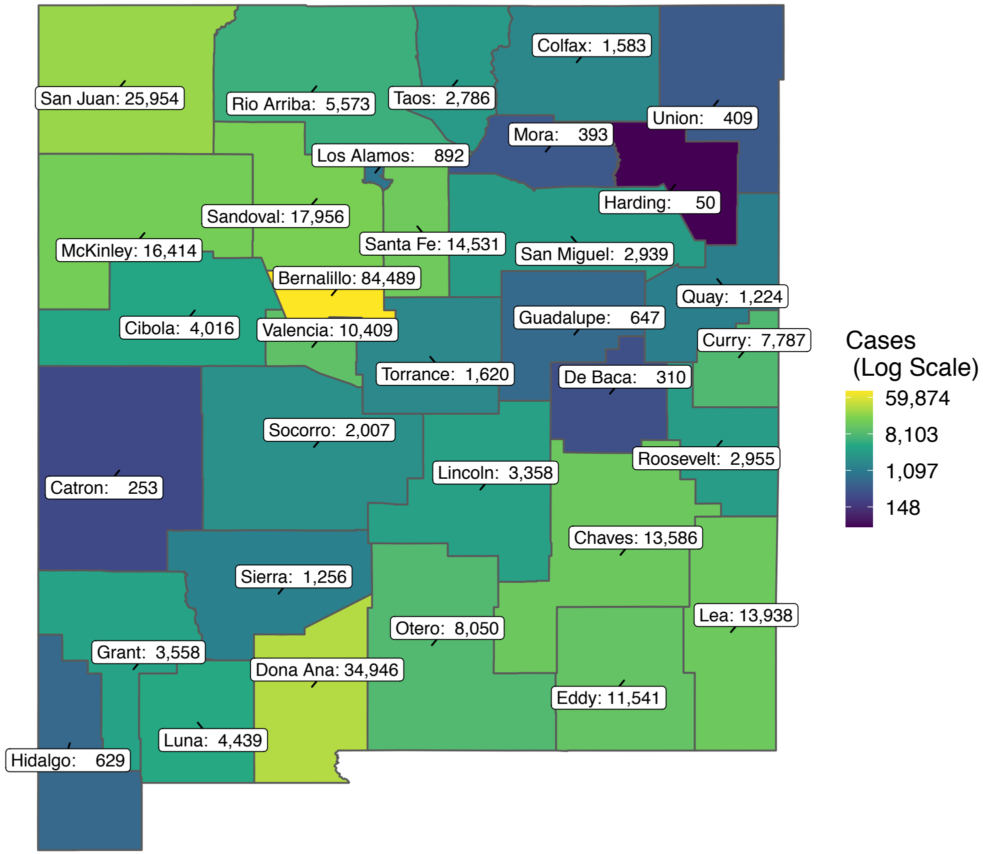
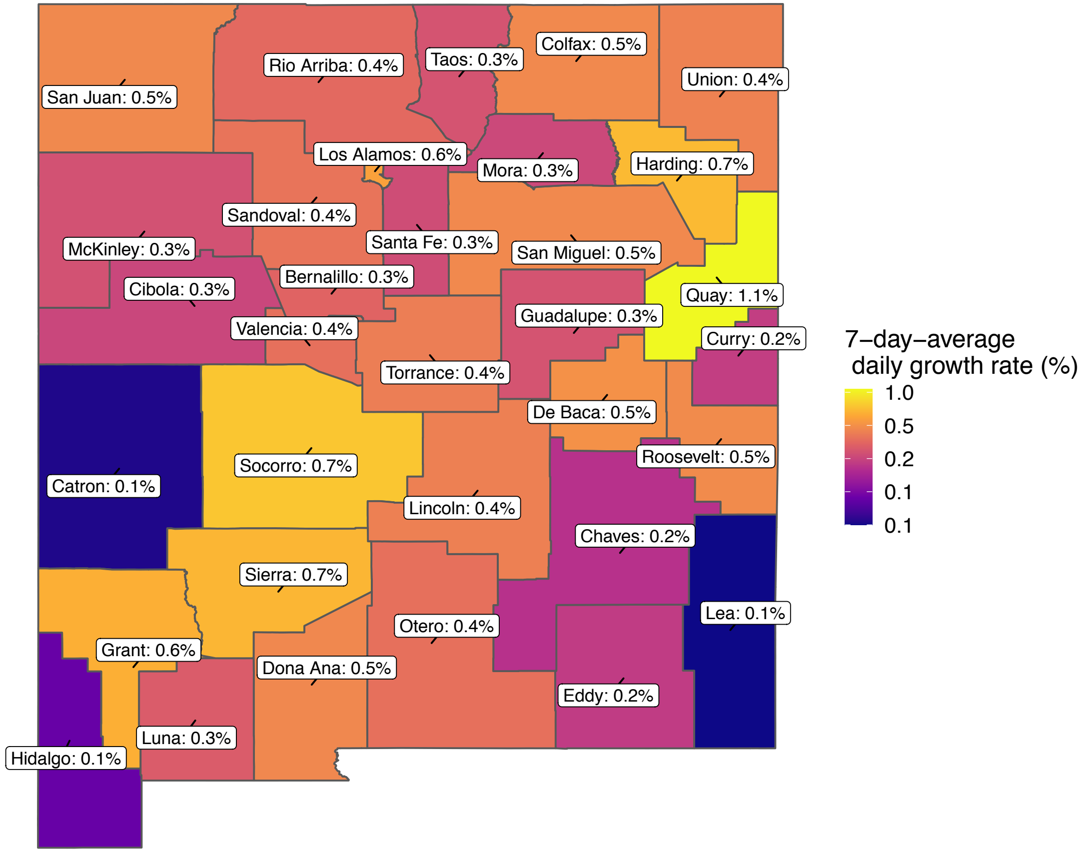
Modeling & Forecasting COVID-19 in NM

November 22, 2021

National Nuclear Security Administration

Cumulative Cases & Daily Growth Rate for NM: Nov 22

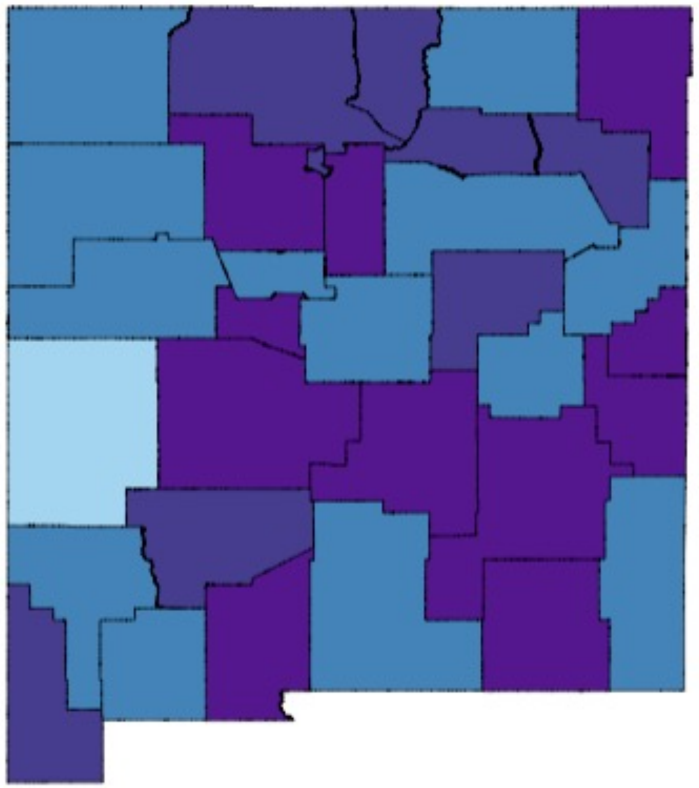




Sierra, Socorro, Harding have elevated cumulative growth rates

*Growth rate is in cumulative cases

Weekly Growth Rate for NM: Another View (Nov 22)



Impacted New Mexicans

Counties with New Cases This Week

Growth Rate	Low	Med	High
Accelerating	0k	0k	814k
Constant	0k	0k	115k
Decelerating	0k	4k	1.16M

Cases Per Capita

Counties With No New Cases In ...

Last Week	*Two Weeks*	*3+ Weeks*
0k	0k	0k

So what?

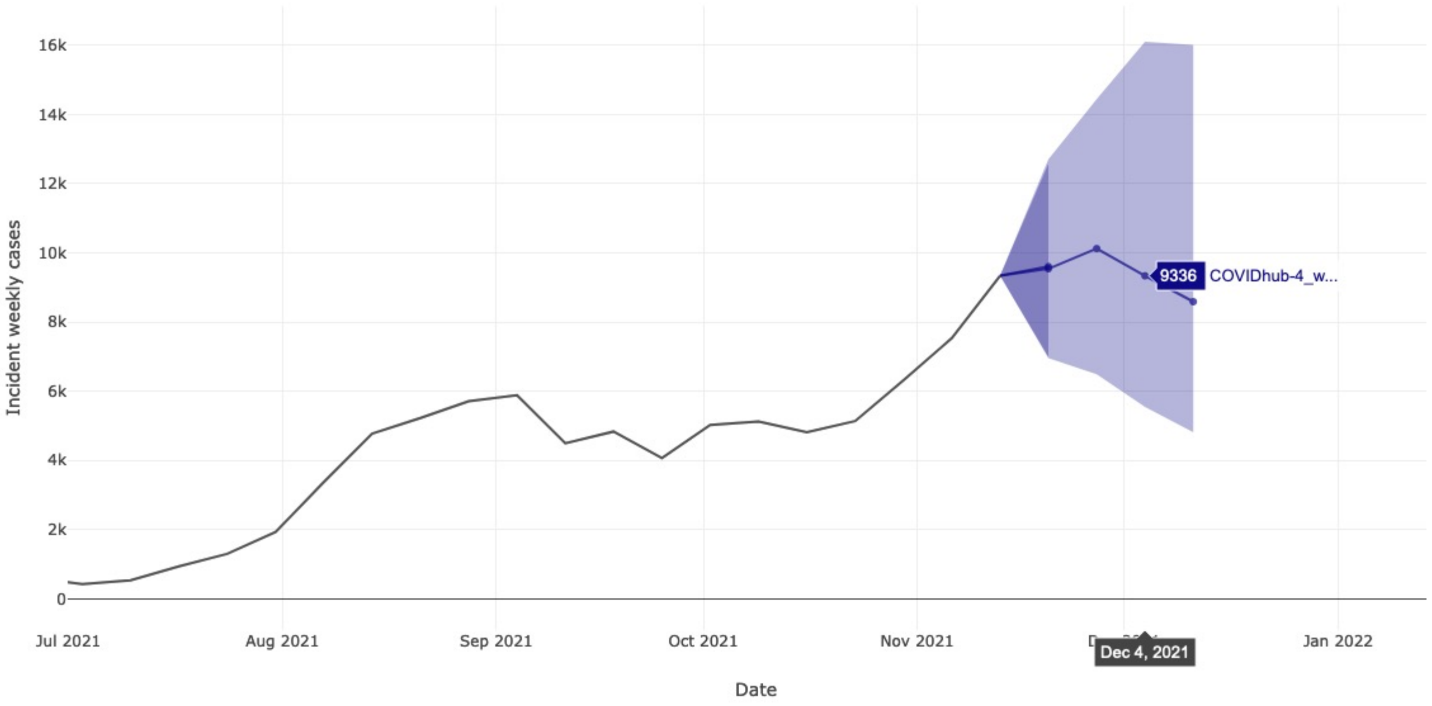
- **Southern central NM, Dona Ana, Santa Fe accelerating and have higher per-capita case counts.**
- **Bernalillo, San Juan, McKinley counties are decelerating**
- **More people in New Mexico are living in a county that has higher per-capita case counts and decelerating or constant**

