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Centre for
Global Infectious
Disease Analysis



Modelling the cost-effectiveness of seroprevalence based COVID-19 vaccination strategies in India.

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Motivating questions

- Pressing need to vaccinate those most at risk of death from COVID-19
- *Population context*: infection has already spread widely, but heterogeneously
 - E.g. urban/rural variations
- What would be the optimal way of targeting a given vaccine supply where it is most needed?
 - E.g. only to communities below a certain threshold seroprevalence?
 - Or those communities with the lowest seroprevalence?

Our approach

- As an illustrative example, consider a state in India
 - Urban and rural settings, both with different seroprevalence and transmission intensity
- Assume there is enough vaccine to vaccinate **50% of the over 50-year-olds** in the state
- Vaccine decision: how would optimal vaccine allocation depend on the seroprevalence in rural and urban settings?
 - Combine epi and supply chain modelling to estimate cost-effectiveness (cost per death averted) of different strategies

Epidemiological modelling

Mathematical model of transmission dynamics of SARS-CoV-2

How many future COVID-19 deaths would be averted by a given vaccination strategy?

Supply chain modelling

Estimate additional resources required for COVID vaccine distribution (in addition to routine universal immunization programme)

Include HR, storage, distribution costs

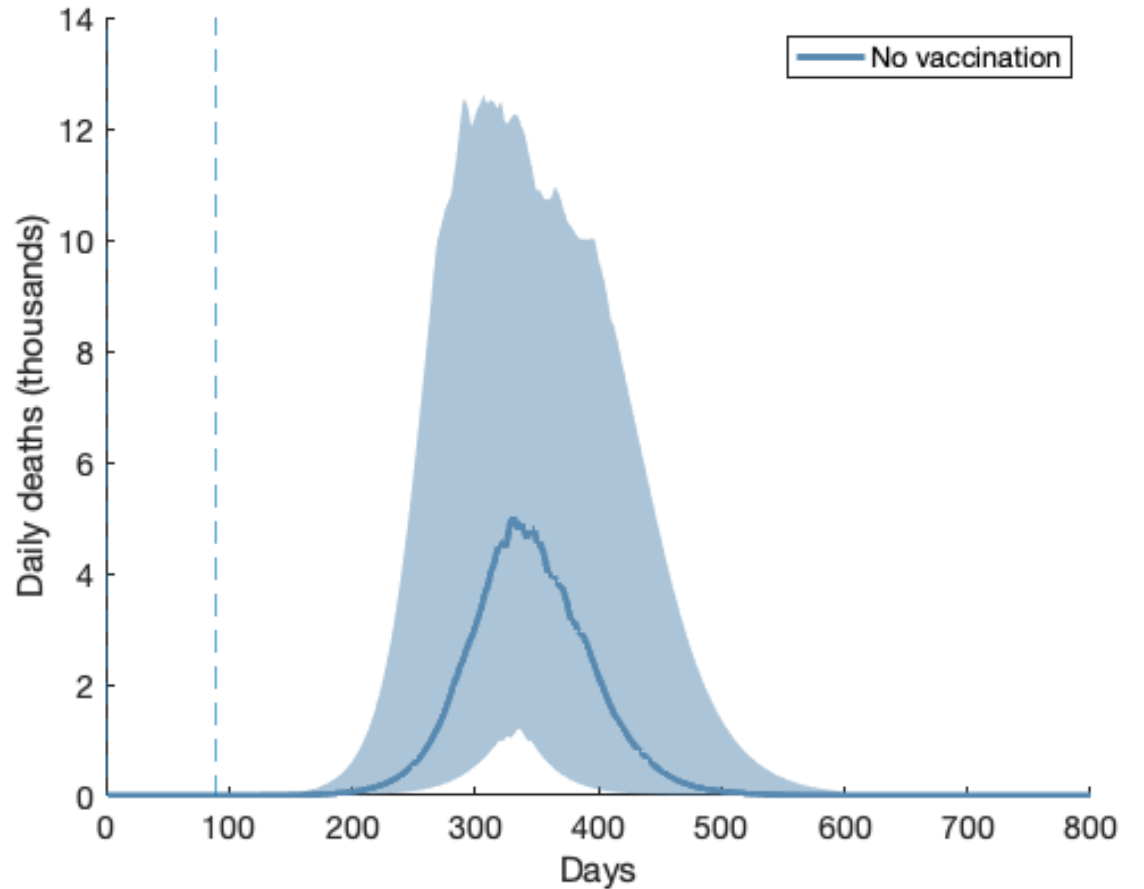
All results are preliminary and should be considered within context of the assumptions made

