COVID-19 for India Updates

March 24, 2020

Eili Klein (Assistant Professor, Department of Emergency Medicine, Johns Hopkins School of Medicine)
Gary Lin (Post-doctoral fellow, Department of Emergency Medicine, Johns Hopkins School of Medicine)
Katie Tseng (CDDEP)
Emily Schueller (CDDEP)
Geetanjali Kapoor (CDDEP)
Ramanan Laxminarayan (CDDEP; Senior Associate, Johns Hopkins Bloomberg School of Public Health; Senior Research Scholar, Princeton University)

*Our COVID-19 modeling estimates for India were produced by a team of researchers affiliated with CDDEP, Johns Hopkins, and Princeton. This work does not reflect the views of CDDEP, Johns Hopkins University or Princeton University.

CDDEP THE CENTER FOR Disease Dynamics, Economics & Policy WASHINGTON DC • NEW DELHI

JOHNS HOPKINS UNIVERSITY

PRINCETON UNIVERSITY

IndiaSIM

- We use IndiaSIM, a well-validated agent-based model of the Indian population. This has been published widely over many years and has been used for government decision-making including by NTAGI for vaccine introduction. A brief summary of the model is attached. The model describes the actual Indian population in full detail of demography (age, gender), location, socio-economic characteristics and access to healthcare. Our unit of analysis is an actual simulated Indian and estimates are reliable down to the district level. The model is fitted to the most recently available NFHS and census data and uses state-of-art agent-based modeling methods.
- We fitted the model to available data from China and Italy. Key parameters include force of infection, age- and gender-specific infection rates, severe infection and case-fatality rates. Seasonality was assumed based on the idea that most respiratory infections decline in the summer and although Covid-19's temperature and humidity is not well understood, it is reasonable to assume that some characteristics of seasonal influenza apply here.

Scenarios

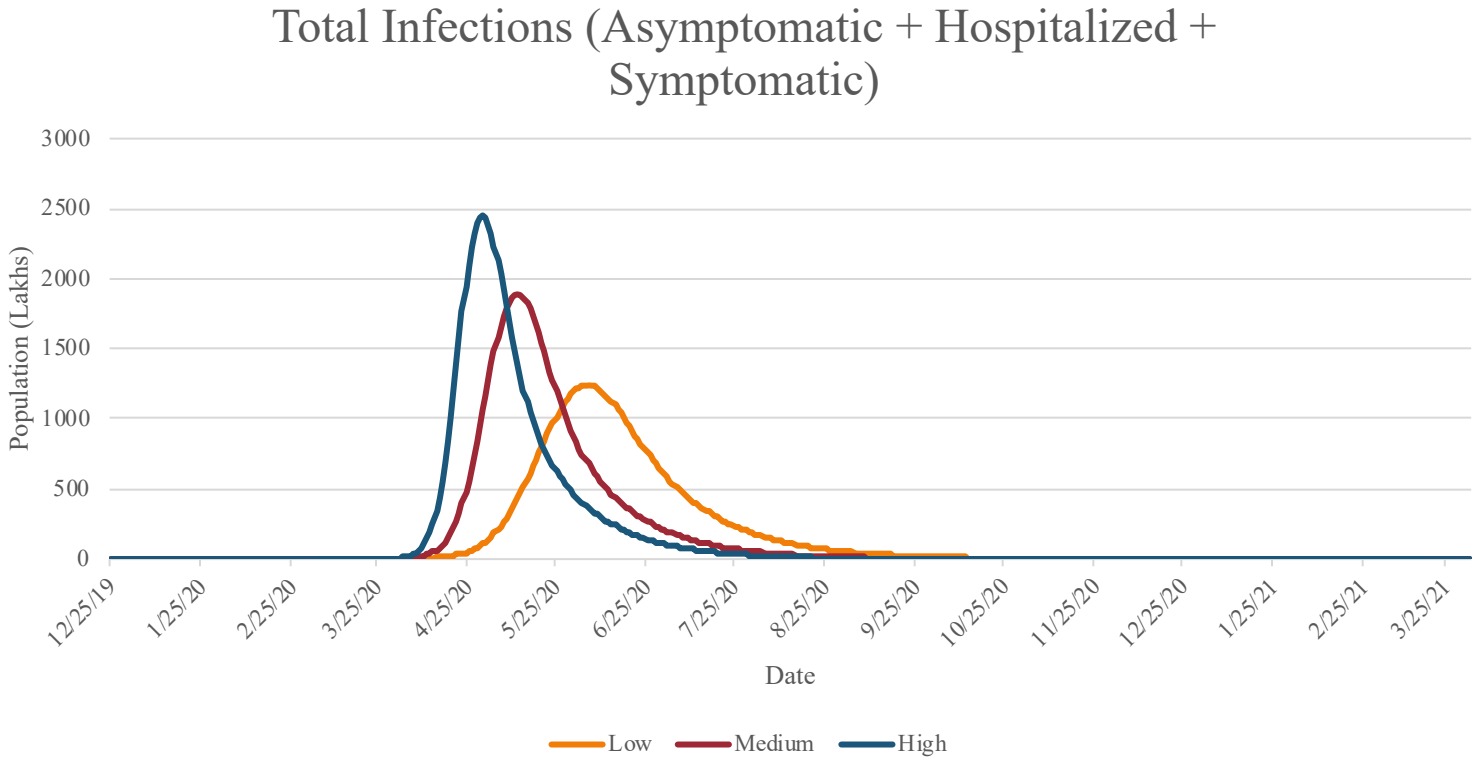
- High – trajectory with current lockdowns but insufficient physical distancing or compliance.
- Medium – Most likely scenario with moderate to full compliance but no change in virulence or temperature/humidity sensitivity.
- Low – Optimistic scenario with decreased virulence and temperature/humidity sensitivity.

What's behind the state estimates

State level estimates are driven by

- Date of seeding of the epidemic based on available testing data
- Presence of major metro cities where initial transmission is more rapid.
- Flight connections to Covid19 affected countries.
- Age and demographic variables