Number of New Mexicans living in regions with particular combinations of per capita case counts and 7-day growth rates

Low <10 cases/100k per week
Med 10-99 cases/100k per week
High >100 cases/100k per week

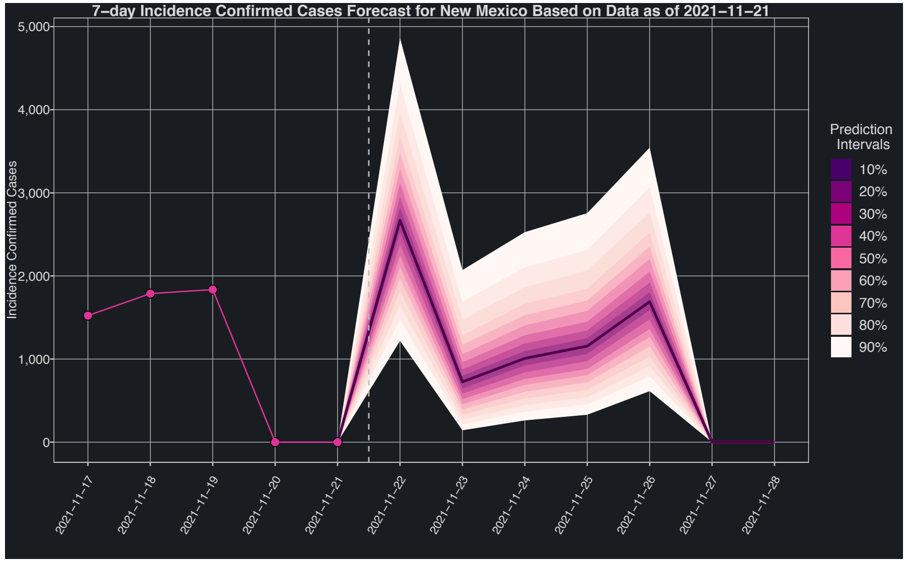
Forecast for Incident Weekly Cases in NM

The CDC ForecastHub shows a 0% decrease in incident weekly cases by Dec 4, 2021 from current counts observed at 9336 (Nov 13)



COVIDhub-4_week_ensemble prediction, COVID 19 ForecastHub
https://viz.covid19forecasthub.org/

Short- & Long-Term Forecast for NM: Cases



6–Week Forecast of Daily Average of Confirmed Cases
for New Mexico Based on Data as of 2021–11–21

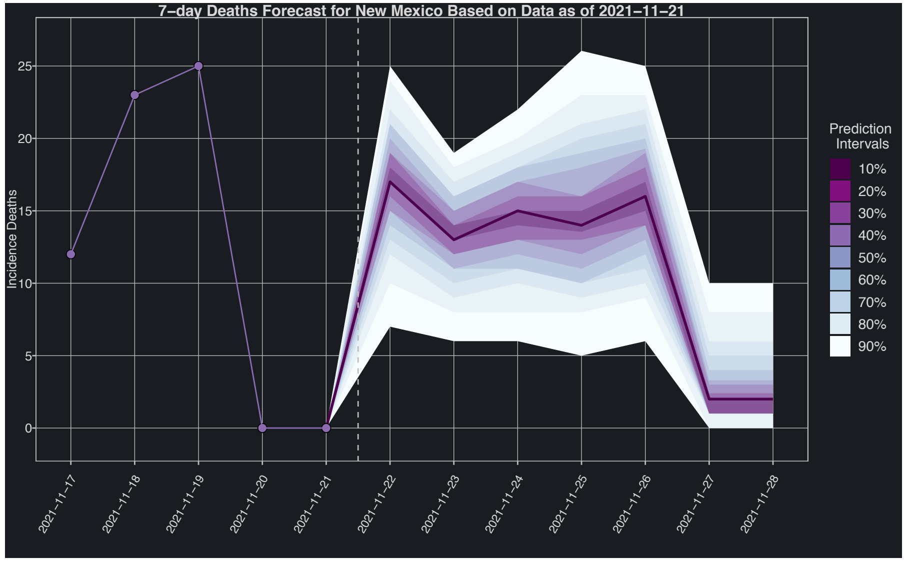
Week End Date	Best Case (5th Percentile)	Middle Case (50th Percentile)	Worst Case (95th Percentile)
2021–11–21		1,408*	
2021–11–28	367	1,036	2,252
2021–12–05	394	1,104	2,369
2021–12–12	403	1,156	2,477
2021–12–19	394	1,201	2,638
2021–12–26	371	1,247	2,825
2022–01–02	337	1,293	3,039

*Last reported confirmed cases count

So what?

Our model suggests that the number of daily cases is expected to range between 390 and 2.200 in the next few weeks

Short- & Long-Term Forecast for NM: Deaths



6–Week Forecast of Daily Average of Deaths for New Mexico Based on Data as of 2021–11–21

Week Start Date	Best Case (5th Percentile)	Middle Case (50th Percentile)	Worst Case (95th Percentile)
2021–11–21		13*	
2021–11–28	4	11	20
2021–12–05	4	11	20
2021–12–12	4	11	20
2021–12–19	4	11	21
2021–12–26	3	11	22
2022–01–02	3	11	25

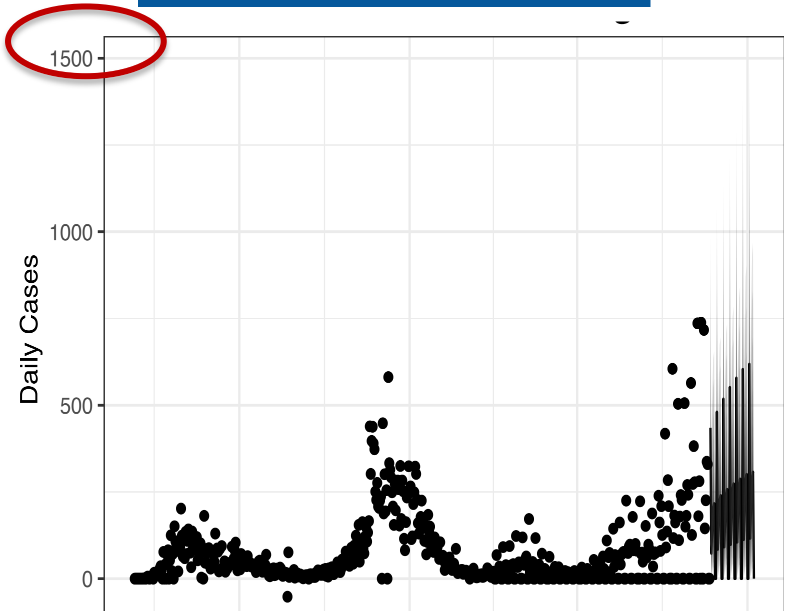
*Last reported confirmed deaths

So what?

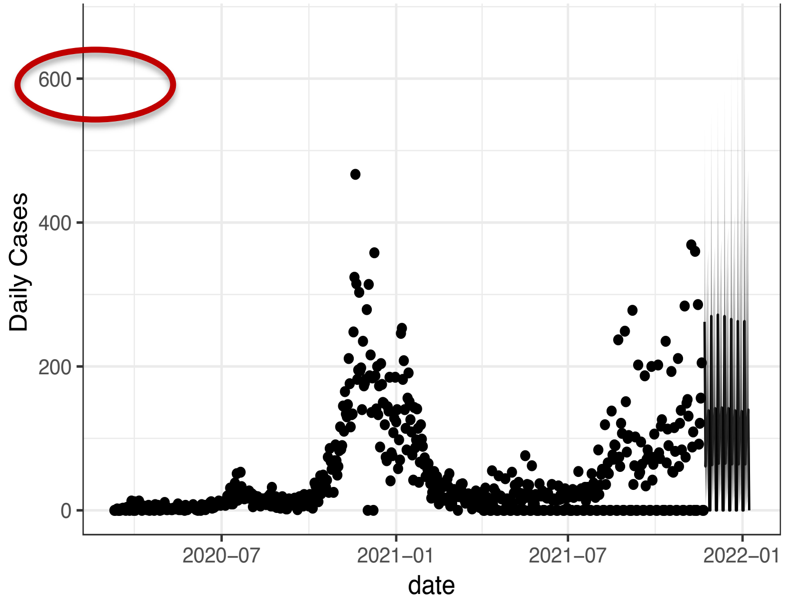
Our model suggests that the number of daily deaths is expected to range between 4 and 20 in the next few weeks

Central & North Regions Daily Cases Forecast

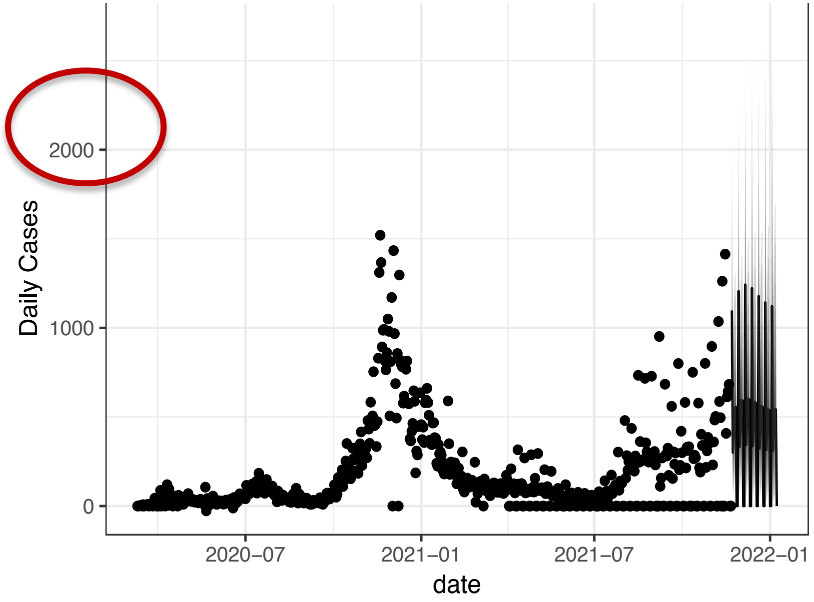
Northwest



Northeast



Central

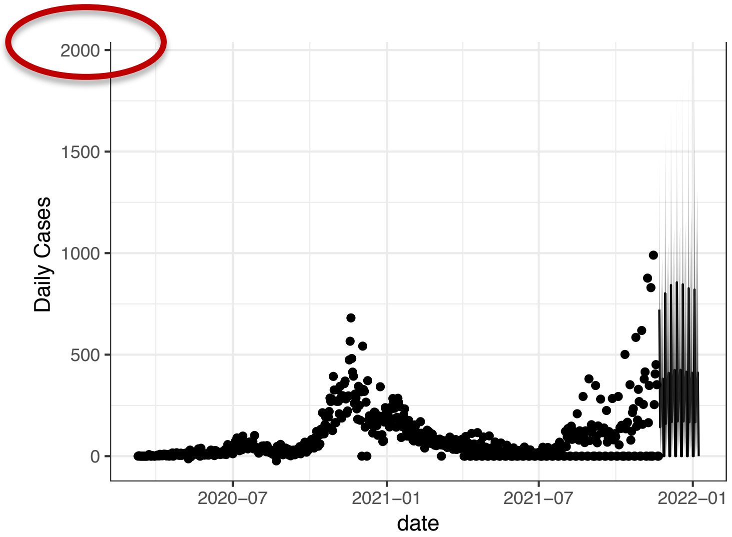


So what?