Mathematical model of transmission dynamics

- Deterministic, compartmental model, with stratifications for:
 - Urban/rural settings
 - Age groups: <18yo, 19 – 49yo, >50 yo
 - Comorbidities (diabetes and hypertension)
- For the purpose of estimating epidemiological benefit, assume emergence of a second wave in future
- Model a vaccine that is 70% effective at reducing infection in all ages
 - Estimate the total deaths that would result

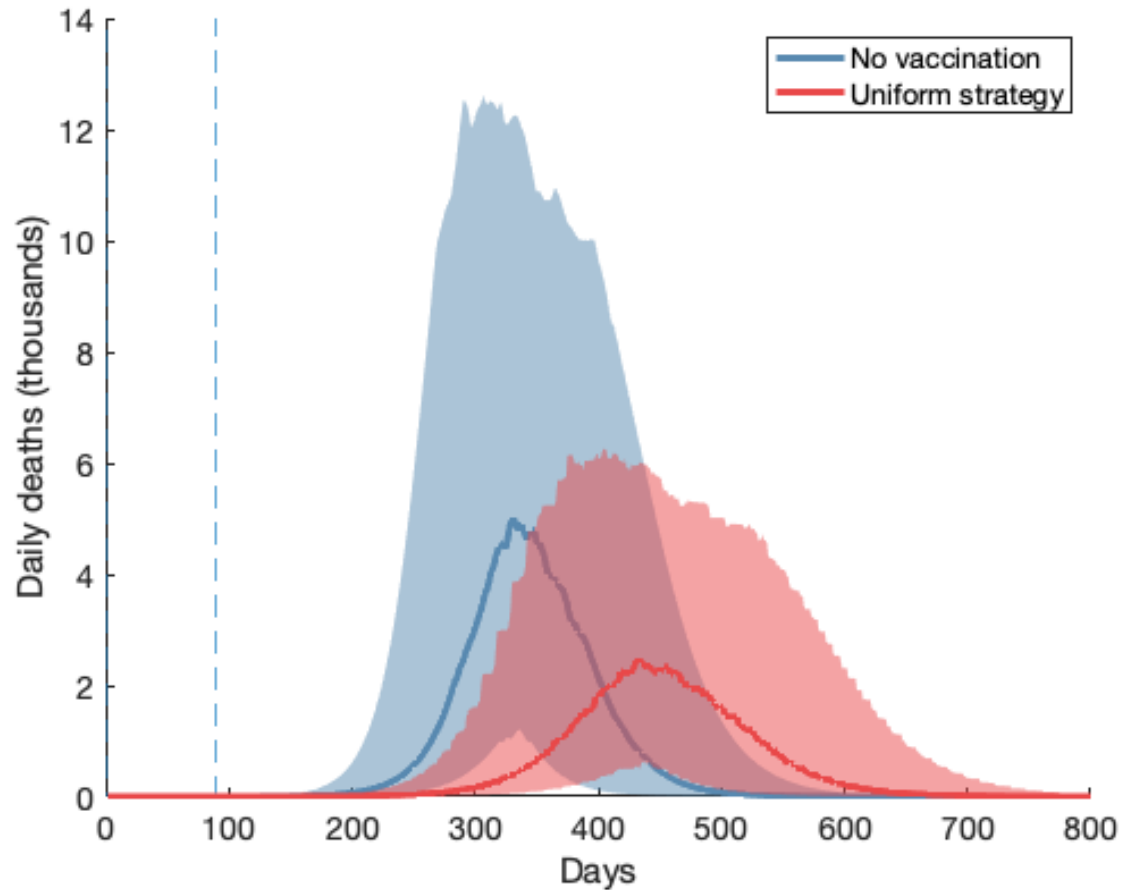
An example

- Scenario: urban areas have 40% seroprevalence, and rural areas have 10%
- Two strategies:
 - **'Uniform'**: Vaccinate 50% of over 50-year-olds in both urban and rural areas
 - **'Low seroprevalence'**: Only vaccinate over 50-year-olds in rural areas (80% coverage)