Predicted Infections from COVID-19 in India

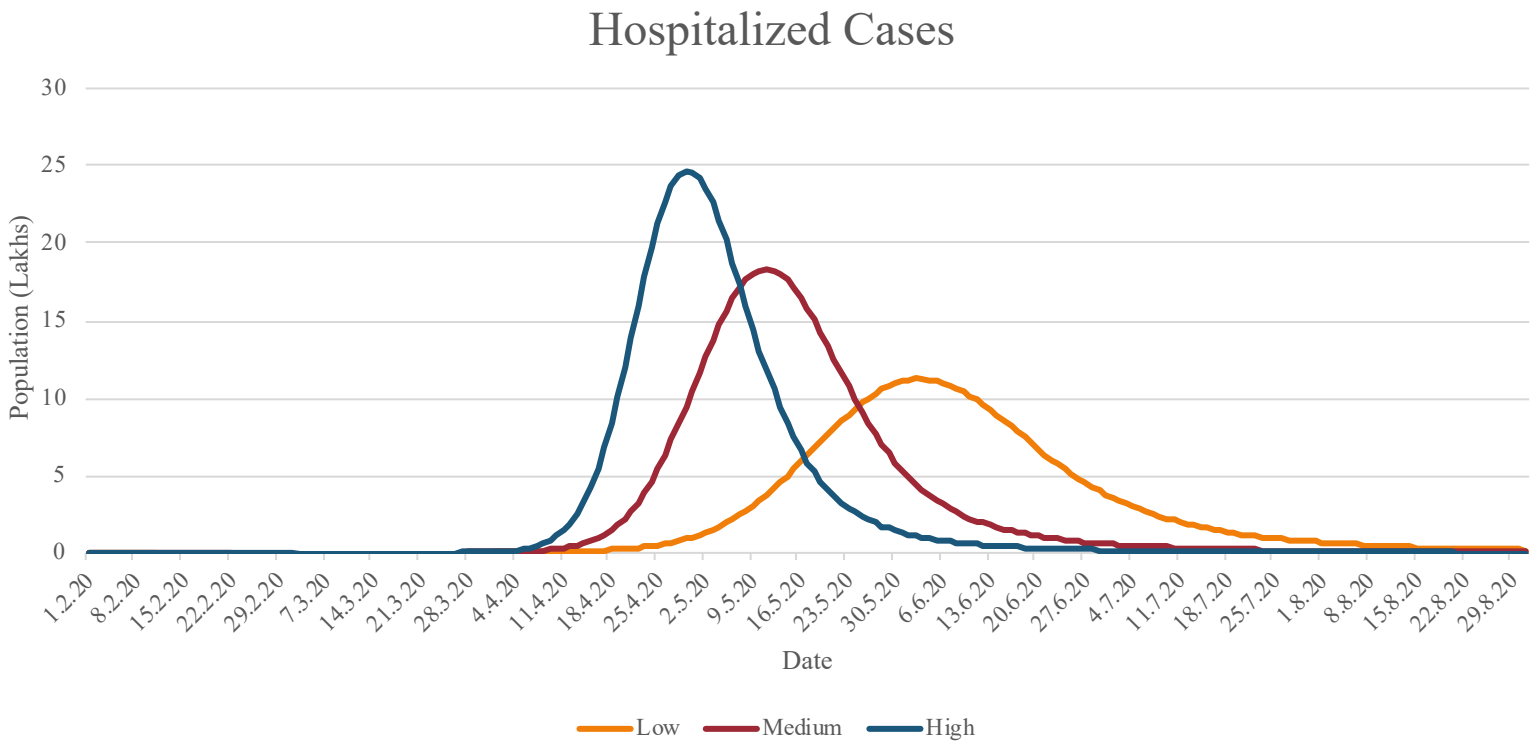


CDDEP THE CENTER FOR Disease Dynamics, Economics & Policy WASHINGTON DC • NEW DELHI

JOHNS HOPKINS UNIVERSITY

PRINCETON UNIVERSITY

Predicted Hospitalizations from COVID-19 in India

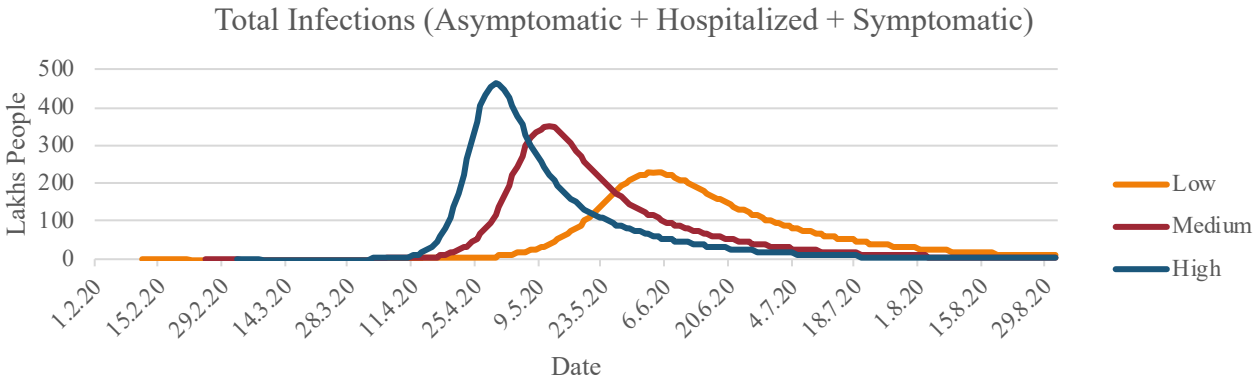


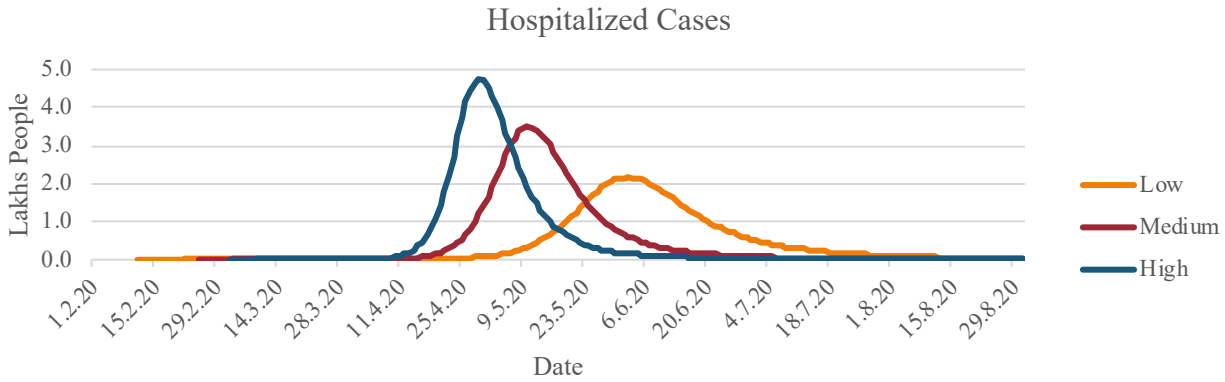
CDDEP THE CENTER FOR Disease Dynamics, Economics & Policy WASHINGTON DC • NEW DELHI