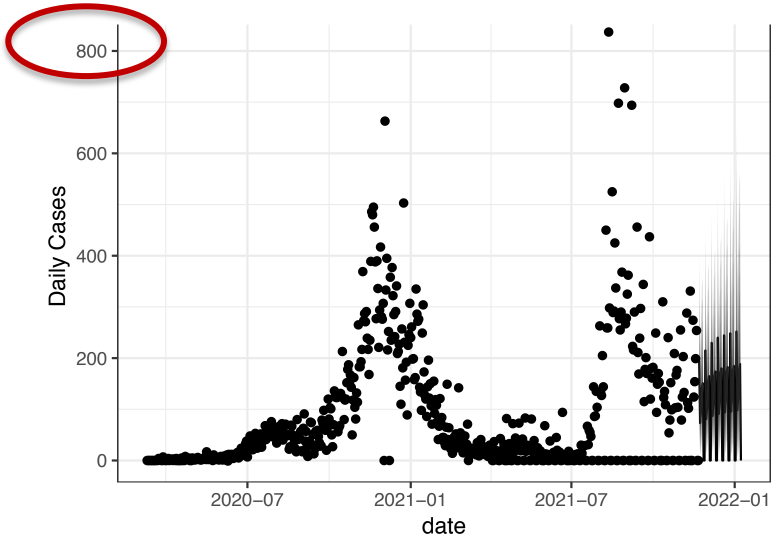
The northwest is increasing, others are forecasted to slowly decrease

South Regions Daily Cases Forecast

Southwest



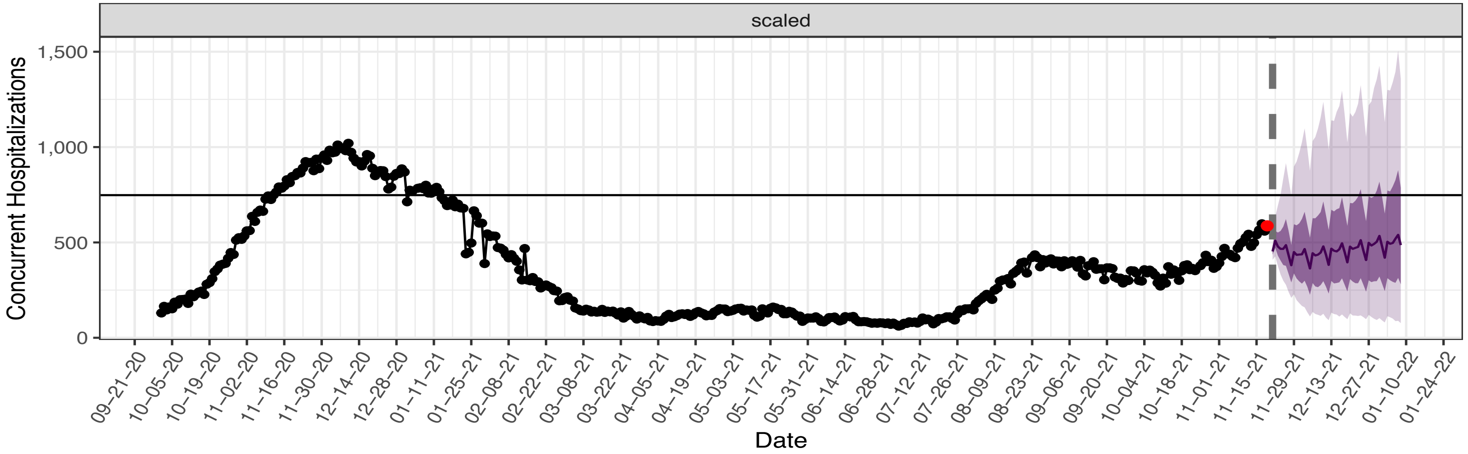
Southeast

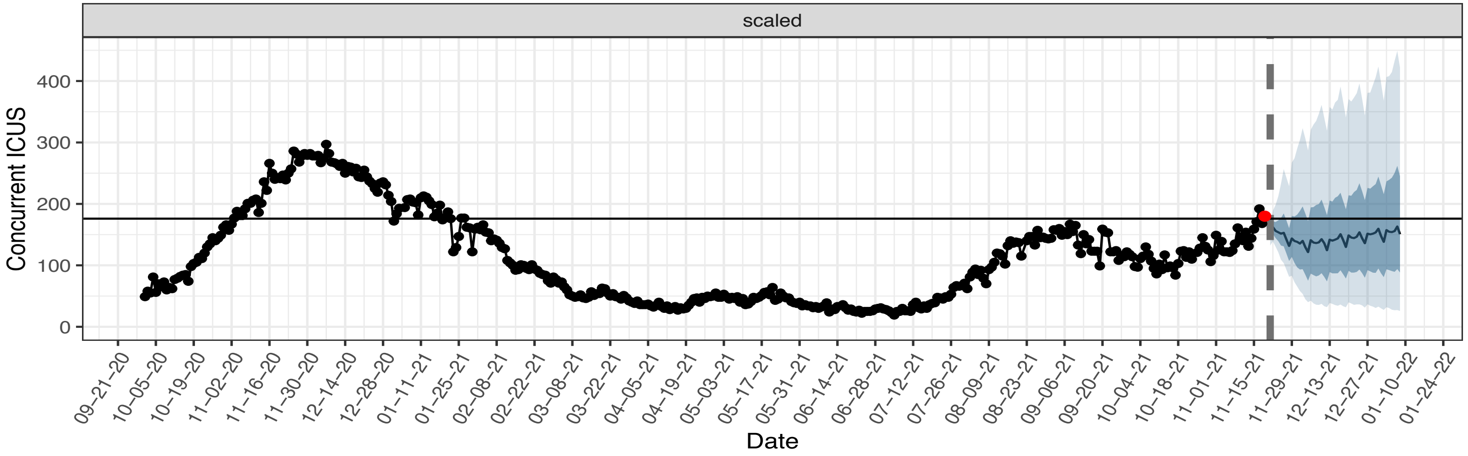


So what?

The southeast region is expected to see the most number of cases followed by the southwest region

Concurrent Hosp & ICU Beds Based on Forecasts – Average Stay of 8 Hosp, 15 Days for ICU/vent & 25% ICU rate



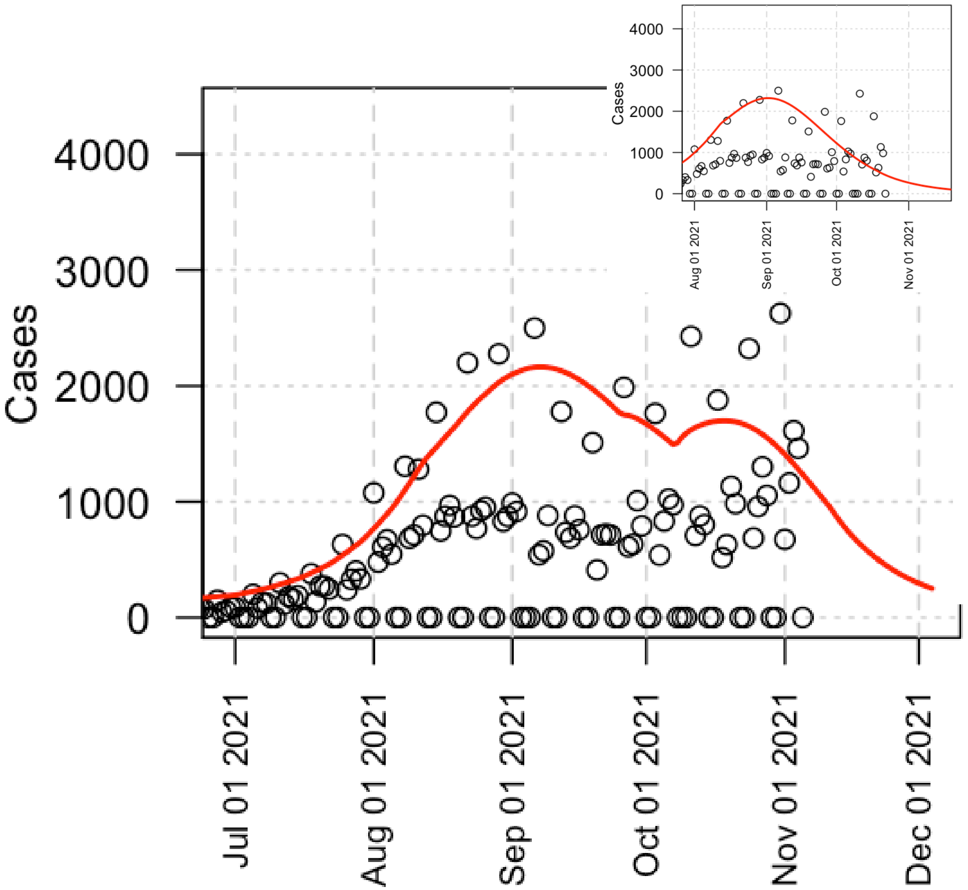


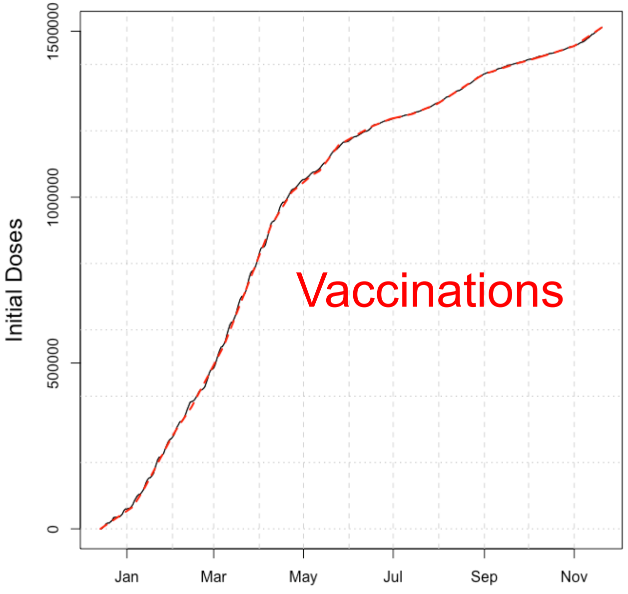
So what?