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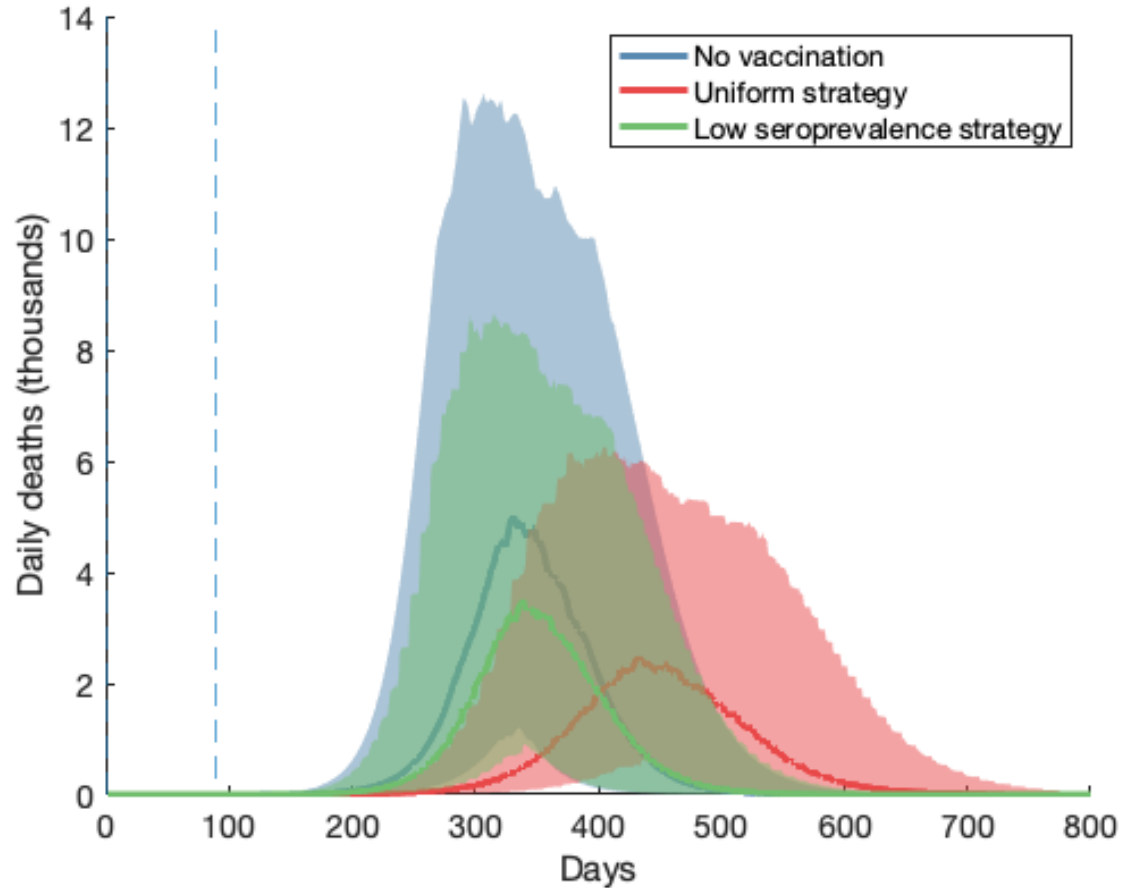
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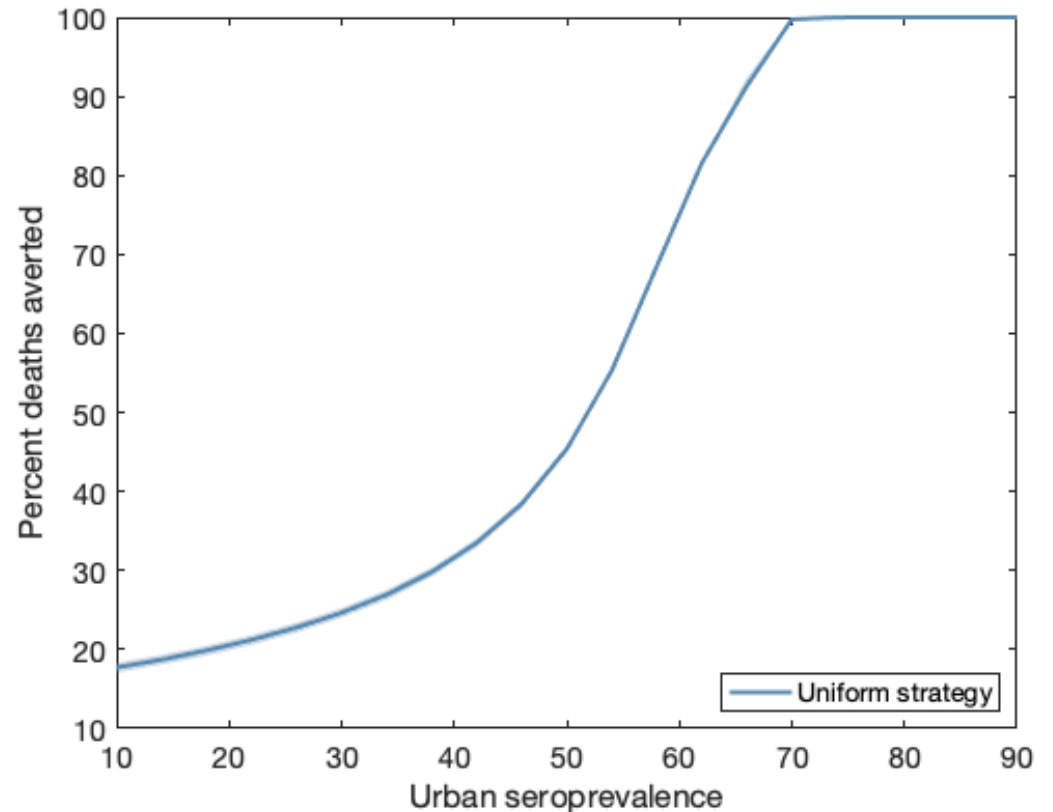
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Vaccination strategy	Percent deaths averted, relative to no vaccine
Uniform strategy	32%
Low seroprevalence strategy	27%



