# Early COVID-19 Vaccination Not Only Prevents Deaths, But Saves Money Too

## Methodological & Detailed Results Appendix

**September 24, 2021**

### Overview

We integrated a supply chain model with an infectious disease transmission model to estimate the costs and health impacts of three differing seroprevalence based vaccination strategies whilst considering supply and distribution capacity within districts in the state (e.g. storage, cold chain, transport, human resource).

Using Punjab, India as a model system, we predicted the epidemiological and economic impact of prioritising vaccine roll out dependent upon known seroprevalence in urban or rural areas after the first wave, in order to reduce the magnitude of a second future wave. Here, known seroprevalence during the first wave in Punjab was 31% for urban areas and 21% for rural areas. Hence, we constructed three vaccines roll out scenarios where an available vaccine stockpile was allocated to cover 75% of the state population by:

1) Vaccinating rural target population first, then urban
2) Vaccinating urban target population first, then rural
3) Vaccinating rural and urban target populations simultaneously according to population demographics

For each of these vaccine roll out scenarios, we assumed that state level vaccination budgets were constrained and additional resources would not be hired or purchased, however resources could be mobilised to where they are needed most. Therefore we further specified three modelled stratifications where we mobilise resources by aggregating and reallocating resources to maximise existing resource capacity within the system:

i. Base case - No aggregation or reallocation of resources across the district or state and existing supply chain is used according to budget constraints.
ii. District-level: Aggregating all existing resources in a district and reallocating them within the same district, for each district.
iii. State-level: Aggregating all resources in the state and reallocating them over the entire state (i.e., across districts)

For each scenario of vaccine supply, we estimated the epidemiological impact under different vaccination strategies, as well as the manufacturing and distribution cost. Combining these estimates with the costs of treating a hospitalised COVID-19 patient, we arrived at overall estimates for cost-effectiveness for each of the 9 strategies.

*Epidemiological Model* – We developed an epidemiological model to project the health impact of the different vaccination strategies to control COVID19 in Punjab, India. The epidemiological model was calibrated by age group, and urban vs rural settings. The epidemiological model was further calibrated to existing historical seroprevalence data and case numbers from the state of Punjab to ensure that modelled numbers match observed data.

*Supply Chain Model* – We also developed a *de novo* supply chain model to estimate: (i) the maximum rate of vaccination, that could be achieved through existing supply chains, and (ii) the total landed cost of vaccination (transportation, storage and delivery of vaccines) by using the existing cold chain and distribution network of the routine immunization program in the public sector. The model was also used to assess whether current transportation, storage and delivery capacity in the routine immunisation supply chain network is sufficient or needs to be mobilised through incentivisation.

*Cost-effectiveness Analysis* - Output from the epidemiological model and supply chain model were then integrated into a cost-effectiveness analysis. Here we estimated the overall cost-effectiveness of the 9 differing vaccination strategies where we calculate the monetary cost (implementation, hospitalisation, manufacturing, and distribution) and the subsequent life-years gained when comparing the base case analysis to a set of differing vaccination strategies. From these projections we will derive incremental cost-effectiveness ratios. The figure below describes each of the different vaccination strategies.

| | | **Vaccination Strategies** | | |
| --- | --- | --- | --- | --- |
| | | Rural First | Urban First | Uniform |
| **Supply chain Scenarios** | Baseline | Direct supply to rural areas first, use supply chain and human resources as deployed | Direct supply to urban areas first, use supply chain and human resources as deployed | Direct supply to both areas in proportion of population, use supply chain and human resources as deployed |
| | District Level Aggregation | Direct supply to rural areas first, redeploy resources from urban to rural areas within each district | Direct supply to urban areas first, redeploy resources from rural to urban areas within each district | Direct supply to both areas in proportion of population, redeploy resources across rural and urban within each district |
| | State Level Aggregation | Direct supply to rural areas first, redeploy resources from urban to rural areas within and across districts | Direct supply to urban areas first, redeploy resources from rural to urban areas within and across districts | Direct supply to both areas in proportion of population, redeploy resources across rural to urban areas within and across districts |

## Detailed Results

Insight 1 Detailed Results

Prioritising urban areas first could have averted up to 11.9% (credible intervals (CI) 0.8% - 25.7%) of cases and 14.9% of deaths. Whereas prioritising rural areas first could have averted 11.2% (CI 0.4% - 37.9%) of cases and 14.6% (CI 1.7% - 41.3%) of deaths. In comparison, allocating vaccines uniformly across rural and urban areas would have averted up to 10.4% (CI 0.5% - 35.8%) of cases and 13.9% (CI 1.7% - 41.3%) of deaths in Punjab.

Prioritising urban areas first would cost approximately ₹92.9 Crores ($12.6 Million) but could also result in ₹202.1 Crores ($27.4 Million) worth of cost savings from averted hospitalisations. When targeting rural areas first, the total vaccination cost could be approximately ₹94.5 Crores ($12.8 Million), yet averted healthcare costs could total an estimated ₹200.1 Crore ($27.1 Million). On the other hand, uniform COVID-19 vaccination across rural and urban areas could cost the Punjab government an estimated ₹94.6 Crores ($12.8 Million (USD)), yet could save approximately ₹186.8 Crore ($25.4 Million) through averting hospitalisations.

Insight 2 Detailed Results

When targeting urban areas first, we found that 20.6% (CI 7.1% - 34.4%) of cases and 24.3% (CI 10.0% - 39.0%) of deaths were averted. Through prioritising rural areas first, we found that 23.6% (CI 6.2% - 57.1%) and 27.6% (CI 9.2% - 59.8%) of cases and deaths were averted, respectively. Whereas, allocating resources in a uniform manner across urban and rural areas resulted in 21.4% (CI 5.6% - 63.6%) of cases and 26.4% (CI 8.6% - 68.7%) of deaths being averted. Hence, by starting a vaccination programme just one month earlier ahead of a wave, all strategies could have almost double the epidemiological impact in comparison to starting a month later.

Here, vaccination campaign implementation costs remain unchanged, but a rural first strategy could avert hospitalisations costing approximately ₹435.4 Crore ($59.0 Million), an urban strategy could save approximately ₹398.1 Crore ($53.9 Million) and a uniform strategy that vaccinates urban and rural areas simultaneously could save an estimated ₹405.3 Crore ($54.9 Million).

Limitations

Here, it is important to acknowledge that, to fully capture the health and economic impacts of vaccination, our model assumes that all individuals who require COVID-19 critical care would receive it in Punjab. In addition, we do not include any parameter of vaccine hesitancy in our model. In reality, Punjab like all other states has varying levels of vaccine hesitancy and was also devastated by the second wave of coronavirus which saw daily demand for supplemental medical oxygen rising to roughly 12 times what was needed pre-COVID-19 times. We stress that to incur the potential yet substantial cost-savings incurred through COVID-19 vaccination, policy makers must also tackle the growing threat of vaccine hesitancy and improve access to and delivery of critical care (including oxygen) across rural and urban areas.