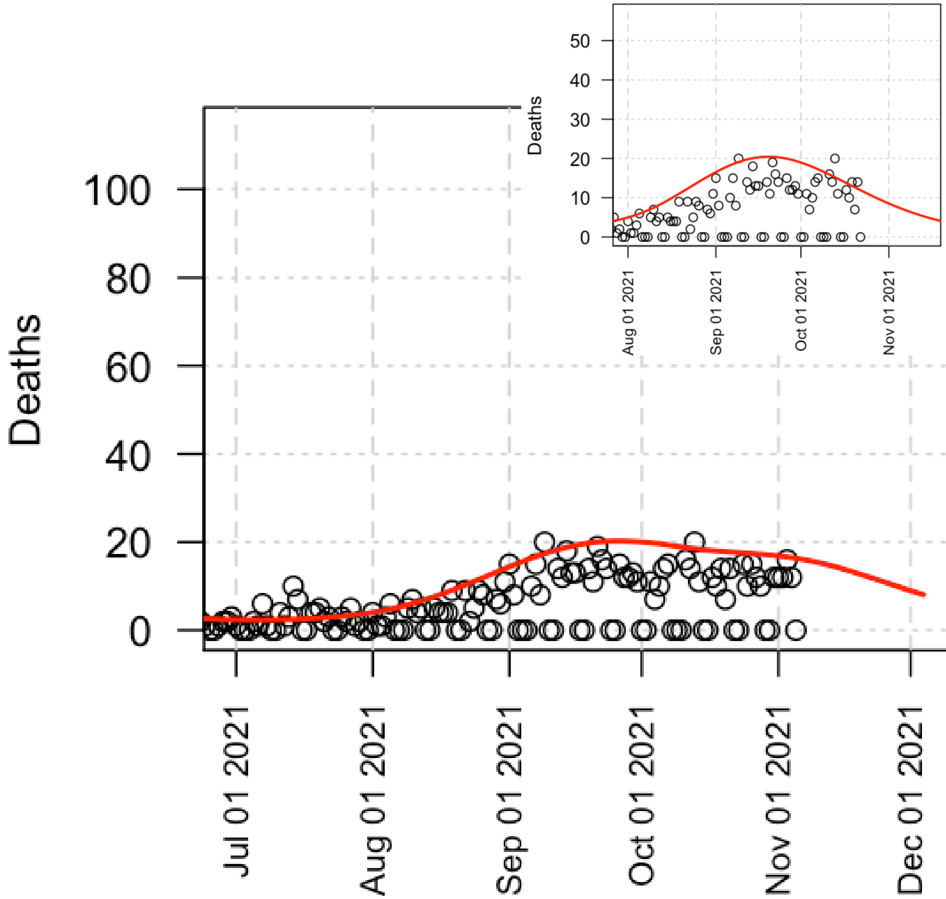
Model is predicting a <u>slow decrease</u> in COVID-19 ICU beds needed over the next 2 weeks with a plateau. However, interpret with caution because we are re-calibrating the hospitalization model.

23 Nov 2021: Epigrid modeling (data through Nov 10, 2021)

- New Mexico has a rising incidence rate. Hospitalization data demonstrate this. No leveling out yet.
- Deterioration of immunity/waning immunity is likely one driving cause (see below).
- Masking remains critical to moderating the consequence of rising cases.
- NM daily deaths showed a peak in mid- to late-September. A further increase in fatalities due to sustained higher transmission is likely or in progress.
- Booster vaccination and new pharmaceuticals may provide a path to further reductions in the fatality rate; Tracing-dependent.

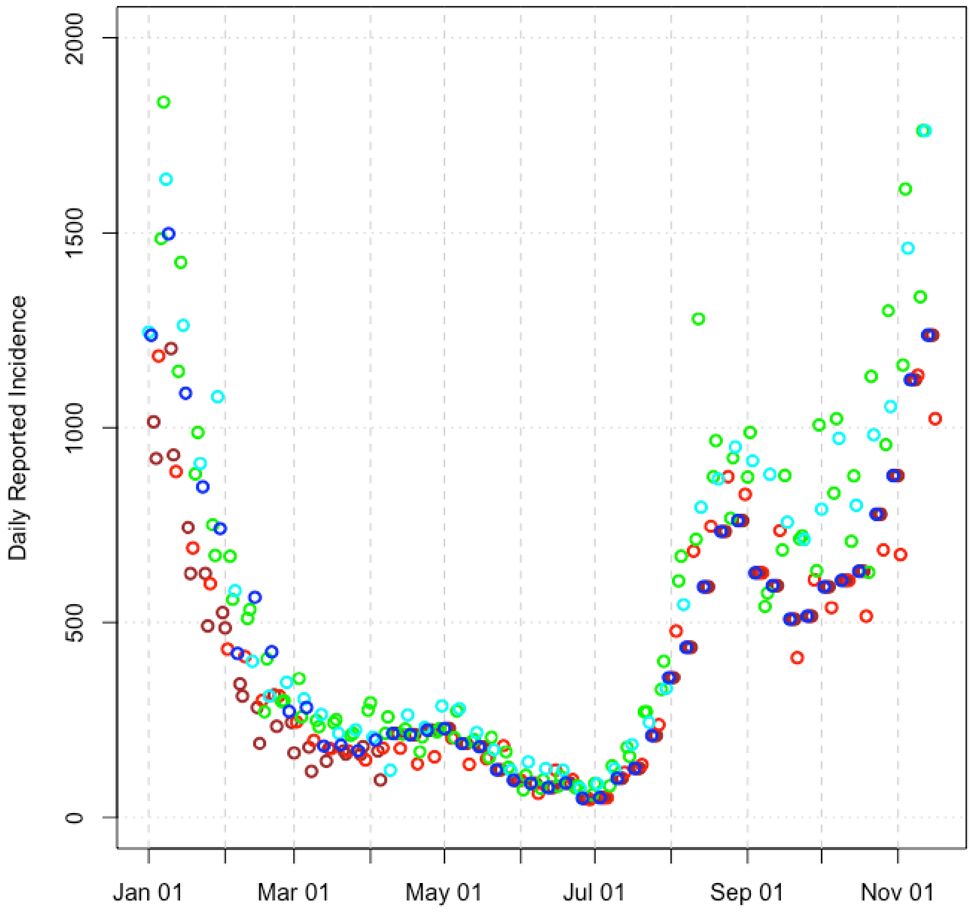






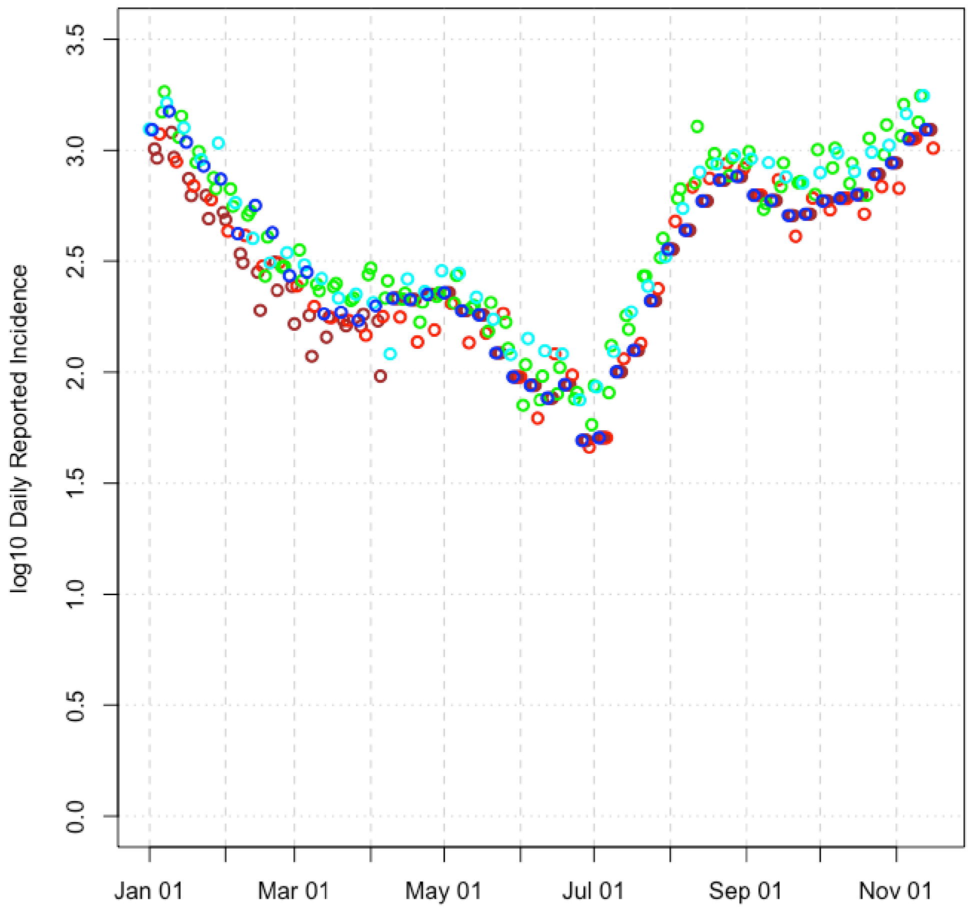
A look at the raw incidence data

- Sunday, Monday
- Tuesday
- Wednesday/Thursday
- Friday
- Saturday



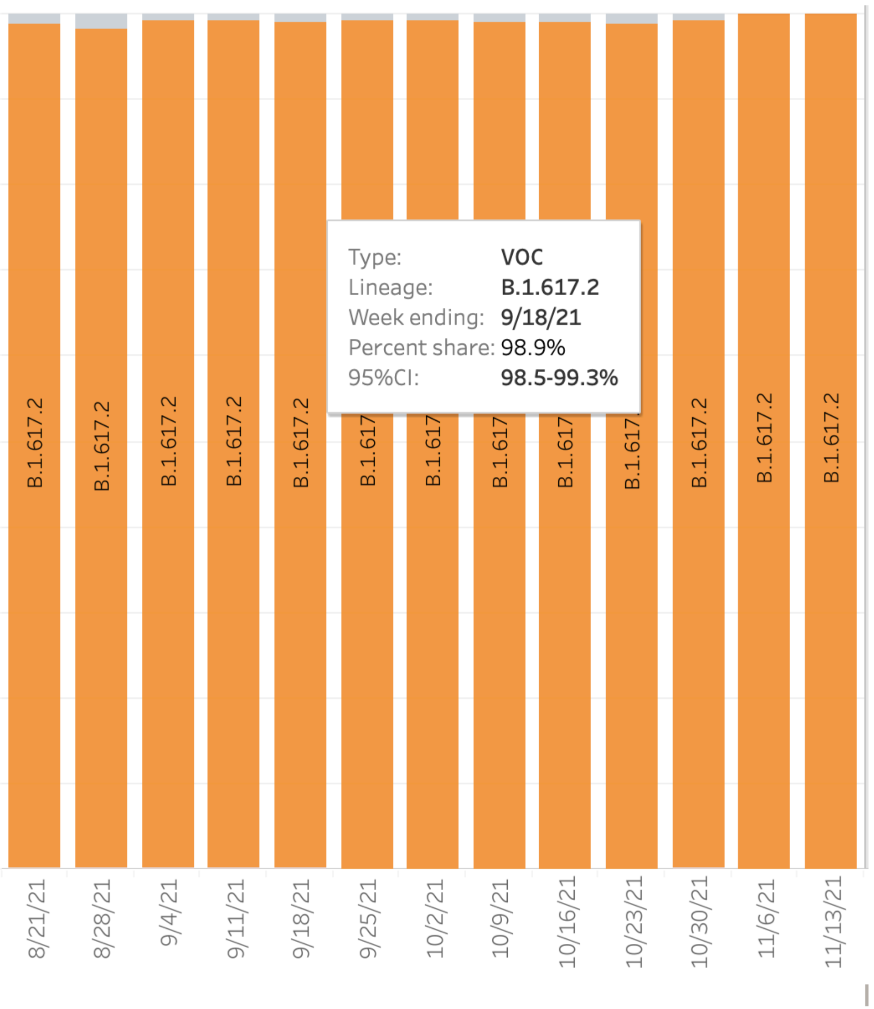
Reported cases rates are rising; within-weekly variation consistent with past performance.

The 190 cases in the Lea county correctional facility are removed from data reported on March 26th. The 1/3 of reported cases that were > 2 weeks prior were removed from March 24th. Case reported for weekends starting April 10-12th are each divided by 3 to estimate individual day counts.