Alternative scenarios for seroprevalence

- Assume that rural areas have seroprevalence of **10%**
- Take a range of different values for urban seroprevalence
- When is a 'Low seroprevalence' strategy favoured over a 'Uniform' strategy?

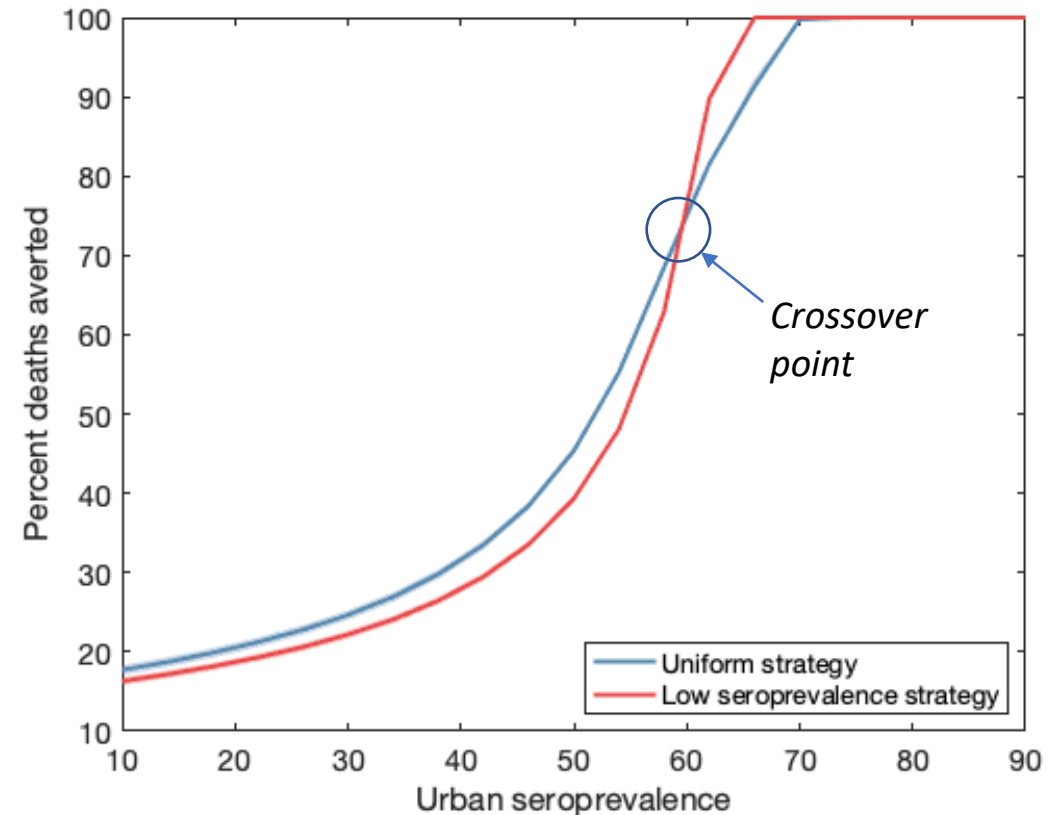


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When urban seroprevalence **exceeds 60%**

