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Predictions and role of interventions for COVID-19 outbreak in India

Crisis Of Virus in INDia (COV-IND)



COV-IND-19 Study Group

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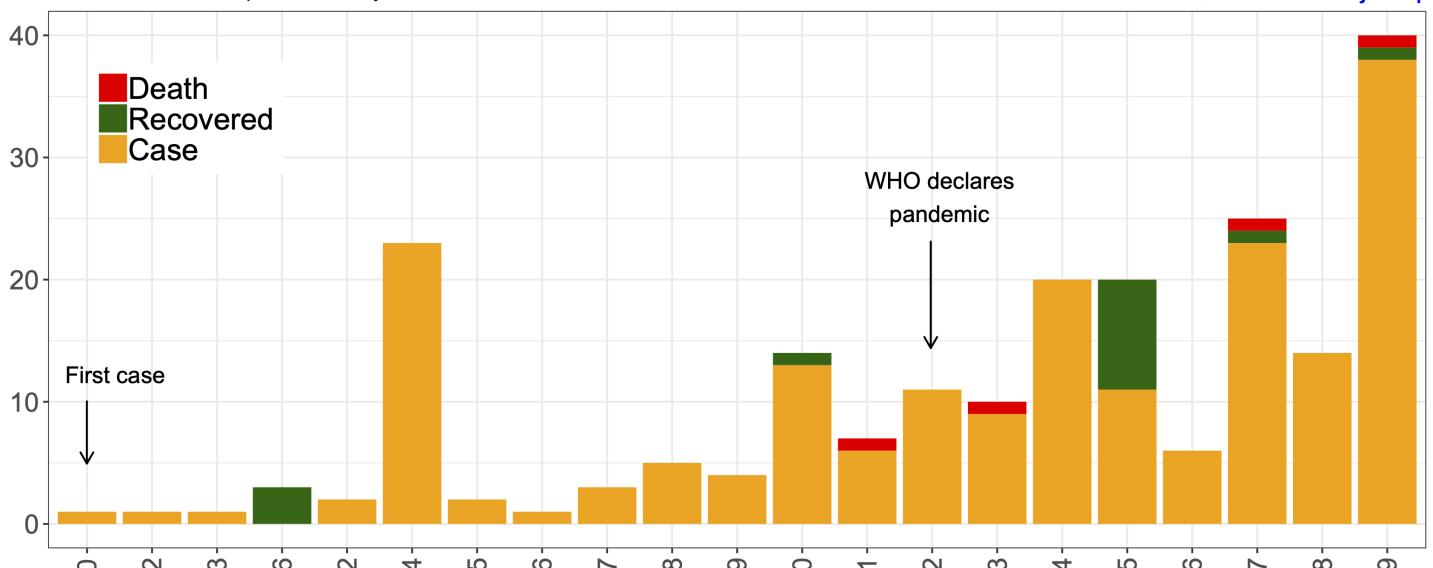
The following summary was prepared by the COV-IND-19 Study Group, an interdisciplinary group of scholars and data scientists (authors at end). An accompanying detailed report can be downloaded [here](#).

Four months since the first case of COVID-19 in Wuhan, China, the SARS-CoV-2 virus has engulfed the world and COVID-19 has been declared a global pandemic. The number of confirmed cases worldwide stands at a staggering 303,594 (as of 6:00 PM EST March 21, 2020, Microsoft bing coronavirus tracker). Of these, only 315 confirmed cases are from India (Figure 1), the world's largest democracy with a population of 1.34 billion (compare China at 1.39 billion and USA at 325.7 million).

COVID-19 Confirmed New Cases/Recovered/Deaths by Day in India

Data source: Johns Hopkins University CSSE

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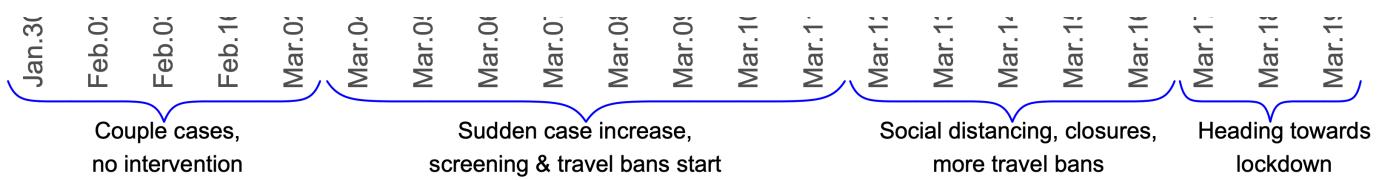


Figure 1. Description of the cases, recovered and fatalities in India with landmark policy/recommendations.