JOHNS HOPKINS UNIVERSITY

PRINCETON UNIVERSITY

UTTAR PRADESH



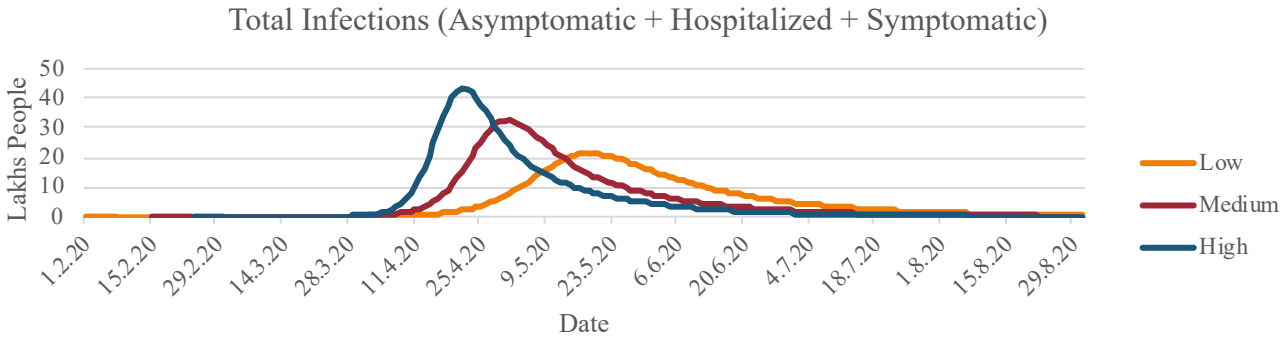


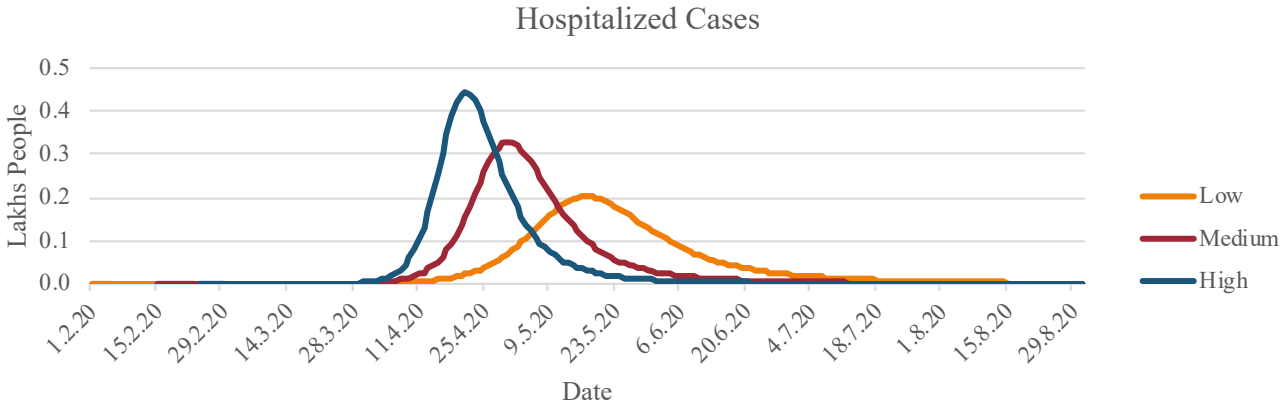
CDDEP THE CENTER FOR Disease Dynamics, Economics & Policy WASHINGTON DC • NEW DELHI

JOHNS HOPKINS UNIVERSITY

PRINCETON UNIVERSITY

DELHI



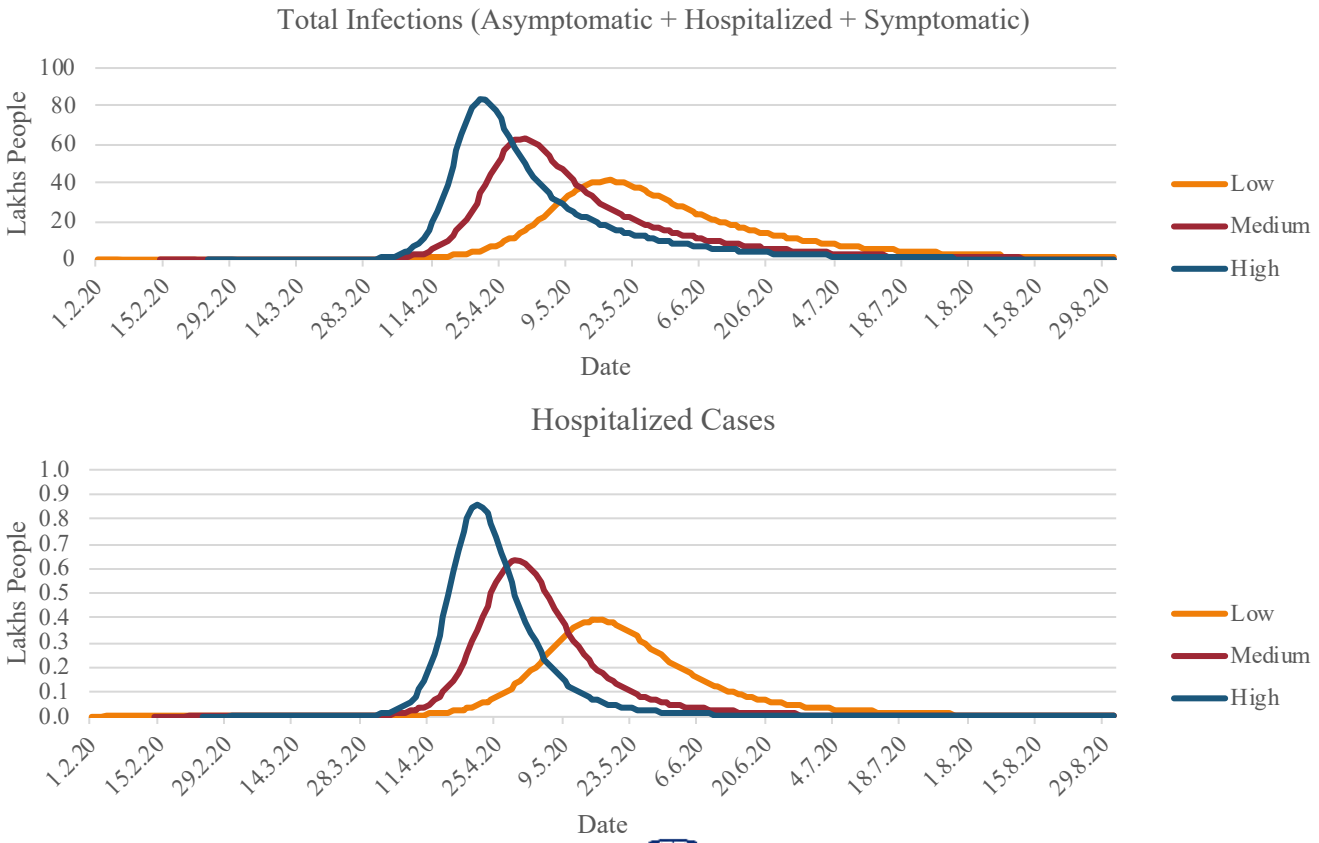


CDDEP THE CENTER FOR Disease Dynamics, Economics & Policy WASHINGTON DC • NEW DELHI