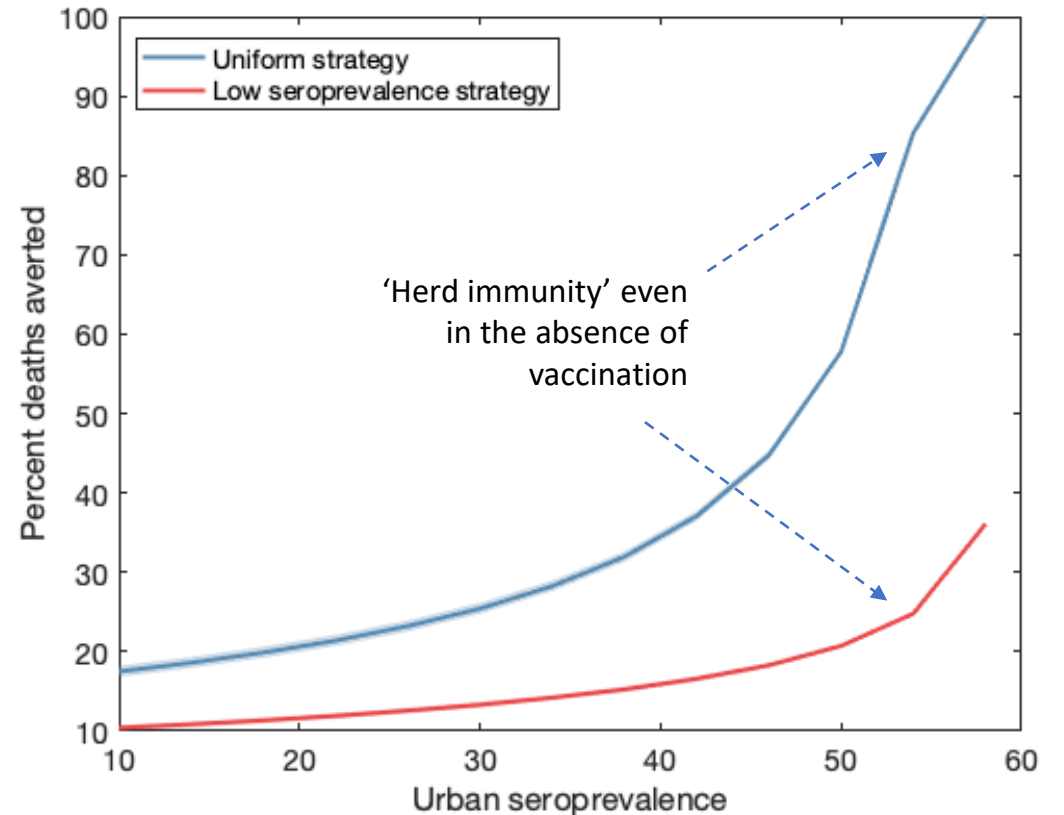
...but...obvious caveats...