India is being vigilant and wise in instituting the right public health interventions at the right time including sealing the borders with travel ban/canceling almost all visas, closing schools and colleges in certain states and diligently following up with community inspection of suspected/exposed cases with respect to adherence of quarantine recommendations (see **Table 1** for details).

Table 1

While India seems to have done well in controlling the number of confirmed cases compared to other countries in the early phase of the pandemic (**Figure 2**), there is a critical missing or unknown component in this assessment: “**The number of truly affected cases**,” which depends on the extent of testing, the accuracy of the test results and, in particular, the frequency and scale of testing of asymptomatic cases who may have been exposed. The frequency of testing has been very low in India — only 11,500 subjects have been tested as of March 18. When there is no approved vaccine or drug for treating COVID-19, entering phase 2 or phase 3 of escalation will have devastating consequences on the already overstretched healthcare system of India. As seen for other countries like the US or Italy, COVID-19 enters gradually and then explodes suddenly.

Figure 2. Early phase of the epidemic and daily growth in cumulative case counts in India compared to other countries affected by the pandemic. The zero on the horizontal axis is the day where confirmed cases exceeded 50.

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The COV-IND-19 Study Group takes a data-driven approach to explore three extremely time-sensitive and important questions:

- What can India expect in the next few months?
- How will this affect the general public of India?
- How can the government and people of India prepare for this crisis?

We construct a predictive model for case counts in India and provide projections over a time horizon under hypothetical public health interventions of varying intensities. We provide a summary of our findings and recommendations (interested readers may take a look at our [detailed report](#)). We conclude that it is highly appropriate to adopt draconian measures for the largest democracy in the world, acting early, before the growth of COVID-19 infections in India starts to accelerate. We provide an assessment of the economic, social and healthcare implications for such interventions in India. We conclude that until we acquire biological herd immunity from COVID-19, there is need for social and economic immunity: not just coverage for testing and treatment for COVID-19 for everyone in India, but subsidies and incentives for the common public to survive the consequences of the severe interventions that are needed to stop the virus from creating a catastrophe in India.

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1. How many COVID-19 cases can we expect in India in the next few weeks?

We analyzed the current data from India with standard epidemiologic tools of modeling disease transmission and estimating the theoretical number of infected at any given time [Song et al. 2020], and compared projections for India against US and Italy. We used current daily data (up to March 16) from the 2019 Novel Coronavirus Visual Dashboard operated by the Johns Hopkins University Center for Systems Science and Engineering (JHU CSSE) [Dong et al. 2020]. In the absence of any intervention, India can expect to see an exponential growth of COVID-19 cases within a few weeks

(Figure 3). The predicted cumulative number of cases in India on March 31 is 379, on April 15 is 4836, and on May 15 is **58643**. Our current estimates are at best underestimates for India based on early phase data, given the low frequency and scale of testing in India. The upper credible limit to these corresponding to these case count estimates are 2507, 28925 and approximately **915 thousand**, respectively. The rate of growth of COVID-19 cases in India until March 19 seems to follow the pattern of US with a lag of around 13 days, just like US numbers were similar to that of Italy by 11 days in the early stages of the pandemic. A slower rate of growth is predicted in India by our model based on the current data when compared to Italy and USA, mainly due to small number of confirmed cases (likely due to low frequency of testing) and the large Indian population. However, availability of testing and community transmission may lead to a spike in a single day and that will shift the projection curve significantly and India can definitely start looking like USA or Italy in terms of case counts.