JOHNS HOPKINS UNIVERSITY

PRINCETON UNIVERSITY

KERALA

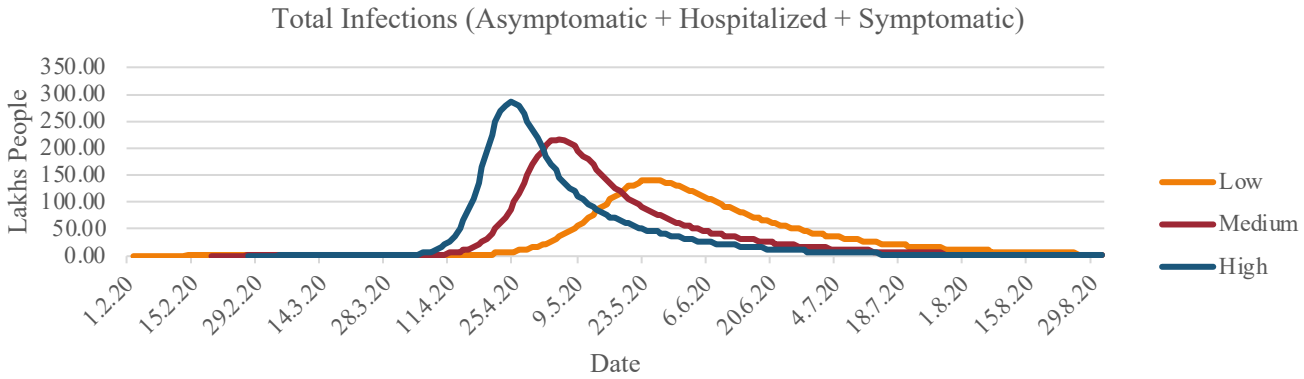


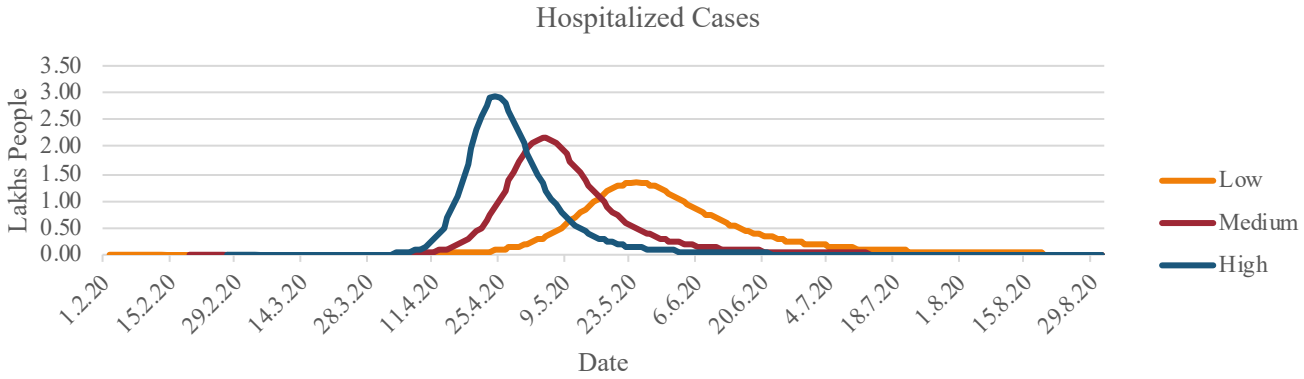
CDDEP THE CENTER FOR Disease Dynamics, Economics & Policy WASHINGTON DC • NEW DELHI

JOHNS HOPKINS UNIVERSITY

PRINCETON UNIVERSITY

MAHARASHTRA



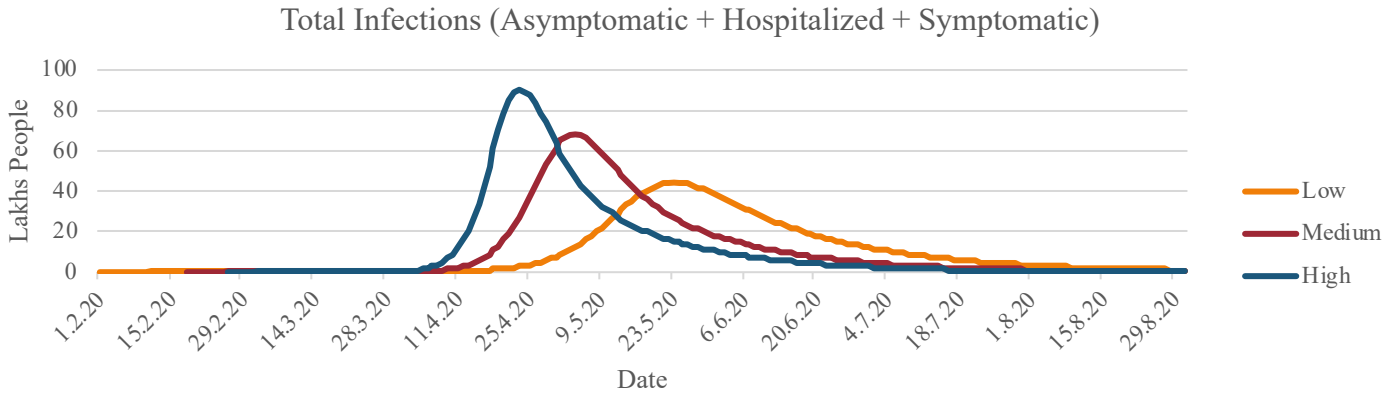


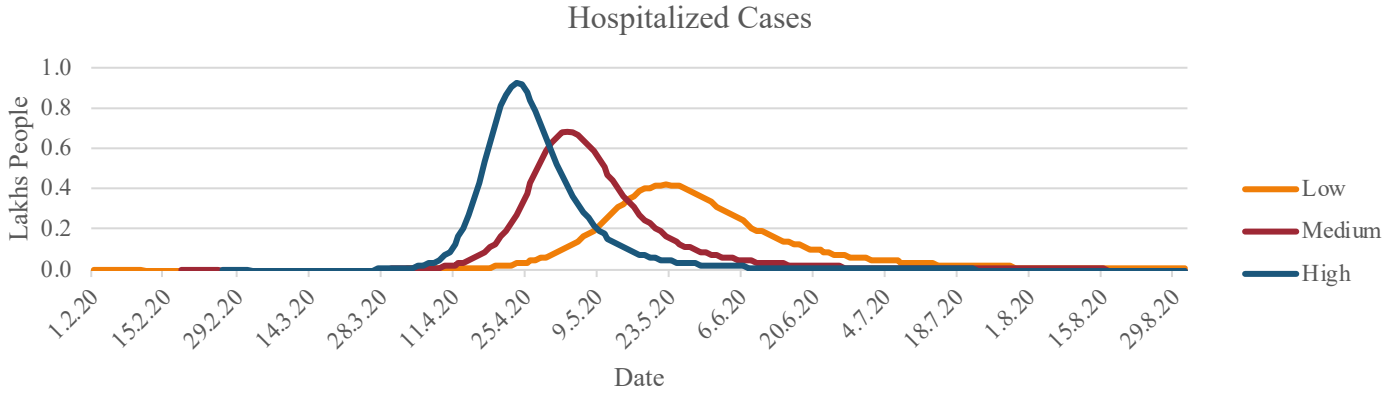
CDDEP THE CENTER FOR Disease Dynamics, Economics & Policy WASHINGTON DC • NEW DELHI

JOHNS HOPKINS UNIVERSITY

PRINCETON UNIVERSITY

TELANGANA





CDDEP THE CENTER FOR Disease Dynamics, Economics & Policy WASHINGTON DC • NEW DELHI

JOHNS HOPKINS UNIVERSITY

PRINCETON UNIVERSITY

Main Takeaways

1. Estimates are based on IndiaSIM, an agent-based model of the Indian population. This model is focused on the period up to July.
2. Immediate social distancing focused on the elderly population is essential. We have modeled a three-week period of complete isolation for the elderly. The longer this period, the more we are able to delay infections into the post-July period.
3. Model is sensitive to hospital outbreaks of COVID19 induced by admission of infected patients into hospitals. Need for large, temporary hospitals to handle this load over the next three-month period. Secondary, hospital-based transmission fuels the epidemic.
4. Testing, particularly of those coming in with respiratory symptoms is essential to separate those in hospitals. **Need two-stage, preemptive testing in symptomatic elderly immediately to reduce deaths.**
5. Immediate and continuing serological surveys needed to monitor the stage of the epidemic. We are currently flying blind.
6. Ventilator demand will be 1 million. Current availability in India is estimated to be between 30K and 50K ventilators (the US has 160K and is running short in most places).
7. Mortality in healthcare workers could further increase deaths in the general population. Healthcare workers need personal protective equipment (i.e., masks and gowns) to protect themselves. Without them they get sick further straining the capacity of the healthcare system to respond