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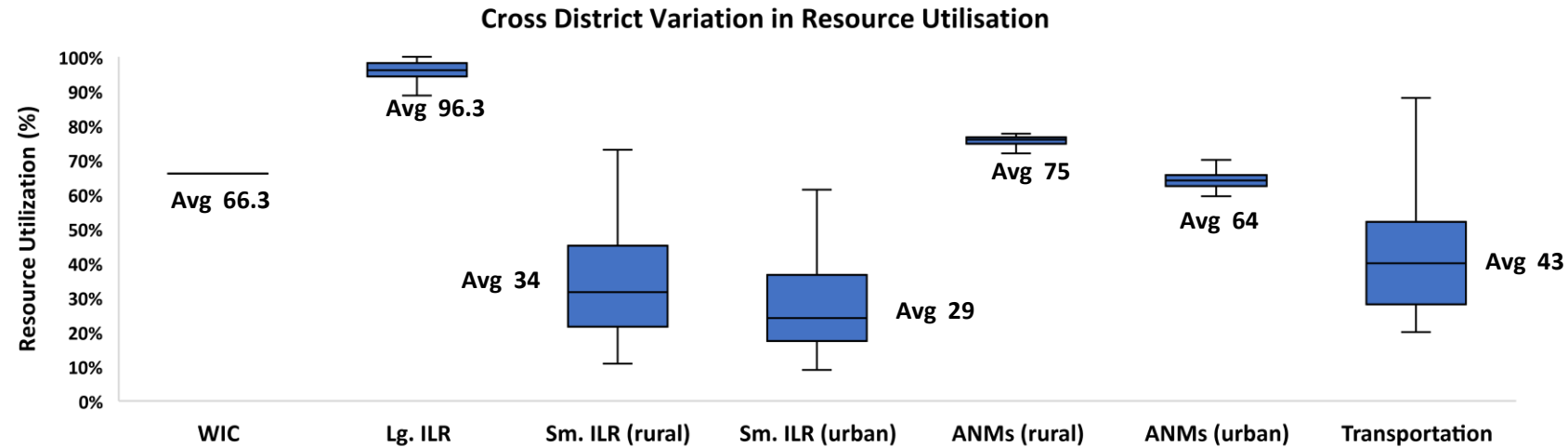
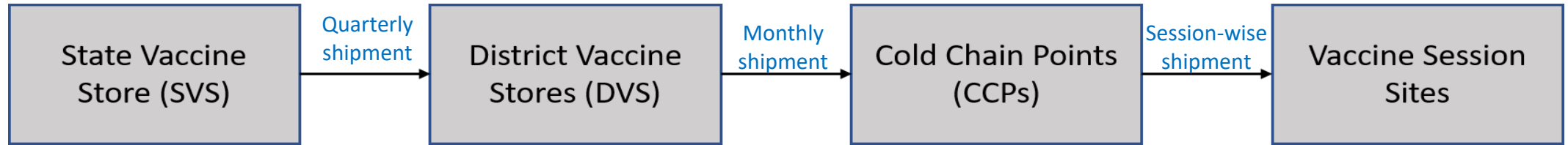
A uniform strategy is always preferred when rural seroprevalence is sufficiently high