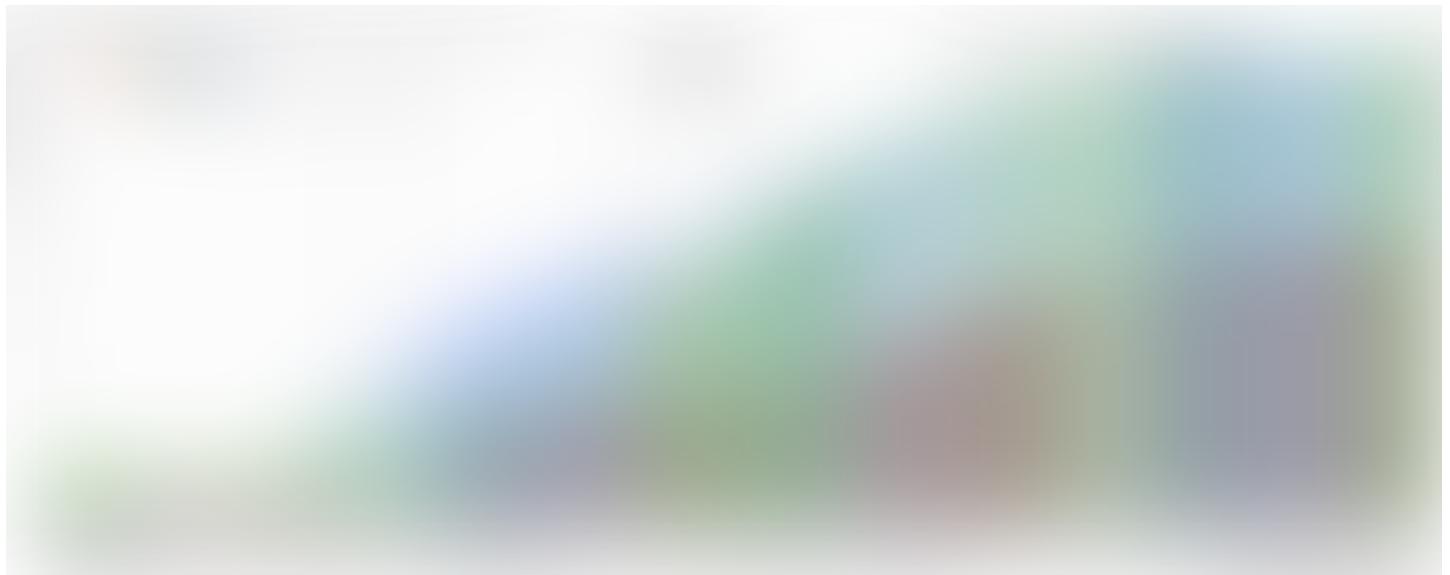


Figure 3. Daily growth in cumulative case counts in India compared to the US and Italy (all affected by the pandemic) up to May 15. Observed data are shown for days up to March 16. Predicted future case counts for March 17 and onwards based on observed data until March 16 using the eSIR model assuming no intervention has been implemented. Observed case counts for March 17, 18 and 19 are also plotted that show how close these predictions are and that the predictions for India are likely conservative. The counts are adjusted for the total population of each country (data from the World Bank and the United States Census Bureau).

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2. Who are the most vulnerable to COVID-19 infection and why is that critical for India?

Specific vulnerable populations have been identified to be at higher risk of severity and fatality from COVID-19 infection: older persons and persons with pre-existing medical conditions (e.g., high blood pressure, heart disease, lung disease, cancer, diabetes, immunocompromised persons) [WHO; CDC]. **Table 2** provides a description of the approximate number of individuals in these high-risk categories in India. With the predicted surge in the number of cases, it will be impossible for the healthcare providers to support the sheer volume of cases. India has the most overstretched healthcare system where it is hard to provide care in times of “normal” patient volume. The number of hospital beds per 1000 people in India is only 0.7, compared to 6.5 in France, 11.5 in South Korea, 4.2 in China, 3.4 in Italy, 2.9 in the UK, 2.8 in the USA, and 1.5 in Iran [World Bank]. Beyond the fragile population characterized by health and economic indicators, we have to remember that healthcare and front-line workers are among the most vulnerable [Wang et al. 2020].

Table 2

3. Do interventions like travel bans and social distancing help arrest the projected exponential growth of COVID-19 in India?