Variant Monitoring: not driving the current rise in cases

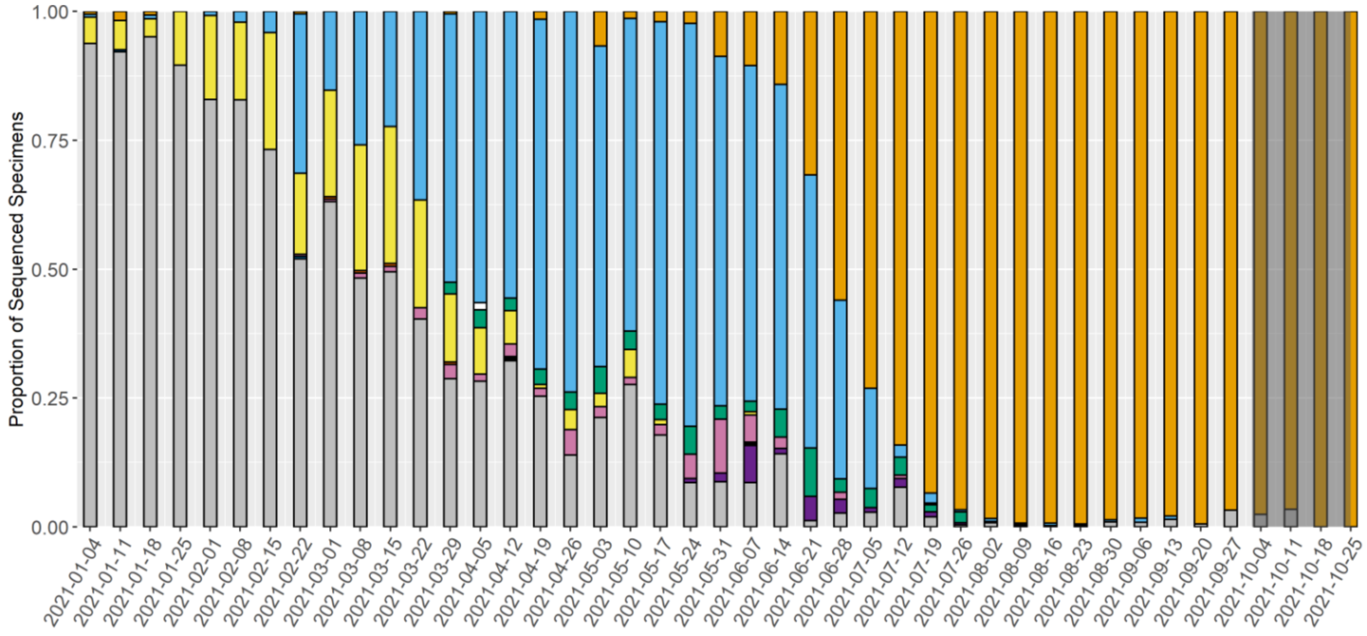
https://www.cdc.gov/covid-data-tracker/#variant-proportions **



Screen shot of CDC variant data only, no static image available

- B.1.617.2, “Δ”, ”Delta”, is the “Indian” variant.
- New variants have appeared without evident intermediates.

New Mexico’s data are consistent with Delta being dominant.



Correlation? How does “date-of-40%-vaccinated” go with current incidence trend?

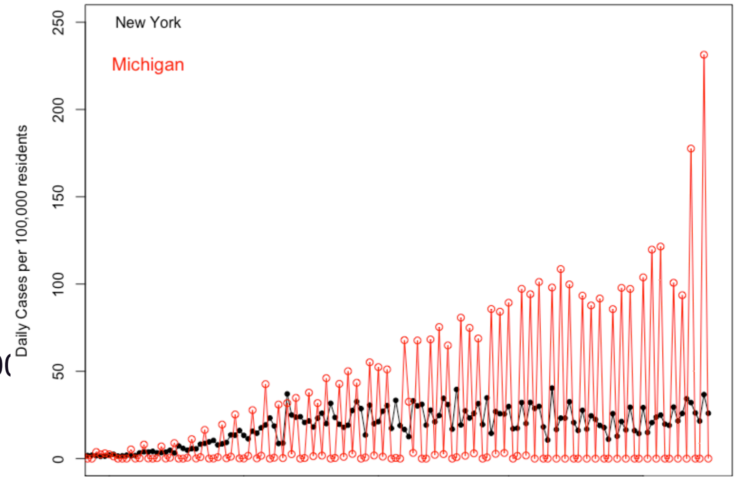
Trends over the last 3 weeks: Increasing: Illinois, New Mexico, New York, Michigan, Pennsylvania, Ohio. Steady: California, N. Carolina, Texas. Modest Declines: Florida, Georgia. Declining: n/a

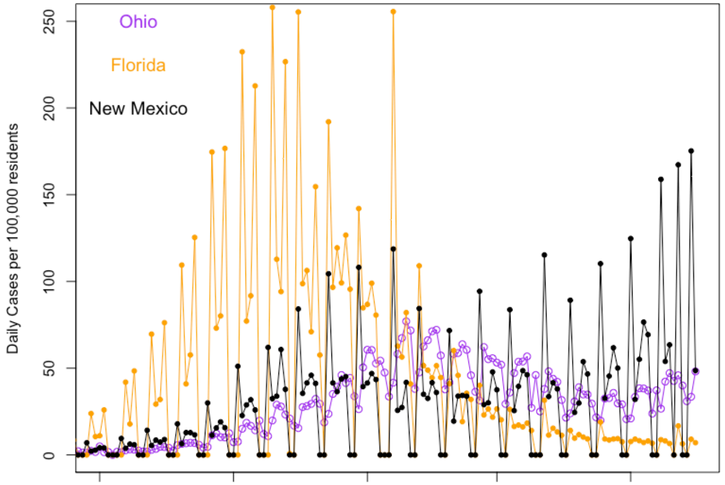
Date-of-40%-vaccinated:

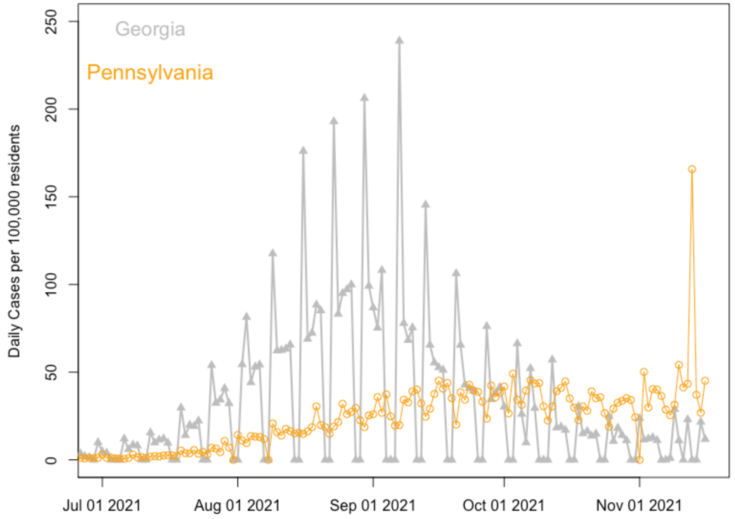
Red = May 2020, or earlier

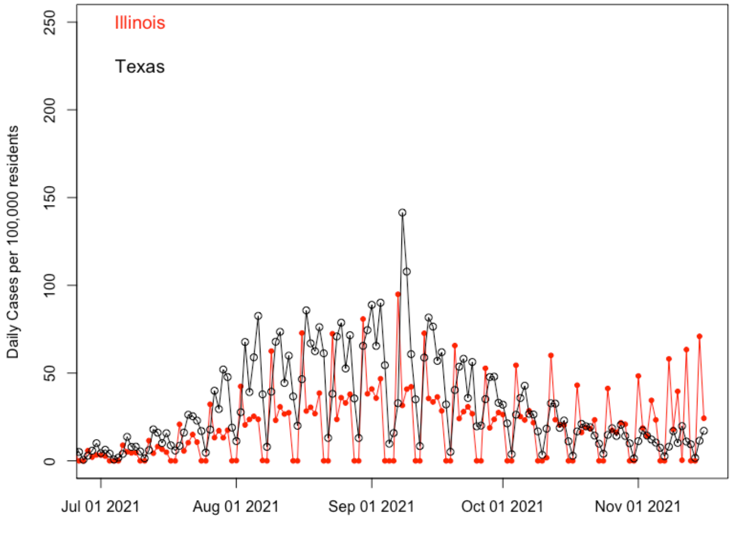
Green = after May 2020

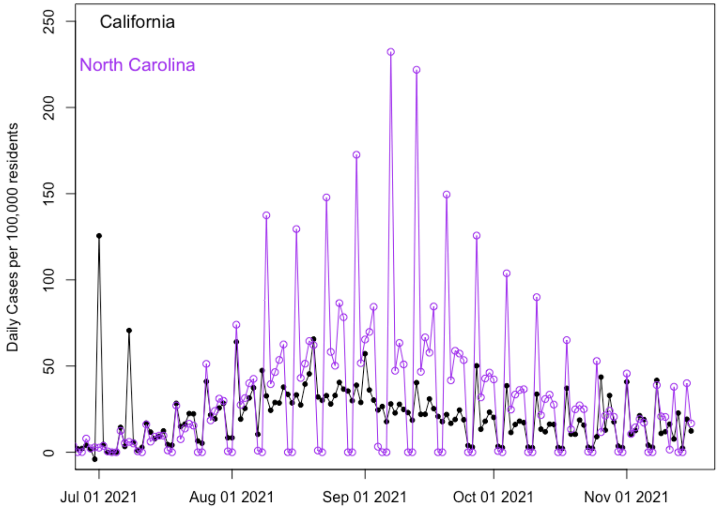
Daily rates per 100,0(
residents averaged
November 10th thru
November 19th 2021.