Supply chain modelling

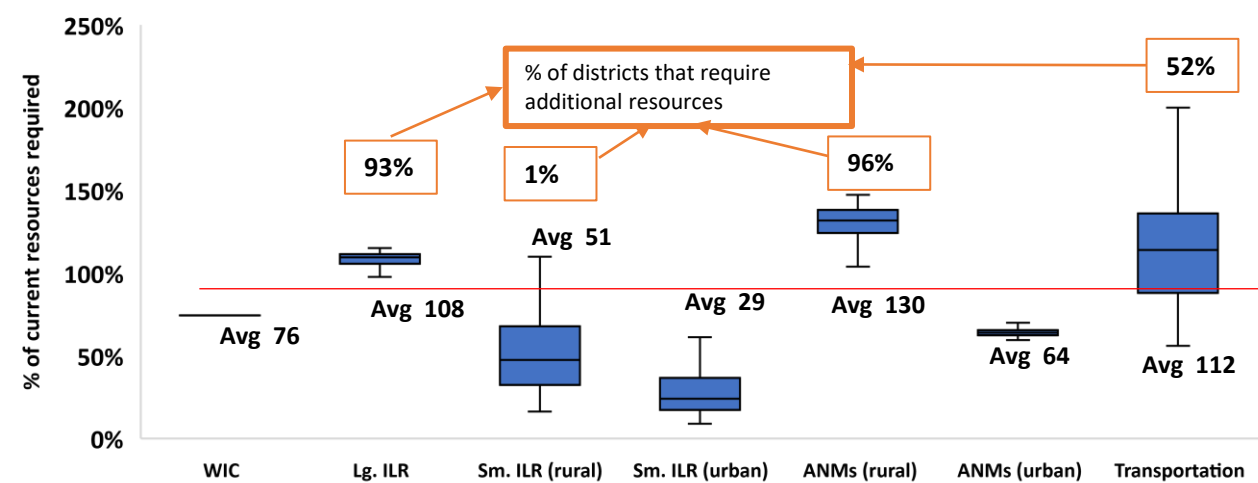
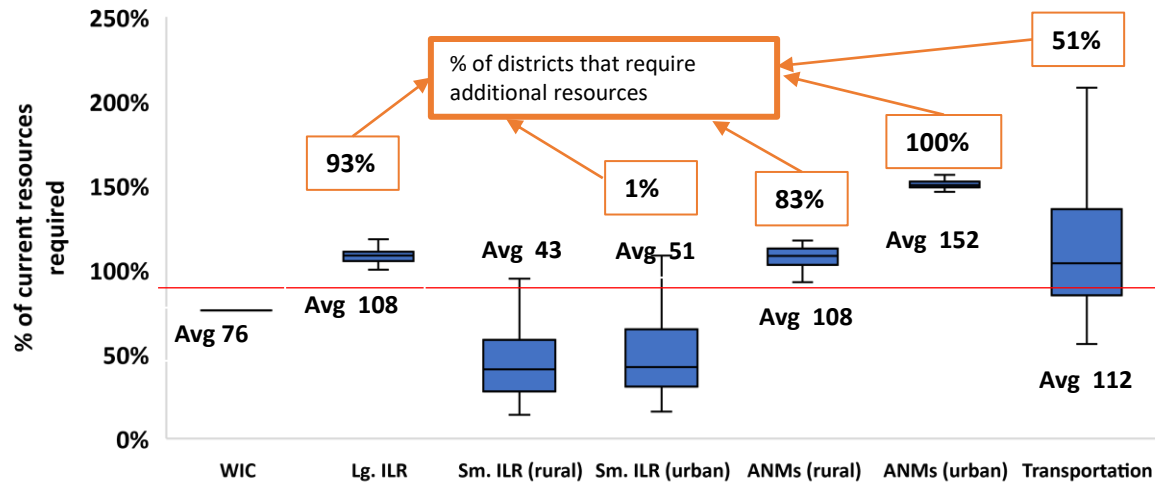
- Assume that the cold chain for routine immunization (RI) will be used for the distribution and administration of COVID vaccines
- Develop a mathematical model to estimate the utilization of transportation, storage and vaccine administration capacity due to routine immunization activities
- Validate the model by comparing the average cost per dose of routine immunization with published estimates
- Use the model to estimate **additional resource requirements** and **incremental cost** for different strategies of COVID vaccination for the first phase covering population >50 years
 - Vaccine availability: 50% of requirement to cover target population
 - Campaign duration: 3 months
 - Scenarios: uniform, priority to low seroprevalence areas (rural)
 - Throughput: 100 per session, 30 per vaccinator
 - Frequency of sessions: Calculated using above assumptions
- **Rely on publicly available aggregate data to generate preliminary and approximate estimates, which are subject to change with more detailed data**

Estimates for cold chain utilization for routine immunization (RI)



- Few districts may have shortage of small ILR capacity in Rural areas.
- Significant small ILR capacity available across all districts in Urban areas.
- Cold chain transportation capacity can become constrained in some districts
- Large ILR and ANM (vaccinator) capacity can become constrained in most districts

Resource utilization with COVID vaccines



Resource requirement is specified in terms of what is currently available for routine immunization activity, e.g., 152% ANMs (Urban) indicates that across the state, 52 % more vaccinator capacity than what is currently available for routine immunization will be required for COVID vaccination campaign in urban areas

- Existing Large ILR capacity barely enough to handle routine immunization + COVID vaccination demand
- Small ILR capacity in rural and urban areas of some districts may fall short of need
- Vaccinator capacity needs to be increased by recruiting temporary resources from other parts of the public health system or private sector, curtailing outreach activities associated with RI
- 50 % of the districts will need to expand their vehicle capacity to cover the target population

Incremental cost of COVID-19 vaccination

Scenario (Coverage)	Cost (INR)	Excluding vaccine cost*	Including vaccine cost!
Uniform	per dose	21.96	221.96
	Total (Mn.)	728	7,368
Low Seroprevalence	per dose	19.06	219.06
	Total (Mn.)	629	7,229