Yes! We took a close look at what might be coming in the next few weeks and months, based on what we have seen in other countries and an epidemiological model that have been gainfully employed to assess the effect of interventions in Hubei province [Song et al. 2020]. We find that without enforcing any intervention, the predicted counts are going to exceed the estimated capacity of hospital beds in India, which is 70 per 100,000 Indians (**Figure 4**). It should be noted that 70 hospital beds per 100,000 people is an upper bound on treatment capacity. Given an average occupancy rate of 75%, only a quarter of these are available [Sindhu et al. 2019]. Moreover, critically ill COVID-19 patients (about 5–10% of those infected) will require ICU beds, which constitute between 5 and 10% of bed capacity in Indian hospitals [Yeolekar & Mehta 2008] with very high occupancy rates. The predicted number of cases by May 15 will be at 161 per 100,000 (i.e. 2.2 million cases nationwide) without any intervention and will drastically reduce to 1 per 100,000 (i.e. 13,800 cases nationwide) with the most severe form of intervention. Here, instead of adjusting the case counts for the total population of India (as in **Figure 3**), which is perhaps leading to the underestimation of case counts in **Figure 3**, we adjusted our estimates using the total population from major cities of the Indian states or union territories that are currently COVID-19 hotspots (namely, Kochi, Mumbai, Pune and Bengaluru). This analysis shows the impact and necessity of interventions, and all people in India, regardless of their vulnerability to COVID-19, should adopt the public health guidelines issued by the Ministry of Health and Family Welfare in India.

Figure 4. Daily growth in case counts in India per 100,000 people and how that is affected by different non-pharmaceutical intervention strategies. Observed case counts are shown until March 18, after which the predicted future case counts from the eSIR model are shown. The case counts are based on the total population of the cities Mumbai, Pune, Kochi and Bengaluru (censusindia.gov.in) since the current COVID-19 hotspots of India are in the states of Maharashtra, Kerala and Karnataka.

4. Can we rely on summer temperatures to thwart the COVID-19 outbreak in India?

Probably not! We did not find enough statistical evidence from the current COVID-19 case count data around the world to support this perception of the general public of India. Though the correlations between average temperature and case counts worldwide were negative in sign, we did not find statistically significant results. Spatial plots for the average monthly temperatures accompanied by total monthly incidence across all countries from January through March indicate a gradual rise in the number of incidences in India starting from January through March (Figure 5). Although the temperatures in India are very high during the months from March onward, we cannot rely on the hypothetical prevention (with inconclusive evidence) governed by meteorological factors and need public health actions, regardless of the weather.