Summary for Policy

1. Delays in testing are seriously reducing the ability of the population to protect itself. This is the most important way in which we can contain the epidemic. An increase in the official number of detected cases in the short term could encourage the population to take distancing more seriously and will reduce panic compared to a big spike later.
2. Border closures at this stage have little to no impact and add further economic disruption and panic. While international transmission was important in the first stage, domestic transmission is now far more relevant.
3. A national lockdown is not productive and could cause serious economic damage, increase hunger and reduce the population resilience for handling the infection peak. Some states may see transmission increase only after another 2 weeks and lockdowns should be optimized for when they could maximize the effect on the epidemic but minimize economic damage. State level lockdowns in the most affected states could change the trajectory of the epidemic and should commence ***immediately***. Any delay allows for more secondary cases to emerge. Lockdowns should be guided by testing and serological survey data and should be planned on a rolling basis. We will expand these recommendations shortly.
4. Preparedness for case load should be the highest priority at this time. We will be issuing guidance based on the model for state level needs for bed capacity, oxygen flow masks and tanks and ventilators.
5. Temperature and humidity increases should help us in reducing case load. Although the evidence is limited, it is plausible.
6. We need to focus on both children under the age of five and the elderly. Early testing and healthcare in this population could help significantly reduce the mortality toll of the epidemic.
7. We should be prepared for multiple peaks in the model (we have only shown what happens in July) and we should be prepared for more cases and deaths later in the year.

For research, updates and tools on drug resistance and other global health topics, visit:

www.cddep.org

Thank you!

CDDEP THE CENTER FOR Disease Dynamics, Economics & Policy
WASHINGTON DC • NEW DELHI

JOHNS HOPKINS UNIVERSITY

PRINCETON UNIVERSITY

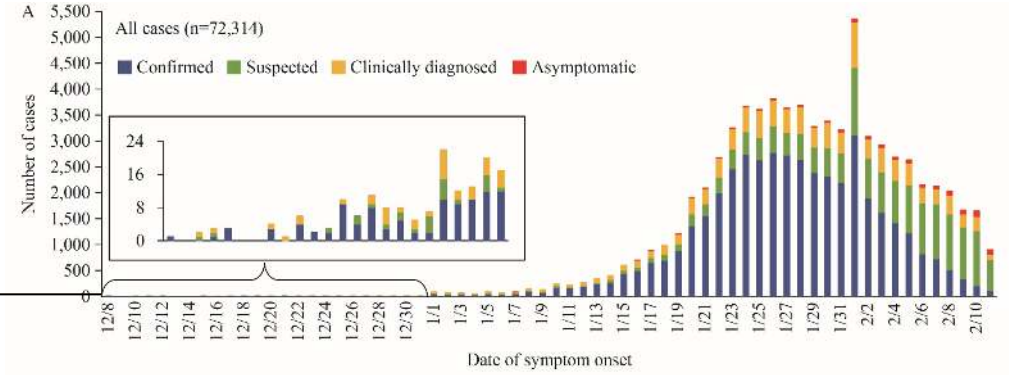
Background Slides

Current Situation

- Data from China and models suggest that by the time cases are recognized there has already been transmission ongoing for weeks
- In India initial infections likely first arrived in early February

Data from Wuhan

Potentially first case in November



CDDEP THE CENTER FOR Disease Dynamics, Economics & Policy WASHINGTON DC • NEW DELHI

JOHNS HOPKINS UNIVERSITY

PRINCETON UNIVERSITY

Projections for India

- Created using IndiaSIM, a validated, simulated population of the Indian population based on NFHS and other national data. Previously used for NTAGI for vaccine introduction modeling.
  - Each individual in this simulated model represents an actual Indian in terms of age, income, location, health system access and other covariates found in NFHS data.
- Why might India do better than other countries?
  - Relatively young population.
  - Seasonality that is expected for COVID-19 could delay infections into later in the year.
- Why might India do worse?
  - Nutrition challenges in younger population relative to China and Italy with unknown impacts on children.
  - Greater opportunities for disease transmission and difficulty of social distancing.

Transmissibility of COVID-19

Reproduction Number (R_0) –

The average number of people an infected person will infect

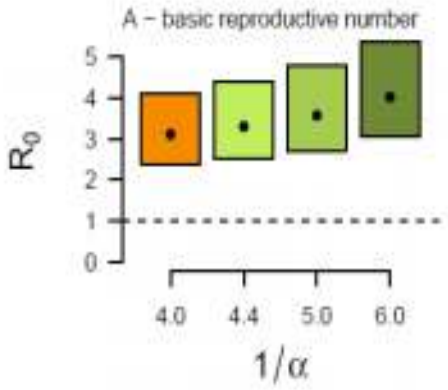
Based on Contact Rates –

i.e. How many people a person contacts

And the probability the virus is transmitted

Best estimate is that R_0 is between 2 and 3

Emerging evidence that increased temperature and humidity would reduce this to 1.8 in a month.



https://doi.org/10.1101/2020.01.23.20018549.

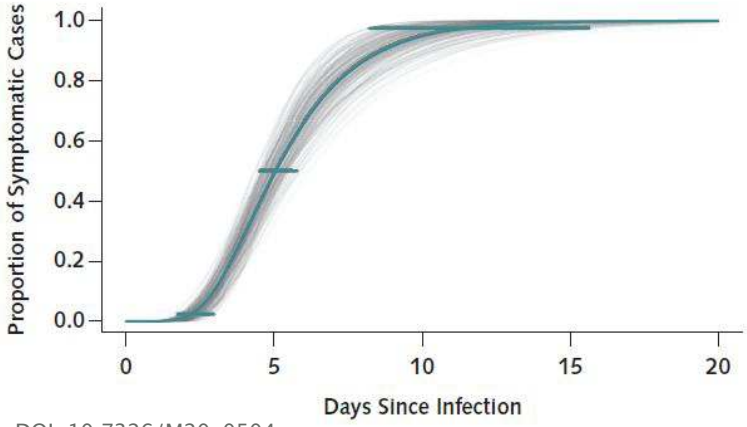
CDDEP THE CENTER FOR Disease Dynamics, Economics & Policy WASHINGTON DC • NEW DELHI