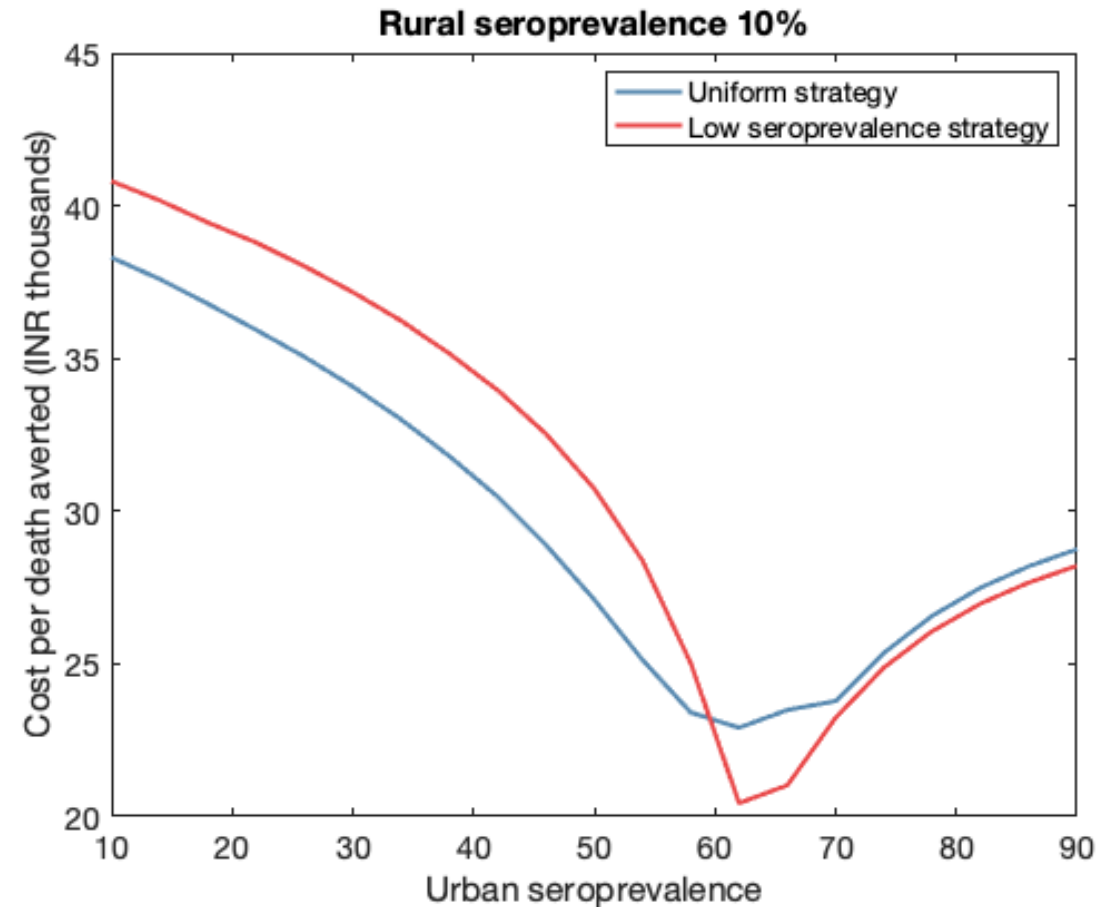
*Cost includes vaccine storage and maintenance, distribution and personnel cost.

! Cost includes all the above and vaccine cost at INR 200 per dose.

- Higher incremental cost for uniform coverage is because of higher additional resource requirements, especially vaccinators, in urban areas

Cost-effectiveness

- Taking again the example where rural seroprevalence is 10%
- Bringing in the costs of vaccination programme to estimate the cost per death averted
- Similar conclusions to those shown earlier, for impact: low seroprevalence strategy is more cost-effective than uniform if the urban exceeds 60%
 - Again, similar results to those shown earlier, when rural seroprevalence is 40%



Concluding remarks

- Given a vaccination strategy, our combined modelling allows joint estimation of:
 - Its potential epidemiological impact
 - Its potential cost
- Model framework is flexible
 - Although we have used urban/rural populations as examples, can be adapted e.g., to address different districts
 - Also, can accommodate alternative scenarios for vaccine timing, efficacy, delayed dosing and target populations etc
- For the targeted use of a finite vaccine stockpile, seroprevalence can be valuable in identifying priority populations
 - However, decision may not be as simple as specifying a single, universal threshold
 - We have shown how such thresholds might be affected by alternative scenarios for seroprevalence in rural areas
- Vaccinators (e.g., ANMs) have been found to be the most constrained resource through supply chain modelling across a wide variety of contexts and scenarios that we have analysed, followed by ice-lined refrigerators at district vaccine stores
- *Ongoing work*: Identify heuristic(s) that could be used across settings, considering collective information (across geographical areas) on seroprevalence