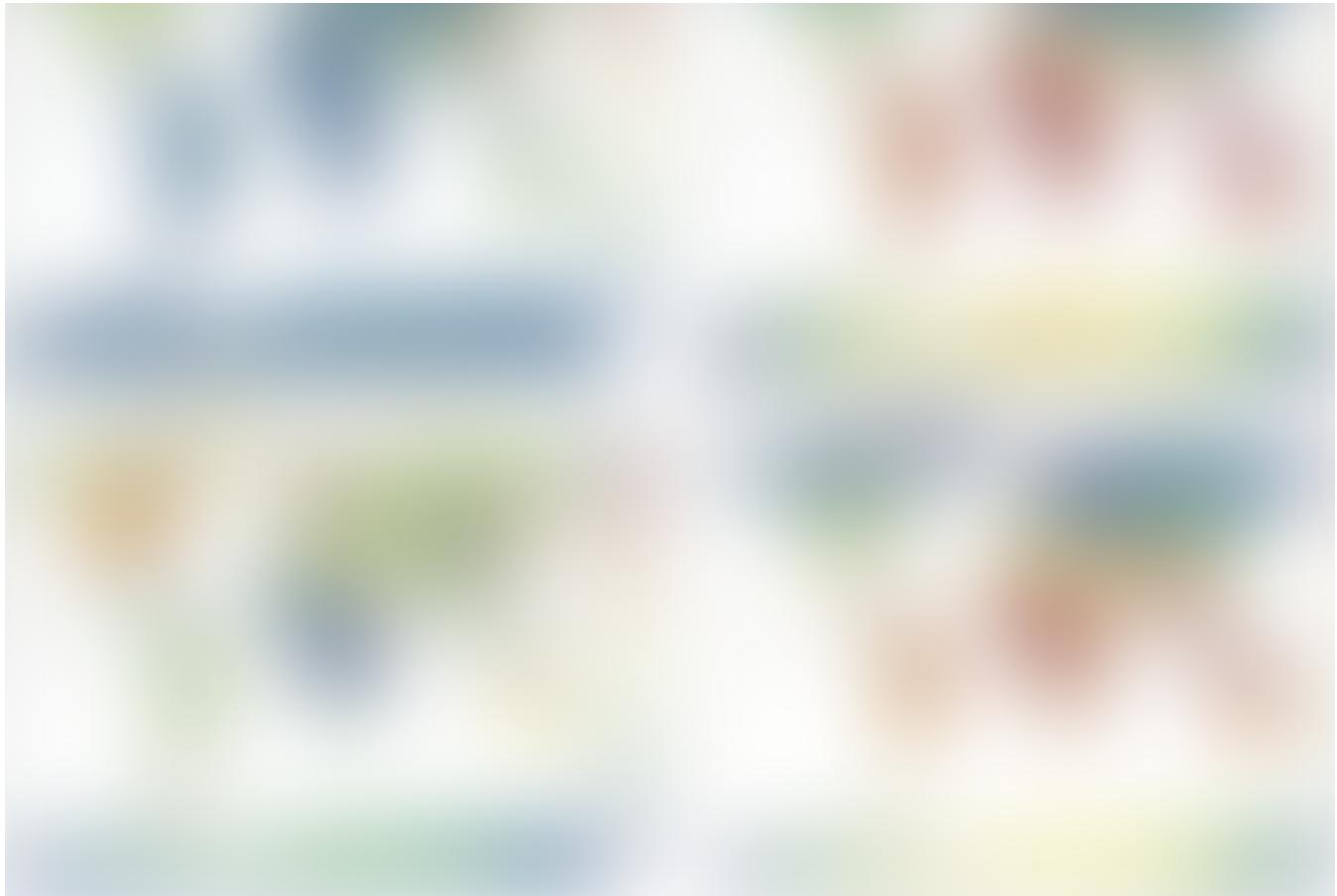


Figure 5. Left: Country-wise total monthly incidence of COVID-19 in the months of January, February and March (until 15th). The horizontal lines approximately indicate the equator, the tropic of cancer and the 60N latitude. Right: Average monthly temperature (in C) during the months of January, February and March.

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5. What long-term impact will interventions like travel bans and social distancing have on India?

Though the epidemiologic and mathematical calculations make a convincing case for enforcing severe interventions, they come at a tremendous price to social and economic health. Economic losses can spread from directly impacted sectors (like hospitality and transportation) to others (like online retail and apparel) through a contagion process not dissimilar to that of the virus itself. It can last months or even years after the restrictions on social mobility are lifted, because the damage from business closings and layoffs are often irreversible.

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6. What can the Government of India do NOW?

The management of this COVID-19 crisis requires strong partnership of the government, the scientific community, the health care providers and all citizens of India (and all global citizens). Following are some recommendations some of which are based on what has been effective in other countries:

- Drastically increase the number of tests administered daily as there are often asymptomatic cases that go on to infect others and so early diagnosis is extremely important. Government should join hands with the private sector to increase testing capacity.
- Continue traffic ban, social distancing, quarantine and similar interventions to slow down the spread of the virus.
- Provide free coverage for testing and treatment for COVID-19 for everyone in India.
- Immediately prepare to protect the health care workers and first responders who are at the front line of this pandemic. This involves ensuring a steady supply chain of medical resources (masks, gloves, gowns, ventilators), and protecting our healthcare workers (physically and psychologically). Full gears (protective suit, medical goggle, cap, face shield, mask and gloves) are absolutely essential when seeing suspected cases. These protection strategies worked in China.
- Reduce all non-essential medical care and expand number of beds and ICU beds.
- Set up COVID-19 testing mobile labs, hospitals and mobile cabins (also called ‘Fangchang’) like South Korea and China (Huoshenshan hospital).
- Ensure the healthcare facilities have adequate supply of medications that are currently being recommended. For instance, antiviral drugs “remdesivir and chloroquine are highly effective in the control of 2019-nCoV infection in vitro” indicating promise for treating COVID-19 patients [Wang et al. 2020]. WHO spokesperson recommended the use of paracetamol (also known as acetaminophen or Tylenol) to self-medicate for fever, as opposed to ibuprofen.
- Provide livelihood assistance over the quarantine period to those who test positive. This will incentivize people to get tested and comply with social isolation protocols. For many people in India, loss of several weeks of earnings can be economically devastating and since symptoms are mild for most infected people, it is

unreasonable to expect that all sick people will tightly follow restrictions unless economically protected.