JOHNS HOPKINS UNIVERSITY

PRINCETON UNIVERSITY

Disease Timeline: Transmission without symptoms

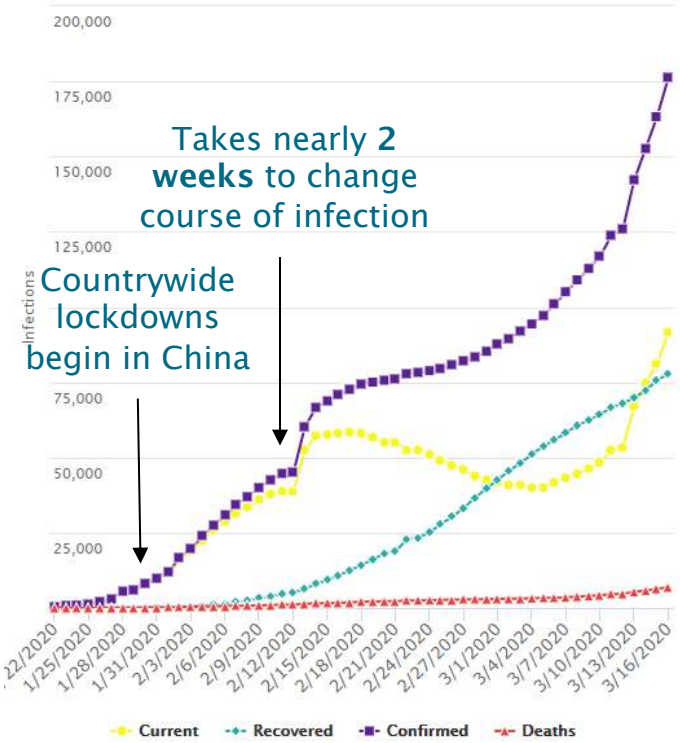
- Disease Parameters:
  - Incubation time: 6 days (SD 2 days)
  - Time to hospitalization: 3.5 days (SD 1.8 days)
  - Days in Hospital: 12 days (SD 3.4 days)
  - Contagious time non-hospital: 9 days (SD 3 days)



DOI: 10.7326/M20-0504

The dynamics are slowed –
People who will show symptoms next week are **already infected** and incubating the virus. Some of these will transmit **before** they are symptomatic.

Global Trends in Confirmed Cases



CDDEP THE CENTER FOR Disease Dynamics, Economics & Policy WASHINGTON DC • NEW DELHI

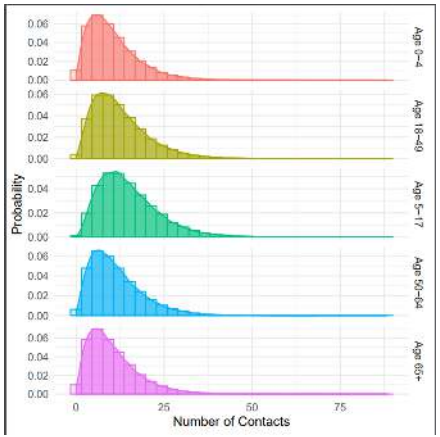
JOHNS HOPKINS UNIVERSITY

PRINCETON UNIVERSITY

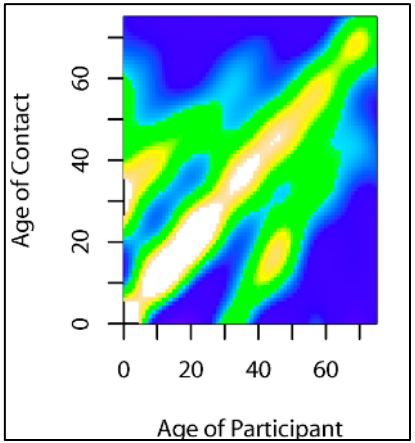
Model Assumptions

- Contact and Transmission depends on type of contact and with whom contact is made
  - Contact patterns highly variable by age (e.g. kids have higher rates of contact[1]).
  - Household contact rates are higher than outside contacts.
  - Age-related assortative contact patterns[1]

Contact Rates by Age

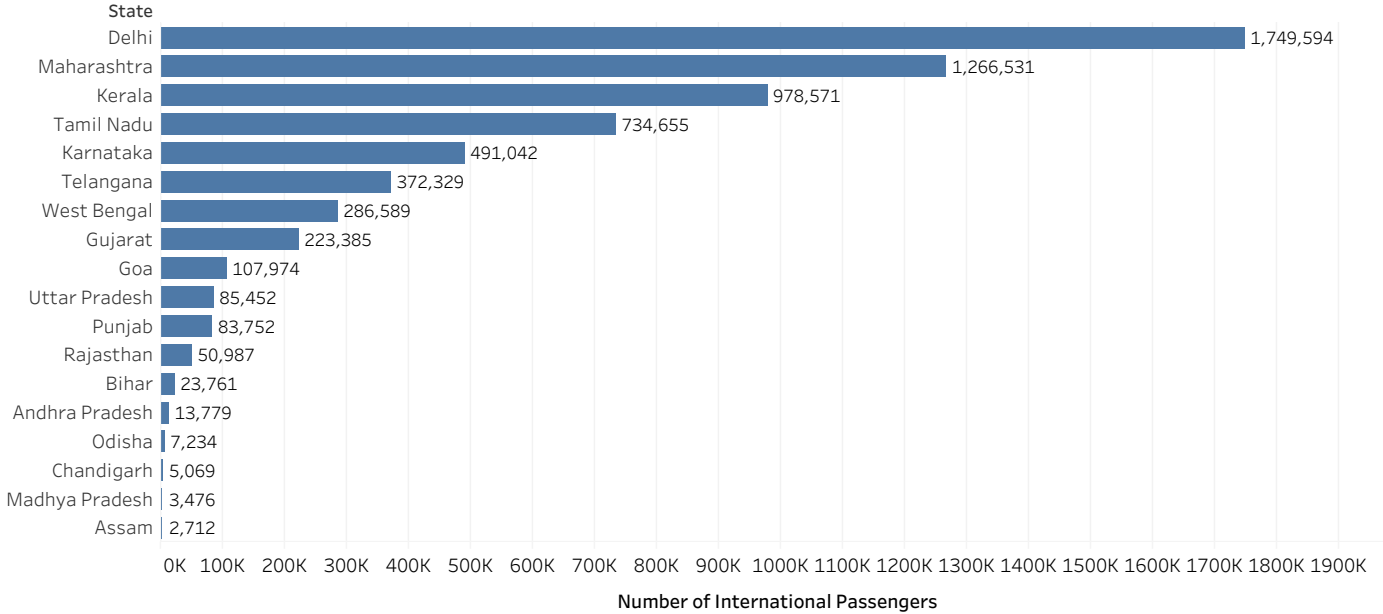


Age Assortative Contact



1. 10.1371/journal.pmed.0050074

Number of International Airline Travelers by Indian State, January 2020



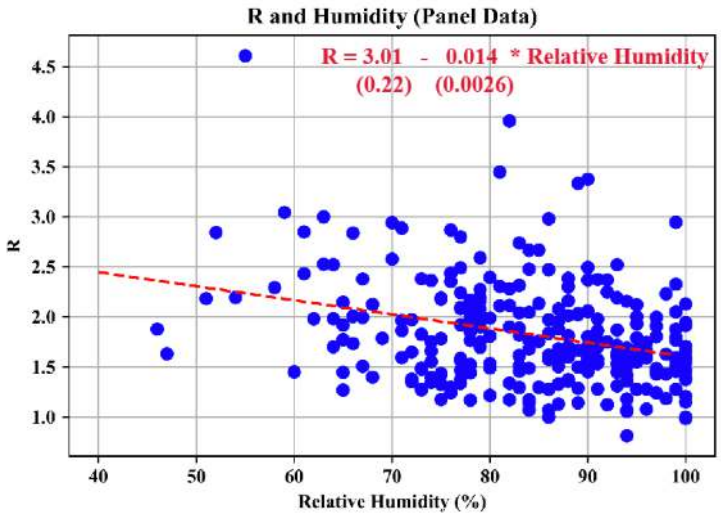
CDDEP THE CENTER FOR Disease Dynamics, Economics & Policy WASHINGTON DC • NEW DELHI

