breathing air
```

SARS CoV-2 affects multiple organ systems

Heart: Nearly 20% of COVID-19 patients have heart damage. About 40% have blood that clots abnormally.

Kidneys: About 30% of hospitalized COVID-19 patients have kidney failure.

Pancreas, liver = also targets of COVID-19. Affects about 50% of patients.

Eyes: up to one-third of hospitalized patients develop conjunctivitis—pink, watery eyes

Brain and central nervous system: 5% to 10% of COVID-19 patients have neurologic signs. Encephalitis, seizures, loss of consciousness, loss of sense of smell, meningitis, and other signs have been reported.

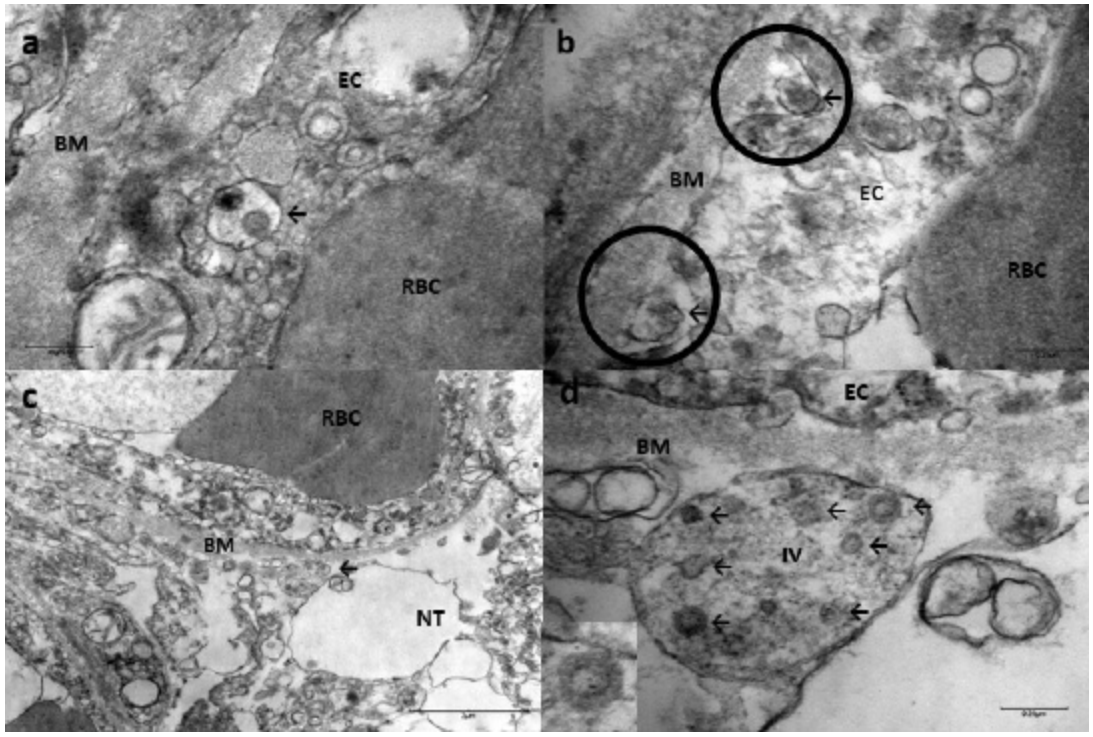
JOURNAL OF
MEDICAL VIROLOGY

COMMENTARY | Free Access

Central Nervous System Involvement by Severe Acute Respiratory Syndrome Coronavirus -2 (SARS-CoV-2)

Alberto Paniz-Mondolfi, Clare Bryce, Zachary Grimes, Ronald E Gordon, Jason Reidy, John Lednicky, Emilia Mia Sordillo, Mary Fowkes

First published:21 April 2020 | https://doi.org/10.1002/jmv.25915



SARS CoV-2 particles were found in neurons (in frontal lobe sections) and in endothelial cells in brain capillaries.