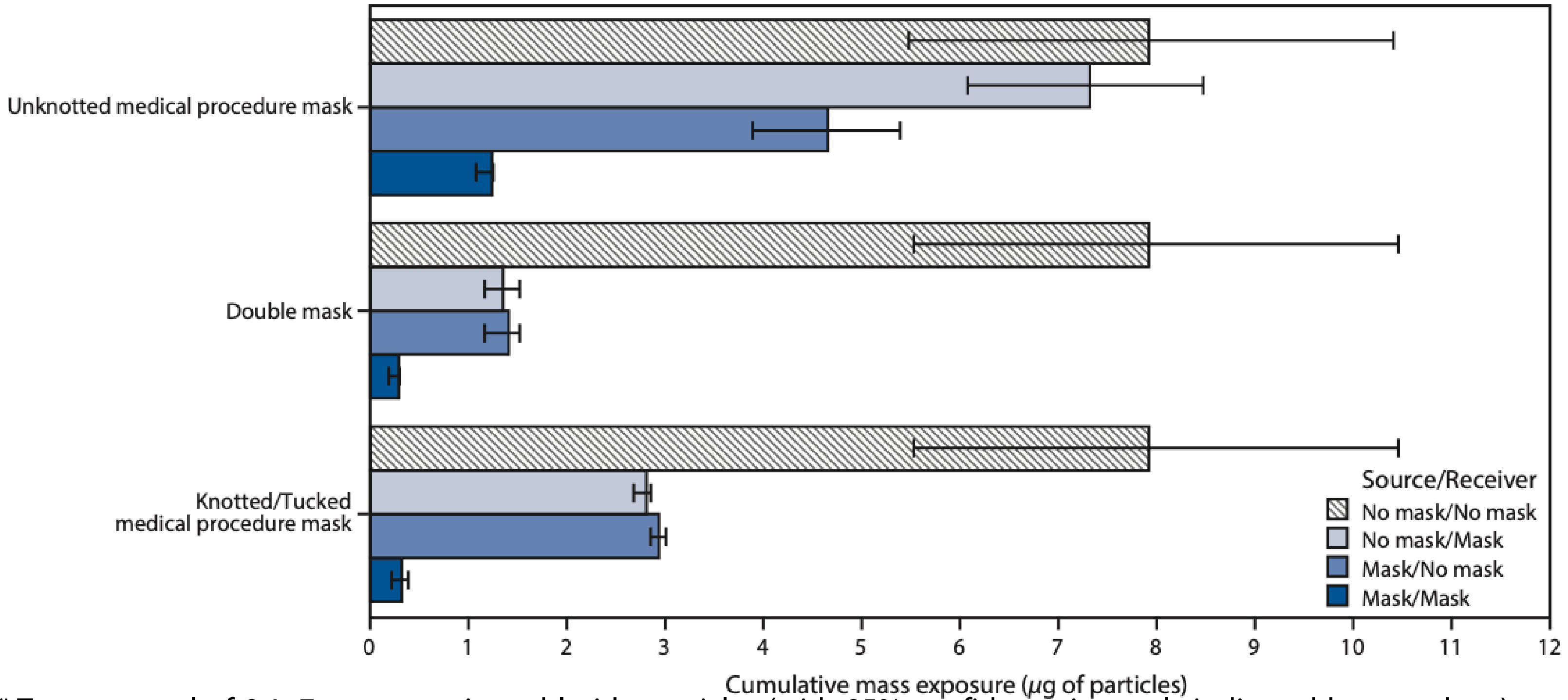


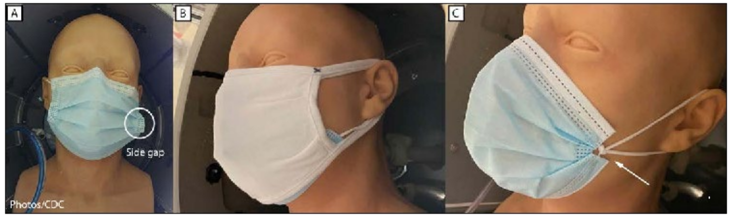


Masking guidance is confident enough that optimization of guidance is now > 6 months old.

Brooks *et al*. Masking, MMWR, 02/10/2021

FIGURE 2. Mean cumulative exposure* for various combinations of no mask, double masks, and unknotted and knotted/tucked medical procedure masks†





Results from the first experiment demonstrated that the unknotted medical procedure mask alone blocked 56.1% of the particles from a simulated cough (standard deviation [SD] = 5.8), and the cloth mask alone blocked 51.4% (SD = 7.1). The combination of the cloth mask covering the medical procedure mask (double mask) blocked 85.4% of the cough particles (SD = 2.4), and the knotted and tucked medical procedure mask blocked 77.0% (SD = 3.1).

Also: Chu et al. The Lancet 27 June 2020

* To an aerosol of 0.1–7 μm potassium chloride particles (with 95% confidence intervals indicated by error bars) measured at mouthpiece of receiver headform configured face to face 6 ft from a source headform, with no ventilation and replicated 3 times. Mean improvements in cumulative exposures compared with no mask/no mask (i.e., no mask wearing, or 100% exposure) were as follows: *unknotted medical procedure mask*: no mask/mask = 7.5%, mask/no mask = 41.3%, mask/mask = 84.3%; *double mask*: no mask/mask = 83.0%, mask/no mask = 82.2%, mask/mask = 96.4%; *knotted/tucked medical procedure mask*: no mask/mask = 64.5%, mask/no mask = 62.9%, mask/mask = 95.9%.

† Double mask refers to a three-ply medical procedure mask covered by a three-ply cloth cotton mask. A knotted and tucked medical procedure mask is created by bringing together the corners and ear loops on each side, knotting the ears loops together where they attach to the mask, and then tucking in and flattening the resulting extra mask material to minimize the side gaps.

The historical basis for *updated science* re: respiratory masking guidance has become clear over the last 18 months

WIRED MAGAZINE, BACKCHANNEL **05/13/2021 06:00 AM**

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The 60-Year-Old Scientific Screwup That Helped Covid Kill

All pandemic long, scientists brawled over how the virus spreads. *Droplets! No, aerosols!* At the heart of the fight was a teensy error with huge consequences.

EARLY ONE MORNING, Linsey Marr tiptoed to her dining room table, slipped on a headset, and fired up Zoom. On her computer screen, dozens of familiar faces began to appear. She also saw a few people she didn't know, including Maria Van Kerkhove, the World Health Organization's technical lead for Covid-19, and other expert advisers to the WHO. It was just past 1 pm Geneva time on April 3, 2020, but in Blacksburg, Virginia, where Marr lives with her husband and two children, dawn was just beginning to break.

Marr is an aerosol scientist at Virginia Tech and one of the few in the world who also studies infectious diseases. To her, the new coronavirus looked as if it could hang in the air, infecting anyone who breathed in enough of it. For people indoors, that posed a considerable risk. But the WHO didn't seem to have caught on. Just days before, the organization had tweeted "FACT: #COVID19 is NOT airborne." That's why Marr was skipping her usual morning workout to join 35 other aerosol scientists. They were trying to warn the WHO it was making a big mistake.

Over Zoom, they laid out the case. They ticked through a growing list of superspreading events in restaurants, call centers, cruise ships, and a choir rehearsal, instances where people got sick even when they were across the room from a

FEATURED VIDEO

CES HQ 2021: Covid Vaccines and Triumphs in Medicine

This *chain of standards and guidance* leading to sub-optimal messaging in 2020 is now documented.

How did we get here: what are droplets and aerosols and how far do they go? A historical perspective on the transmission of respiratory infectious diseases

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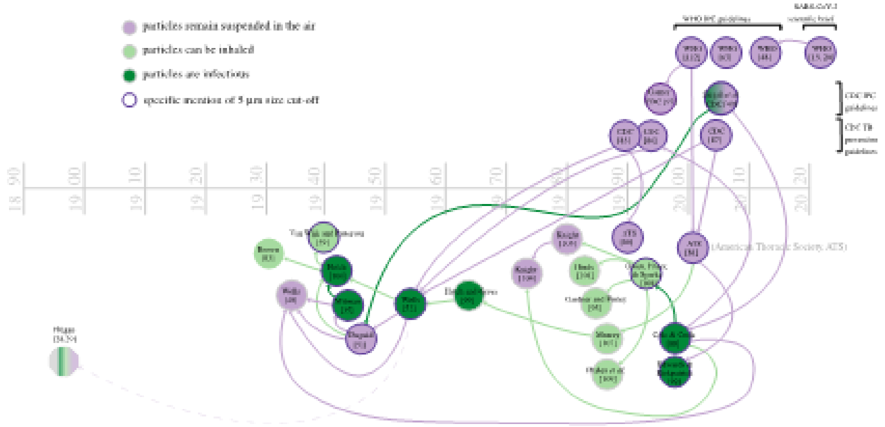
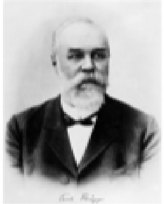
[2]Department of Chemistry and CIRES, University of Colorado, Boulder, CO, USA
[3]Fluid Dynamics of Disease Transmission Laboratory, Massachusetts Institute of Technology, Cambridge, MA, USA

The COVID-19 pandemic has exposed major gaps in our understanding of the transmission of viruses through the air. These gaps slowed recognition of airborne transmission of the disease, contributed to muddled public health policies and impeded clear messaging on how best to slow transmission of COVID-19. In particular, current recommendations have been based on four tenets: (i) respiratory disease transmission routes can be viewed mostly in a binary manner of 'droplets' versus 'aerosols'; (ii) this dichotomy depends on droplet size alone; (iii) the cut-off size between these routes of transmission is 5 µm; and (iv) there is a dichotomy in the distance at which transmission by each route is relevant. Yet, a relationship between these assertions is not supported by current scientific knowledge. Here, we revisit the historical foundation of these notions, and how they became entangled from the 1800s to today, with a complex interplay among various fields of science and medicine. This journey into the past highlights potential solutions for better collaboration and integration of scientific results into practice for building a more resilient society with more sound, far-sighted and effective public health policies.



Carl Flügge (1847–1923)

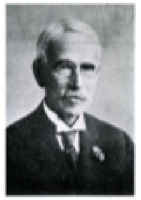


Seminal work on establishing importance of droplets in repiratory disease transmission, with a team that produced an extensive body of science on air, water, and dust mediated routes of disease transmission. His team discussed the role of type of emission (singing, talking, coughing, etc.) on dispersal distance, extended suspension and delay in settling of droplets, role of indoor air and infectiousness of dried mucous. The 5 µm size is mentioned, and ranges of 1–2 m are discussed with respect to exhalation type.

William Wells (1887–1963)

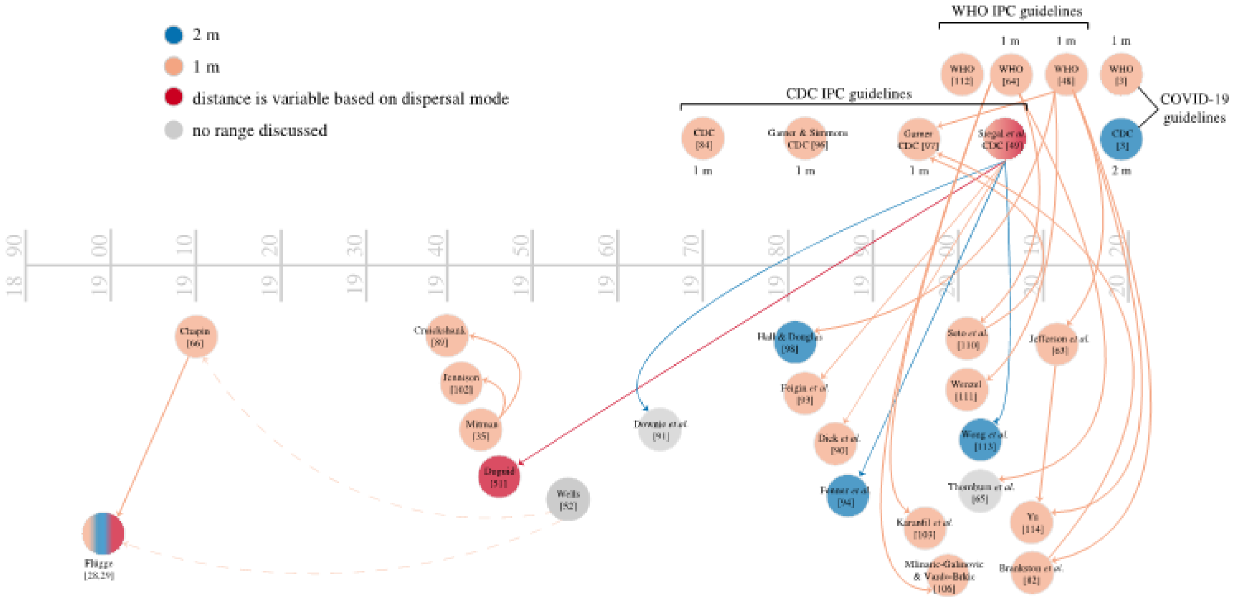
Pioneered the physics-based dichotomized view of respiratory disease transmission held today, splitting routes of transmission into large droplets versus small droplets routes (aerosols or airborne route). He did not introduce the 5 µm cutoff, but rather a 100 µm size cutoff between the two. He did not link the droplet sizes to distances directly.