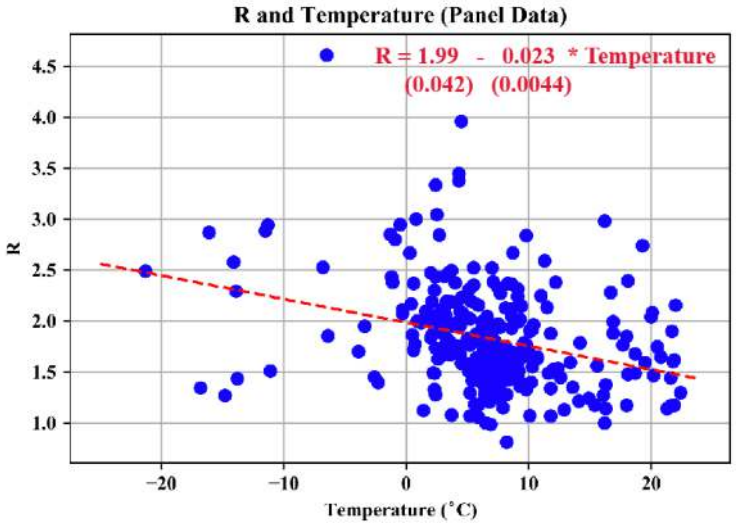
JOHNS HOPKINS UNIVERSITY

PRINCETON UNIVERSITY

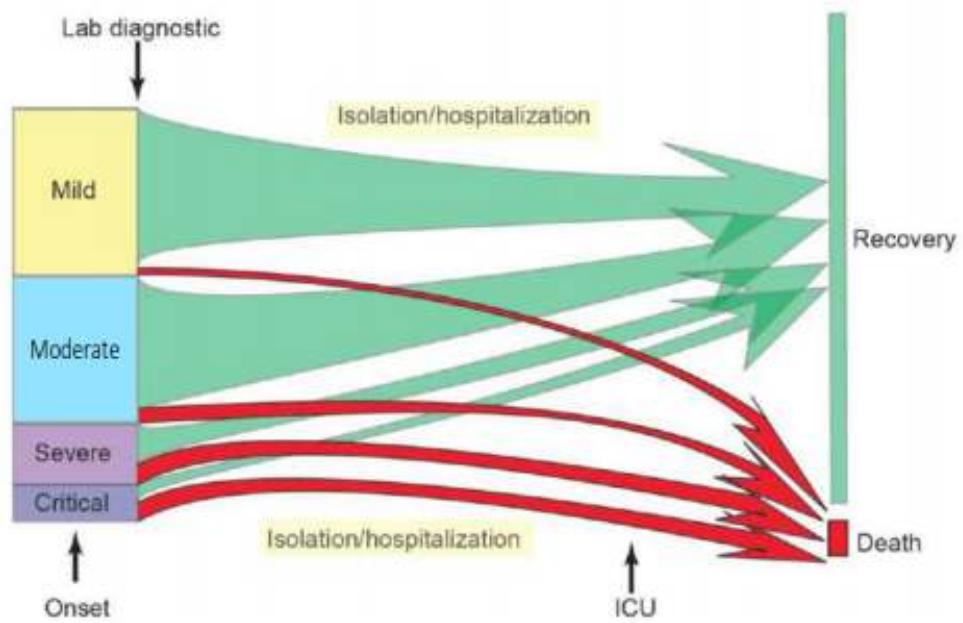
Temperature and humidity

Evidence from China indicates that higher temperature and humidity are likely to lower the transmission rates but it is unclear how this will translate to the India context.





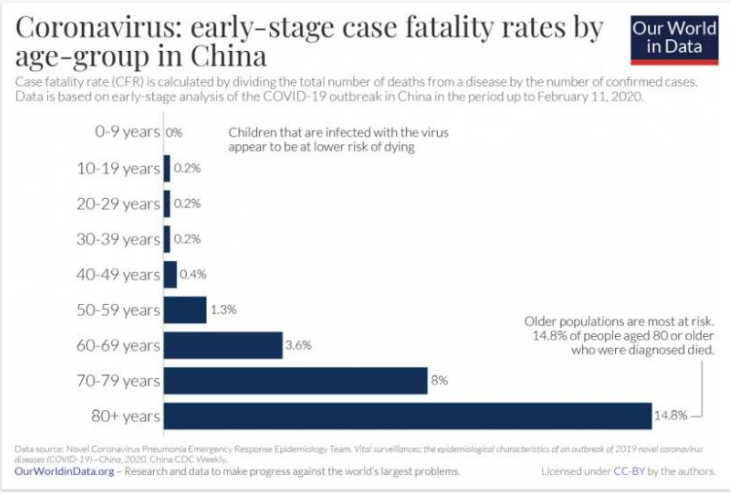
Mortality higher in older individuals



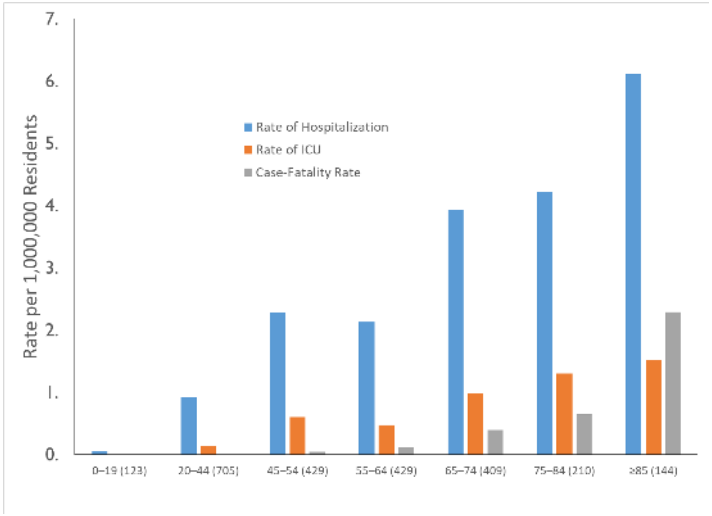
A large percentage of cases are mild, but for older individuals the mortality rate is strikingly higher

Mortality higher in older individuals

In China mortality was much higher in the elderly…



…The US is similar.