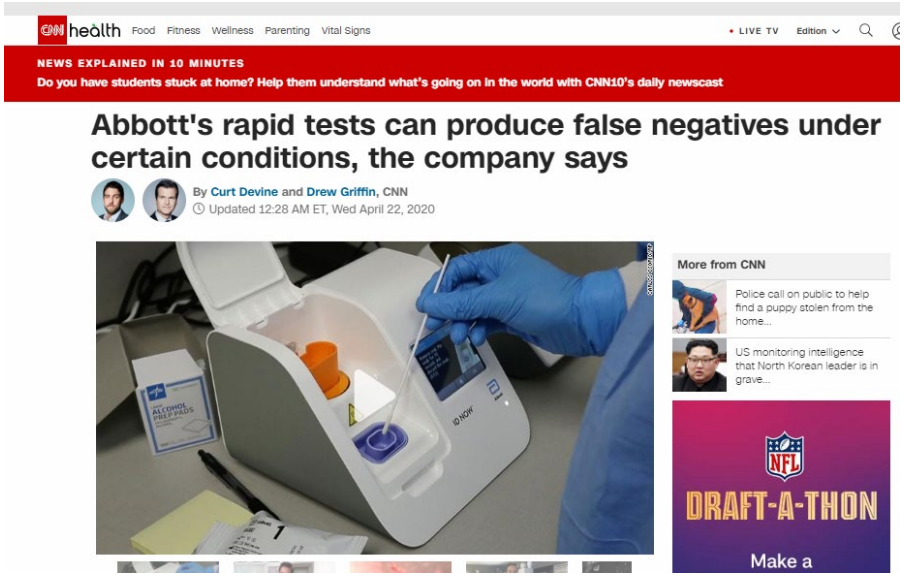
NOTES: Diagnostic tests for SARS CoV-2

1. Nasal swab specimens: Specimen of choice of RT-PCR tests.
- 30% or higher false NEGATIVE. Why?
- Proper collection of specimen.
- Type of swab. Flocked vs spun.
- Supply shortage.
- Specimen choice should include blood and stool (or rectal swab)?

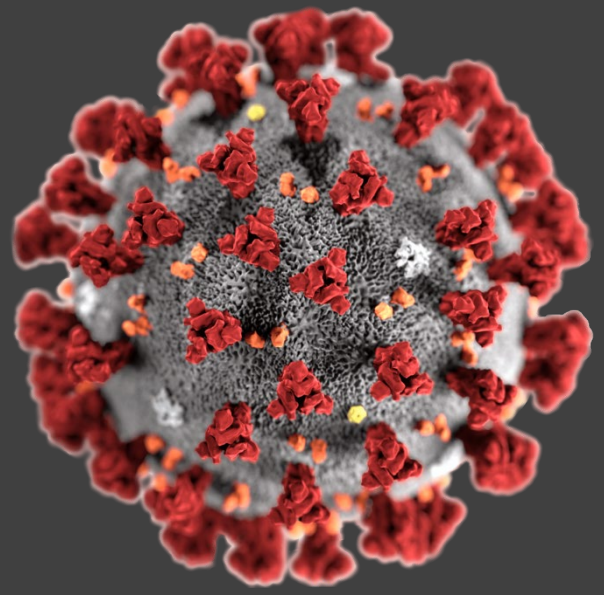
2. Antibody tests.
- There are > 70 tests available worldwide.
- IMPORTANT: antibodies to coronaviruses tend to be short-lived

29 commercial assays designed to detect antibodies to SARS CoV-2 are on sale in the US, only three of which have been granted the FDA's backing in the form of an emergency use authorization.

- None of these tests, even those with EUAs, have had their accuracy evaluated by the FDA or any other regulatory body.
- Abbott says the IgG test it released in the US last week, when performed at least two weeks after a patient has first exhibited symptoms, has a sensitivity of 100% and specificity of 99.5%.
- Te antibody test sold in the US by Becton Dickinson, developed by BD's partner Biomedomics, has sensitivity of 88.7% and specificity of 90.6%.
- Roche will commercialize its antibody test next month.



