Modeling & Forecasting COVID-19 in NM

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Cumulative Cases & Daily Growth Rate for NM: Nov 22

Sierra, Socorro, Harding have elevated cumulative growth rates

*Growth rate is in cumulative cases
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 growth.

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
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/
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.
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

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 slow decrease 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

11/23/2021 |   3
Los Alamos National Laboratory

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

• 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.

Screen shot of CDC variant data only, no static image available
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 100,000 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 †

* 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.

Also: Chu et al. The Lancet 27 June 2020
The historical basis for *updated science* re: respiratory masking guidance has become clear over the last 18 months. 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 p.m. 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...
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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The COVID-19 pandemic has exposed major gaps in our understanding of the transmission of viruses through the air. These gaps—dashed recognition of airborne transmission of the disease, contributed to misaligned 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, forward-thinking and effective public health policies.
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 H₂O 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 mmH₂O (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

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


### Time to settle 5 ft (unit density spheres)

<table>
<thead>
<tr>
<th>Aerodynamic diameter (microns)</th>
<th>time</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>41 hours</td>
</tr>
<tr>
<td>1</td>
<td>12 hours</td>
</tr>
<tr>
<td>3</td>
<td>1.5 hours</td>
</tr>
<tr>
<td>10</td>
<td>8.2 minutes</td>
</tr>
<tr>
<td>100</td>
<td>5.8 seconds</td>
</tr>
</tbody>
</table>

[https://www.cdc.gov/niosh/topics/aerosols/pdfs/aerosol_101.pdf](https://www.cdc.gov/niosh/topics/aerosols/pdfs/aerosol_101.pdf)
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 et al 2020
Efficacy of the materials used in cloth face masks (NaCl particle tests) 06/14/2020

  ➢ 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.

  ➢ 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

  – 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, sweatshirts, towels, etc, was 40 - 90% (and depended on particle size).

• 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.

• Surgical masks filter coronavirus particles
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

• Tea Cloth Masks give roughly a factor of 2 reduction in particles getting to children’s mouths

• Exposure thru the eyes is not well quantified, but could be significant: For Respiratory Syncytial Virus the eye and nose routes appear equally sensitive
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

• Tea Cloth Masks give roughly a factor of 2 reduction in particles getting to children’s mouths

• Exposure thru the eyes is not well quantified, but could be significant: For Respiratory Syncytial Virus the eye and nose routes appear equally sensitive