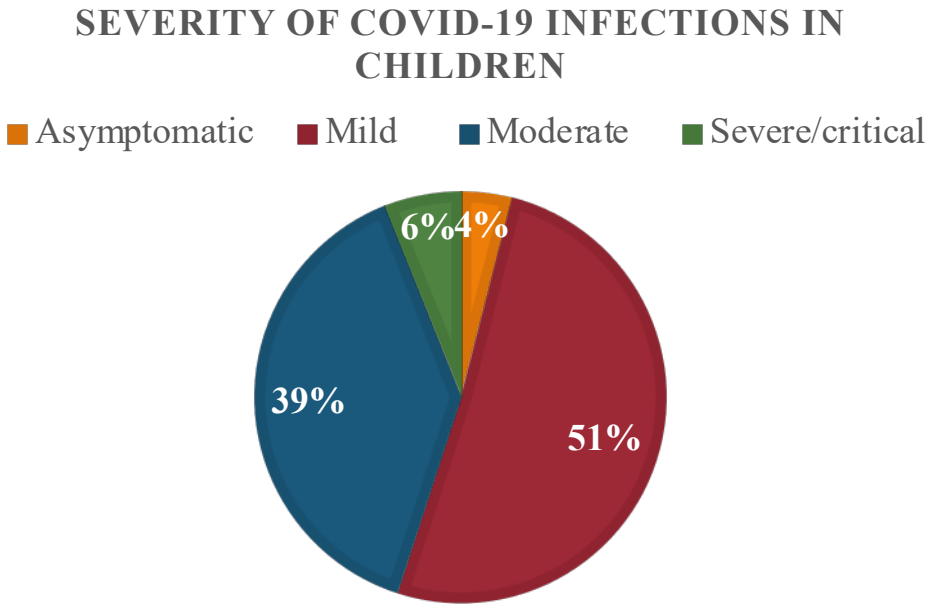
CDDEP THE CENTER FOR Disease Dynamics, Economics & Policy
WASHINGTON DC • NEW DELHI

JOHNS HOPKINS UNIVERSITY

PRINCETON UNIVERSITY

Evidence on children

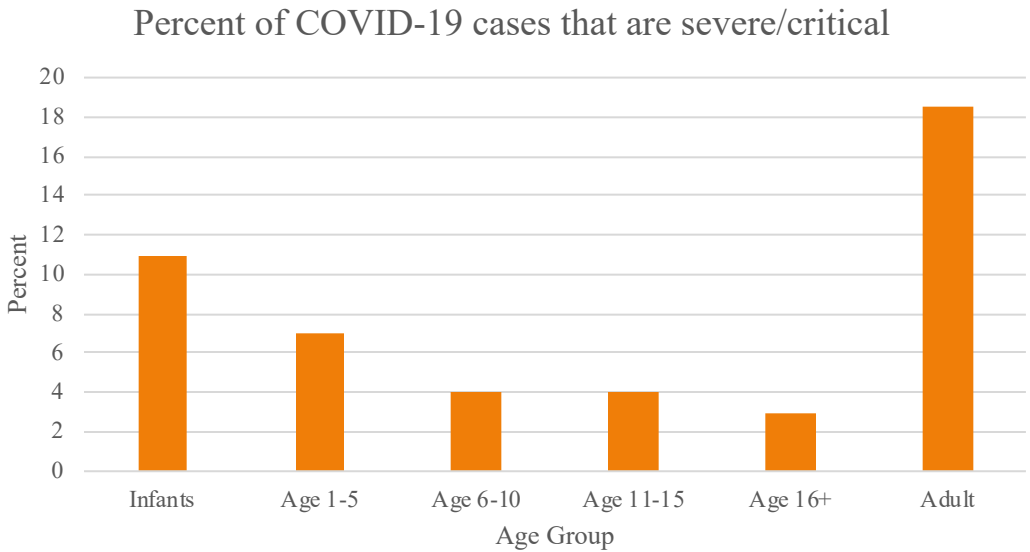
- Children are less likely to be infected and also less likely to be hospitalized than adults.
- Illness is less likely to be severe in children than in adults.



Source: Dong Y, et al. *Pediatrics*. March 16, 2020

Evidence on children

- Children have overall lower levels of severe or critical infection than adults.



Source: Dong Y, et al. *Pediatrics*. March 16, 2020

Country comparison: South Korea vs Italy

	South Korea	Italy
Population	51 M	60 M
Total testing (till March 17, 2020)	286,716	148,657
Mortality among those infected with COVID-19 (till Mar 17, 2020)	81 deaths	2,500 deaths Death toll has surpassed China's, becoming the country with the highest number of coronavirus deaths in the world
Death rate with COVID-19	0.7%	8%

S Korea: has been conducting around 12,000-15,000 tests every day, and has the capacity to do 20,000 daily; it has done ~ 250,000 tests till date.

Ref: 1. Population 2. Total testing 3. Business Insider

Testing protocol in South Korea

- Trace, test and treat protocol
- Early and efficient testing
- Drive-thru COVID-19 testing centers, Covid-19 testing tents, at-home testing kits
- External quality assessment services screen hospitals and health institutions before they are certified to test patients for the virus.
- **Disease surveillance system is "preemptive" in that it was scanning and discovering patients early on**

Testing protocol in South Korea

Test	Test category	Kit name (examples)	Company (examples)	Testing time	Accuracy	Specimen
Rapid diagnostic tests (RDTs)	Screening (antibody-based test)	COVID-19 Ag GICA Rapid	PCL	10 min	~85%	Nasal discharge
Real-time PCR	Confirmatory (nucleic acid-based test)		Seegene, Kogene, SolGent Co, Sd Biosensor	5-6 hours to 2 days	~98%	Nasopharyngeal specimen

Ref: 1. Population 2. Total testing 3. Business Insider

WHO Interim Guidance

- Screening of Naso/oropharyngeal swab (for upper respiratory) and sputum/endotracheal aspirate/bronchoalveolar lavage (for lower respiratory infection) with nucleic acid amplification tests (NAAT), such as RT-PCR.
- Also test for other respiratory pathogens using routine laboratory procedures.
- Serological surveys: aid investigation of an ongoing outbreak and retrospective assessment of the attack rate or extent of an outbreak.
- Viral sequencing: supports confirmation of the presence of the virus, regular sequencing of (some samples)-useful to monitor for viral genome mutations that might affect the performance of medical countermeasures, including diagnostic tests.

Source: WHO Interim Guidance 2nd March Laboratory testing for coronavirus disease 2019 (COVID-19) in suspected human cases.

WHO Interim Guidance | COVID-19 Lab confirmation protocol

Laboratory-confirmed by nucleic acid amplification tests (NAAT) in an area with no COVID-19 virus circulation

A positive NAAT result for at least two different targets on the COVID-19 virus genome, of which at least one target is preferably specific for COVID-19 virus using a validated assay (as at present no other SARS-like coronaviruses are circulating in the human population it can be debated whether it has to be COVID-19 or SARS-like coronavirus specific);

OR

One positive NAAT result for the presence of betacoronavirus, and COVID-19 virus further identified by sequencing partial or whole genome of the virus.

Laboratory-confirmed by NAAT in an area with established COVID-19 virus circulation

Simpler algorithm might be adopted in which e.g. screening by rRT-PCR of a single discriminatory target is considered sufficient.

One or more negative results do not rule out the possibility of COVID-19 virus infection.

Source: WHO Interim Guidance 2nd March Laboratory testing for coronavirus disease 2019 (COVID-19) in suspected human cases.

Surveillance networks were tapped to test COVID 19 in China

RT-PCR testing of COVID-19 virus in

- Influenza-like-illness (ILI) and
- Severe acute respiratory infection (SARI) surveillance systems
- Fever clinics

Transmission dynamics

- Transmission within health care settings and amongst health care workers does not appear to be a major feature of COVID-19 in China.
- Investigations among HCW suggest that many may have been infected within the household rather than in a health care setting.

Source: WHO Wuhan report of Joint Commission, https://www.who.int/docs/default-source/coronaviruse/who-china-joint-mission-on-covid-19-final-report.pdf