COVID-19



Highly contagious

- Transmission by
  - Large droplets from the respiratory tract –
- “danger zone” of up to 12 feet
  - Airborne – can drift in air for several hours, creating “toxic cloud”
- Can be transmitted by persons who have no symptoms: this can occur before or after clinical symptoms, or in persons who never have clinical symptoms

Range of clinical presentations

- Most severe – respiratory failure, with fibrosis of lungs – but also involvement of brain, heart, kidney, liver, and GI tract. Presentation with non-respiratory symptoms is not uncommon, particularly among older populations
- At other end of spectrum – up to 50% of infected persons in large, population-based studies are asymptomatic, with another 30-40% having only mild symptoms

Coronavirus: characteristics of 27,127 Florida resident cases

Data verified as of Apr 21, 2020 at 5 PM

Data in this report are provisional and subject to change.

Age group	Cases		Hospitalizations		Deaths	
0-4 years	130	0%	8	0%	0	0%
5-14 years	257	1%	5	0%	0	0%
15-24 years	1,947	7%	61	1%	0	0%
25-34 years	4,043	15%	213	5%	9	1%
35-44 years	4,164	15%	394	9%	18	2%
45-54 years	4,996	18%	572	14%	32	4%
55-64 years	4,758	18%	736	17%	90	10%
65-74 years	3,509	13%	962	23%	212	24%
75-84 years	2,134	8%	803	19%	259	30%
85+ years	1,147	4%	472	11%	247	28%
Unknown	42	0%	0	0%	0	0%
Total	**27,127**		**4,226**		**867**	

Gender	Cases	
Male	13,552	50%
Female	13,437	50%
Unknown	138	1%
Total	**27,127**	

Illustrative Skilled Nursing Facility Outbreaks

Facility A

- Facility was following standard CDC guidelines for skilled nursing facilities
- Index case: sent to Emergency Department with possible stroke
  - Testing in ED: COVID-19
- Screening of patients and staff: 4 (9%) of 43 asymptomatic persons tested were positive for COVID-19

Facility B

- Facility was following standard CDC guidelines
- Index case: sent to Emergency Department with loss of consciousness
  - Testing in ED: COVID-19
- Screening of patients and staff: 9 (5%) of 181 asymptomatic persons tested were positive for COVID-19

Having a testing program for skilled nursing facilities is critically important

- CDC guidelines for Skilled Nursing Facilities provides an important starting point for identifying and controlling outbreaks
- However:
  - Be aware that older patients may not present with “typical” COVID symptoms
  - Both staff and patients may be infected with COVID, even if asymptomatic
  - As of April 13, CDC is indicating a preference for “test-based” rather than “non test-based” criteria for return to work of previously infected staff members

Some General Public Health Thoughts on "Reopening"

Trigger to initiate process: evidence of decreasing transmission within local community across a 14-day period

Prerequisites:

- Local healthcare system has sufficient resources to handle possible surge in patient numbers
- Testing program in place, to accurately identify persons infected with the virus
  - Viral screening (nasopharyngeal swabs) easily accessible, able to handle high volumes, with rapid reporting of results (ideally <4 hours), and sufficient funding to cover cost
    - Screening of symptomatic and asymptomatic individuals
  - Antibody screening – still issues with assays, interpretation of results, but of clear potential value
- System in place for contact tracing, to identify and isolate case clusters

Some General Public Health Thoughts on "Reopening"

Re-opening process

- Staged process: "loosen the faucet" rather than "open the floodgates"
- Continue to encourage physical distancing to 6 feet
- Continue to prohibit mass gatherings
- Limit contact with persons coming from COVID-19 "hot spots" nationally or from international locations
- Be prepared to resume more stringent isolation practices if data show that numbers of COVID-19 cases are increasing

Ongoing public health measures

- Encourage washing hands often, cover coughs, have hand sanitizer available in public areas/entranceways, etc.
- Strongly encourage persons to stay home if ill (and get tested); ideally linked with system of paid sick leave for employees
- Routine surface and object cleaning in public areas
- Avoid crowding, encourage having <50 people in social gatherings
- Vulnerable populations (persons >60 years, or with underlying conditions) should continue to "protect themselves" by engaging in physical distancing as much as possible