Charles Chapin (1856–1941)



Alexander Langmuir (1910–1993)

Leading public health official (Chapin) and leading epidemiologist (Langmuir) who helped start the US CDC. Both were strong opponents of the notion of the airborne route of transmission, with later regret in the context of *measles*. Admission by Langmuir of the burden of 'doctrinal' teaching on public health decision-making and the importance of improving how to maintain the 'eternal skepticism of the true scientist' (Langmuir, 1980).



Mask Basics Data compiled in 06/14/2020

- **Methods or stopping particles are usually classified into**
  - Diffusion
  - Interception
  - Impaction (particle has large inertia and does not follow gas stream)
  - Electrostatic deposition

- **Humans emit a wide range of particle sizes with average of ~ 1 micron. (Morawska, Asadi)**

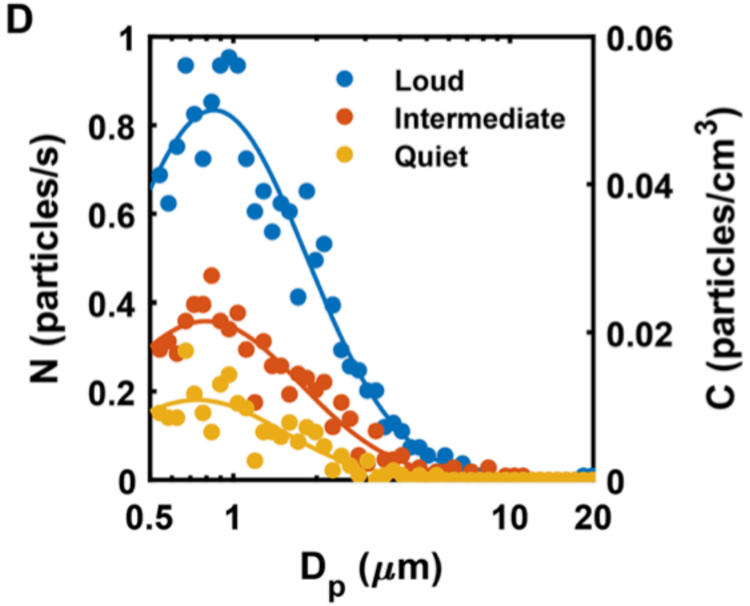
- **N95 and surgical masks are frequently made out of polypropylene (non-woven).**

- **N95 specs:**
  - An exhalation pressure drop of ≤ 245.2 Pa, 25 mm H_20 is recommended by NIOSH.
    - A velocity of 5.3 cm/s is used for testing (Rengasamy)
  - ≥ 95% of 0.3 micron diameter particles are filtered. (This is a hard size to filter.)

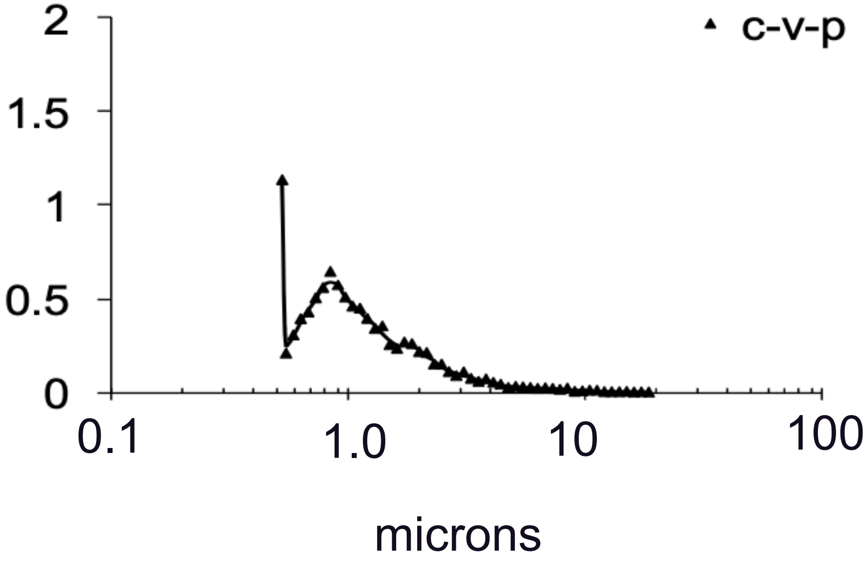
- **Surgical mask specifications** (https://www.primed.ca/clinical-resources/astm-mask-protection-standards/)
  - 95% filtration of Staph. Aureus (average size 0.6-0.8 microns) with a droplet size of 3.0 microns
  - low barrier masks must have a Delta-P of less than 4.0 mmH20 (39 Pa).

What size particles come out of people's mouths? 06/14/2020

- **The most common size is about a micron or slightly smaller when speaking, but there is a wide distribution.**



Asadi et al, "Aerosol emission and superemission during human speech increase with voice loudness", Scientific Reports 2019



Morawska et al, "Size distribution and sites of origin of droplets expelled during expiratory activities." Aerosol Science 2009

Coughs and sneezes: much bigger particles 06/14/2020

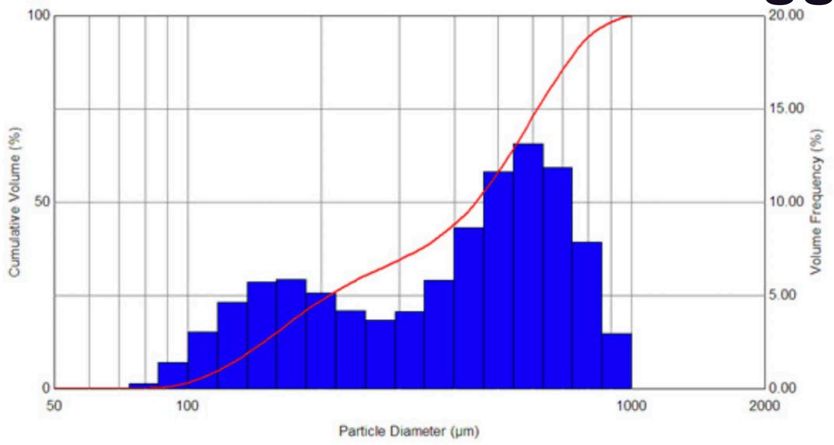


Figure 1: Droplet size distribution of a cough

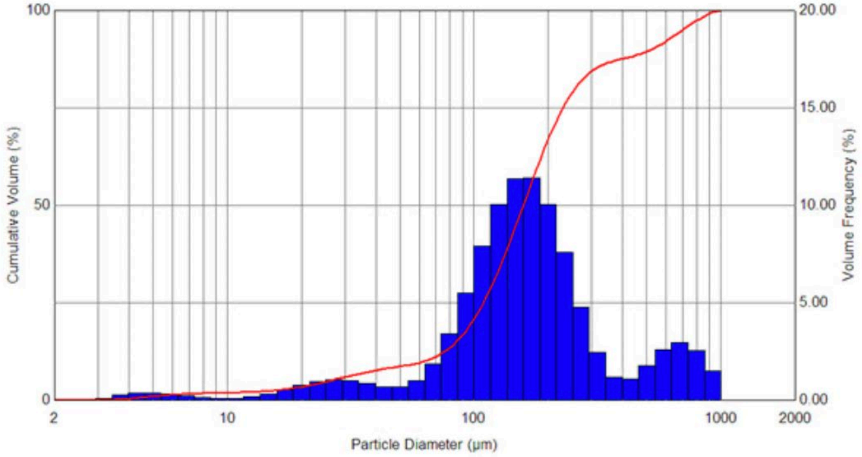


Figure 2: Droplet size distribution of a sneeze

Ward-Smith, Malvern Panalytical https://www.materials-talks.com/blog/2020/04/15/droplet-sizing-of-coughs-and-sneezes/

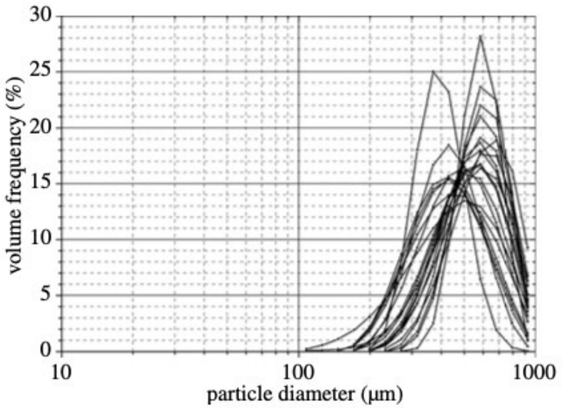


Figure 2. Unimodal distribution measured in the experiment (21 sneezes of 12 subjects).

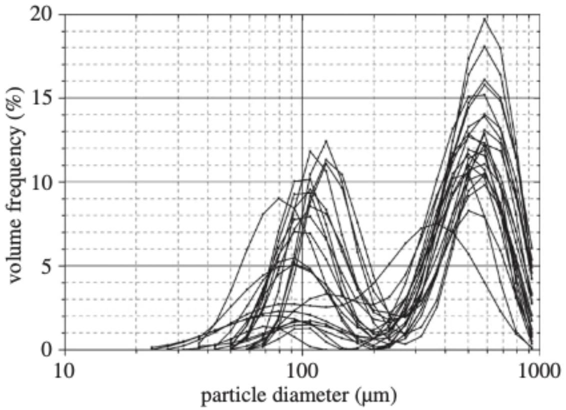


Figure 3. Bimodal distribution measured in the experiment (23 sneezes of 10 subjects).

Han et al. “Characterizations of particle size distribution of the droplets exhaled by sneeze.” J R Soc Interface, 2013

Particle settling data 06/14/2020

Time to settle 5 ft (unit density spheres)