- During periods of social distancing and lockdowns, there is grave livelihood threat to a lot of poor people even if they are uninfected — street hawkers, auto drivers, barbers and shopkeepers, etc. Provide a universal basic income (UBI), or some mildly means tested version of it, over the period of disruption.
- To prevent shutdowns in badly affected sectors, the government may provide GST tax credit to firms based on the difference between past and current sales. Once the pandemic is over and normal business resumes, expansionary monetary and fiscal policy will be needed to revive macroeconomic health.

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7. What can the people of India do NOW?

- Adhere to the public health guidelines issued by the Ministry of Health and Family Welfare in India. Public awareness and co-operation are of utmost importance now.
- Practice #SocialDistancing, which is maintaining physical distance and avoiding crowded places so we can be out of range of the respiratory droplets that are considered the principal source of the coronavirus spread. Continue to maintain social connections virtually with family, friends and people around you. We are in this together for the long haul and we need to watch out for one another. Empathy, resilience and solidarity are necessary for retaining our collective morale high.
- Follow simple personal hygiene and sanitation practices, such as coughing/sneezing into your elbow, regularly washing hands with soap and water for at least 20 seconds or using an alcohol-based hand sanitizer containing 60–95% alcohol, avoiding touching nose, eyes and mouth with unwashed hands and disinfecting all ‘high touch’ surfaces such as counters, tabletops, doorknobs, toilets, keyboards and phones.
- People suspected to be infected or to have been exposed to an infected person should follow quarantine protocols recommended by the Ministry of Health (e.g., isolate themselves in their homes and restrict outside activities, except for getting medical care).

- People who employ and rely on domestic helpers, daily wage earners, etc. who come to work every day to their homes, have an active role to play now. We should consider allowing these workforce “paid leave” under these circumstances. It is for the benefit of both the employer and the employee families.
 - As we evaluate this situation with precaution, prudence and best possible prevention and treatment strategies, it is important to not panic. Recent studies show there have been additional mortality in Hubei province [Zhou et al. 2020] and China [Guan et al. 2020] during this time that can potentially be related to additional stress, anxiety and hypertension.
 - Hoarding food, medicines and other supplies have become an issue in many places. It is important to exercise control and be attentive to the community needs.
 - It is important to commit and adhere to good lifestyle choices: maintain a healthy diet, engage in physical activity and care for other existing co-morbidities in this period of confinement and systemic operational disruption.
 - Be mindful of the mental health challenges associated with this crisis at this moment and that are anticipated in the future [Xiang et al. 2020, CDC].
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In the words of the WHO Director General “the days, weeks, and months ahead will be a test of our resolve, a test of our trust in science, and a test of solidarity.” It will be unwise to be complacent based on current case counts in India. What has happened in the past four months in the world have been a complete failure of our collective societal imagination. In this moment of pause, reflection and disbelief, the world is getting its education on the difference between exponential versus linear growth.

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The **COV-IND-19 Study Group** is comprised of the following scholars and data scientists:

- Debashree Ray — *Departments of Epidemiology and Biostatistics, Johns Hopkins University*

- Rupam Bhattacharyya — *Department of Biostatistics, University of Michigan*
- Lili Wang — *Department of Biostatistics, University of Michigan*
- Maxwell Salvatore — *Departments of Biostatistics and Epidemiology and Center for Precision Health Data Science, University of Michigan*
- Shariq Mohammed — *Departments of Biostatistics and Computational Medicine and Bioinformatics, University of Michigan*
- Aritra Halder — *Department of Statistics, University of Connecticut*
- Yiwang Zhou — *Department of Biostatistics, University of Michigan*
- Peter Song — *Department of Biostatistics, University of Michigan*
- Soumik Purkayastha — *Department of Biostatistics, University of Michigan*
- Debraj Bose — *Department of Biostatistics, University of Michigan*
- Mousumi Banerjee — *Department of Biostatistics and Institute for Health Policy and Innovation, University of Michigan*
- Veera Baladandayuthapani — *Department of Biostatistics, University of Michigan*
- Parikshit Ghosh — *Delhi School of Economics*
- Bhramar Mukherjee — *Departments of Biostatistics and Epidemiology and Center for Precision Health Data Science, University of Michigan*

Contact Bhramar Mukherjee (bhramar@umich.edu) with questions and inquiries

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