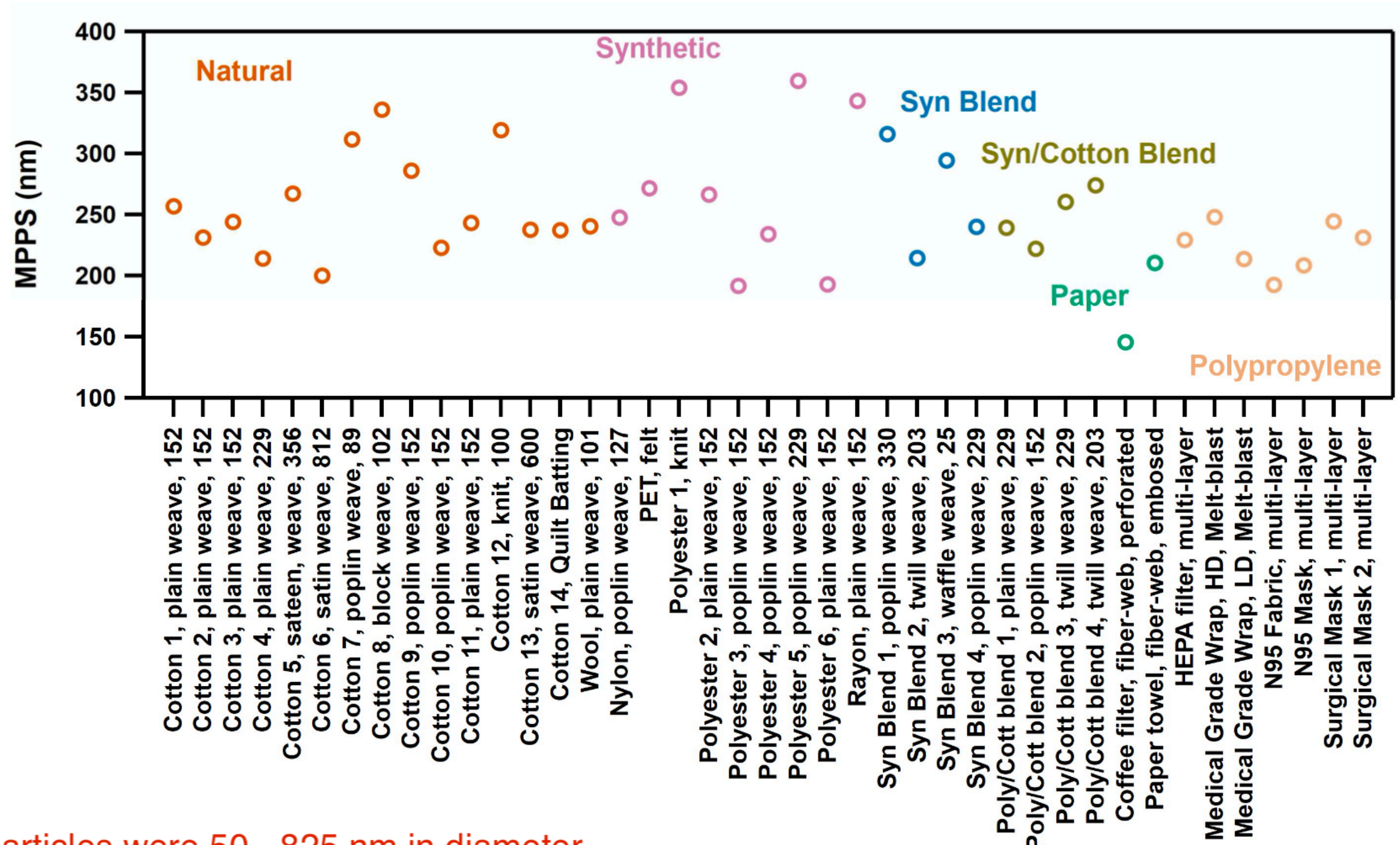
Aerodynamic diameter (microns)	time
0.5	41 hours
1	12 hours
3	1.5 hours
10	8.2 minutes
100	5.8 seconds

https://www.cdc.gov/niosh/topics/aerosols/pdfs/aerosol_101.pdf

06/14/2020

What size particles do we care about?

Coronaviruses are roughly 125 nm in diameter, so anything 100 nm or bigger.



particles were 50 - 825 nm in diameter.

Figure S3: Most penetrating particle size (MPPS). From Zangmeister etal 2020

Efficacy of the materials used in cloth face masks (NaCl particle tests) 06/14/2020

- **Rengasamy et al, "Simple Respiratory Protection—Evaluation of the Filtration Performance of Cloth Masks and Common Fabric Materials Against 20–1000 nm Size Particles", 2010**
  - 20–1000 nm
  - Air velocities 5.5 and 16.5 cm/s
  - measured T-shirts, sweatshirts, towel, scarf, commercial cloth masks
  - Pressure drops: T-shirts (e.g. Hanes) 120 – 213 Pa pressure drop. (100 cm^2 fabric area, air velocity 5.5 cm/s)
  - Most materials blocked 10 – 40% of particles in the 100 – 1000 nm regime (air velocity 5.5 cm/s). A few towels did better with particles at the smaller end of this size range.

- **Konda et al, "Aerosol Filtration Efficiency of Common Fabrics Used in Respiratory Cloth Masks" ACS Nano, April 2020.**
  - 10 nm – 100 microns
  - Air velocities 10 and 26 cm/s
  - measured cotton (various threads per inch TPI), silk; flannel, chiffon and combinations
  - Pressure drops were 2 – 3 Pa (59 cm^2 fabric area, air velocity 10 cm/s)
  - 600 TPI cotton blocked > 60% of particles, silk blocked 40-50%, a surgical mask 60 – 98% in the 100 – 1000 nm regime. Fabric combinations gave results similar to an N95 mask.
  - For particles greater than 1 micron, filtration efficiency increases with particle size.

Efficacy of the materials used in cloth face masks (NaCl particle tests) 06/14/2020

- **Zangmeister et al, "Filtration Efficiencies of Nanoscale Aerosol by Cloth Mask Materials Used to Slow the Spread of SARS-CoV-2, June 2020**
  - 50 – 825 nm
  - Air velocity 6.3 cm/s
  - Measured cotton, wool, synthetics, blends
  - Pressure drops: ~0 – 300 Pa (fabric area 25 cm^2, air velocity 6.3 cm/s)
  - All of the cloth as well as the surgical mask materials blocked < 50% of particles (including 600 TPI cotton)
    - Many materials blocked about 20%, surgical and a few cloth materials blocked about 25 – 35%.
    - material from an N95 mask blocked particles as expected
    - Particles > 825 are blocked better, than the average for particles 50-825 nm

Conclusions:

- Cloth materials may not be very efficient at blocking NaCl particles of the size particles emitted by speaking humans.
  - There is discrepancy between reports (e.g. 600 TPI cotton).
    - The pressure drops reported by Konda et al. (which is also the paper reporting the greatest efficacy) are anomalously low.

Tests of efficacy when people wear masks 06/14/2020

- **van der Sande et al, "Professional and Home-Made Face Masks Reduce Exposure to Respiratory Infections among the General Population" PLoS One 2008**
  - candles were used as the particulate source
  - Tests of adults and children wearing masks; no activity, nodding (yes), shaking head (no), reading, walking in place
  - Tested tea cloth mask, surgical mask, FFP2 (European analog of N95).
  - Outside to inside protection factors were 2-3 for the tea cloth, 2-11 for surgical mask.
    - Inside to outside reduction in particle concentrations were a factor of ~1.25. However, this measurement was probably inaccurate; the FFP2 mask only reduced particle concentration by a factor of 3.

- **Davies et al, "Testing the Efficacy of Homemade Masks: Would They Protect in an Influenza Pandemic?" 2013**
  - masks made from 100% cotton T-shirt material
  - Volunteers wearing masks coughed into a chamber containing culture plates underneath a size separator.
  - The 1.1-2.1 micron range contained the most particles, and there was a clear reduction in culturable particles when either a surgical or homemade mask was worn – more than a factor of 5 in this size range. The surgical mask was roughly a factor of 2 better than the homemade masks.
  - The same study looked at the ability of several materials (cotton T-shirt, scarf, tea towel, pillowcase, linen, silk) to filter *B. atrophaeus* (a rod shaped bacterium, ~1 micron) and a bacteriophage (MS2, 23 nm in diameter)
    - For *B. atrophaeus*, filtration efficiencies were all greater than 50%, and still above 40% of the bacteriophage.
    - Pressure drops were similar between most materials and the surgical mask.

Face shields 06/14/2020

- **Lindsley et al, “Efficacy of face shields against cough aerosol droplets from a cough simulator”, J. Occ and Env. Hygiene (2014)**
  - Chamber ~10’ x 10’ x 7’
  - Cough simulator included influenza virus
  - Two distributions of particle sizes were used. mean = 8.5 microns, mean = 3.4 microns
    - The smallest was larger than the emitted size distribution when people speak
  - In one set-up for which virus was collected for 5 min. after a cough, virus collection was reduced by 96% when the large particle distribution was used, but by only 68% when the small particle distribution was used.
  - When virus was collected for longer times, the reduction was less pronounced (81% vs 96%).

- **Ronen et al, not peer-reviewed, “Examining the protection efficacy of face shields against cough aerosol droplets using water sensitive papers”**
  - Particles appear to all be bigger than 1 micron
  - Efficacy of face face masks for blocking large particle appears quite good.

Discussion/Summary - Data from 06/14/2020

- **Masks and Face shields can block larger particles**
  - Blocks nose, mouth and eyes

- **Masks block some of the small particles**
  - Blocks nose and mouth

- **Exposure thru the eyes is not well quantified, but could be significant**
  - For Respiratory Syncytial Virus the eye and nose routes appear equally sensitive Hall et al, "Infectivity of Respiratory Syncytial Virus by Various Routes of Inoculation" Infection and Immunity, Sept.1981,p.779-783
  - A recent meta-analysis states “Two studies [regarding SARS] provided adjusted estimates with n=295 in the eye protection group and n=406 in the group not wearing eye protection; results were similar to the unadjusted estimate (aOR 0·22, 95% CI 0·12–0·39)”. The same meta-analysis gives an aOR of 0.15 for masks vs no-masks (Masks are surgical or better.). Chu et al, “Physical distancing, face masks, and eye protection to prevent person-to-person transmission of SARS-CoV-2 and COVID-19: a systematic review and meta-analysis” Lancet June 2020

- **Good air ventilation is critical to removing the smaller possibly virus laden particles**
  - There is evidence that pre-symptomatic people transmit (this includes people who haven’t noticed their symptoms), particles emitted while breathing and speaking need to be blocked/removed

PPE effectiveness: Efficacy of common materials for filtration 06/14/2020

- **Penetration of particles thru T-shirts, sweathshirts, towels, etc, was 40 - 90% (and depended on particle size).**
  - Rengasamy et al. "Simple Respiratory Protection—Evaluation of the Filtration Performance of Cloth Masks and Common Fabric Materials Against 20–1000 nm Size Particles" Ann. Occup. Hyg., Vol. 54, No. 7, pp. 789–798, 2010

- **Filtration efficacy of cotton, silk, and flannel varied from < 10% for low thread per inch (TPI) cotton to > 60% for a wide variety of sizes for 600 TPI cotton. Combinations of materials (cotton/silk, cotton/flannel) has similar filtration efficiencies to N95 masks.**
  - Konda et al, "Aerosol Filtration Efficiency of Common Fabrics Used in Respiratory Cloth Masks", ACS Nano 2020, 14, 6339−6347.

- **Surgical masks filter coronavirus particles**
  - Leung et al, "Respiratory virus shedding in exhaled breath and efficacy of face masks," Nature MEDICINE | VOL 26 | May 2020 | 676–680.

Mask effectiveness 06/04/2020

- **Particle spread is reduced by roughly a factor of 3 to 5 with a cloth mask : Masks are about 80% as effective for kids as adults**
  - Davies et al, "Testing the Efficacy of Homemade Masks: Would They Protect in an Influenza Pandemic?" Disaster Medicine and Public Health Preparedness 2013
- **Tea Cloth Masks give roughly a factor of 2 reduction in particles getting to children’s mouths**
  - van der Sande, "Professional and Home-Made Face Masks Reduce Exposure to Respiratory Infections among the General Population" PLoS One 2008
- **Exposure thru the eyes is not well quantified, but could be significant: For Respiratory Syncytial Virus the eye and nose routes appear equally sensitive**
  - Hall et al, "Infectivity of Respiratory Syncytial Virus by Various Routes ofInoculation" INFECTION AND IMMUNITY, Sept.1981,p.779-783

Mask effectiveness – 11/23/2020

- **Particle spread is reduced by roughly a factor of 3 to 5 with a cloth mask : Masks are about 80% as effective for kids as adults**
  - Davies et al, "Testing the Efficacy of Homemade Masks: Would They Protect in an Influenza Pandemic?" Disaster Medicine and Public Health Preparedness 2013
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