Modeling Strategies for the Initial Allocation of SARS-CoV-2 Vaccines

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Question

- What is the potential impact, in terms of preventing COVID-19 infections and deaths, of initially allocating vaccine to one of the following groups after vaccinating healthcare personnel in Phase 1A?
  - Adults aged 65+
  - Adults with high-risk medical conditions
  - Essential workers
Methods: Population
Population Stratification

- 5 Age Groups:
  - 0-4, 5-17, 18-49, 50-64, 65+ (~55 M nationally)

- Risk Status (within each adult age strata):
  - Low-risk
  - High-risk (having 1 or more select high-risk medical conditions)\(^1\)
    - COPD, heart disease, diabetes, kidney disease, or obesity
    - Prevalence of having 1+ condition estimated from BRFSS
      - ~40% of adults (100M nationally), increasing with age
    - Assume 3x higher risk of mortality upon infection relative to the low-risk group\(^2\)


Population Stratification, continued

- **Occupational Status**
  - ~40% of adults aged 18-64 (80M nationally) classified as “essential workers”
    - Healthcare Personnel: 25% of essential workers (20M nationally)
  - Assume essential workers are only able to reduce their workplace contact rates 35% as much as other adults of the same age.
    - Varied from: 20% to 50% in sensitivity

- **Baseline contact patterns:**
  - Social contacts and mixing study, adjusted for the US (Prem 2017)
  - Stratified by age and setting (home, work, school, and other)
Methods: Vaccination
Vaccine Product Assumptions

- Full course: 2 doses given 28 days apart
- Vaccine Efficacy (VE)
  - Both doses: VE = 70%
  - First dose: VE = 17.5% (1/4 of full protection)
  - Sensitivity analysis: reduced immunogenicity in adults aged 65+ (half of above)
    - VE\{age 65+\} = 8.75% (first dose) and 35% (both doses)
- Protection from the first or second dose achieved 14 days following the vaccination
Vaccine: Completeness of Protection

- Every vaccinated person is partially protected

- Infection-Blocking
  - Protection against infection and onward transmission
  - If breakthrough infection, no attenuation of severity or transmission

- Disease-Blocking (Sensitivity Analysis)
  - No protection against infection or onward transmission
  - Reduced risk of severe disease if infected

- Assume no waning of immunity (naturally or vaccine-induced)
Vaccine Allocation Assumptions: Phase 1

Phase 1: Initial Vaccine Supply
200M Courses* Nationally

- 20M Courses
  - Phase 1A: Healthcare Personnel (HCP)

- 180M Courses
  - Phase 1B: Adults Aged 65+
  - Adults with High-Risk Medical Condition
  - Essential Workers

* 1 course = 2 doses
Vaccine Allocation Assumptions: Phase 1B

Phase 1B: Non-Healthcare Personnel Target
180M Courses* Nationally

First 20M Courses

Allocated exclusively to one of:
Adults Aged 65+
Adults with High-Risk Medical Condition
Essential Workers

Wider Availability: 160M Courses

Remaining unvaccinated Phase 1B groups (see above)

* 1 course = 2 doses
Methods: Epidemic Dynamics
Epidemic Scenarios

- Percentage of the population infected 2 months prior to vaccine introduction = 15% (sensitivity analysis 5% & 20%)

- Future epidemic trajectories simulated using compartmental models with time-varying mitigation

- Outcomes (infections and deaths averted) compared 6 months following vaccine introduction
Administration Assumptions

- Assumed 100% of the individuals either vaccinated or not yet eligible for the second dose before moving to subsequent phases
- Vaccine administered regardless of infection history
- 10 million people can be vaccinated each week
  - Phase 1A and Phase 1B fully vaccinated in ~9 months
- Administration of second doses prioritized over first doses
- Timing of vaccine introduction (first administration) varied
  - Before rise in incidence
  - As incidence rises
  - As incidence falls
Vaccine Introduced Before Rise in Incidence

Graph showing the incidence of SARS-CoV-2 infections over days from vaccine introduction.
Vaccine Introduced as Incidence Rises

Incidence of SARS-CoV-2 Infections vs. Days from Vaccine Introduction
Vaccine Introduced as Incidence Falls

Incidence of SARS-CoV-2 Infections

Days From Vaccine Introduction
Approximate Timing of Vaccine Rollout in Context

- **Phase 1A**: Healthcare Personnel
- **Phase 1B**: Adults Aged 65+ OR High-Risk Adults OR Essential Workers
- **Phase 1B: All 3 groups**

Days From Vaccine Introduction

Incidence of SARS-CoV-2 Infections
Findings
Population-Wide Averted Infections: Infection-Blocking Vaccine, Older Adults Receive Full Protection

Initial Phase 1B Target:
- Age 65+
- High-Risk Adults
- Essential Workers

- Initially vaccinating high-risk adults or essential workers in Phase 1B averts approximately 1–5% more infections, compared to targeting age 65+.
  - This difference is greatest in the scenario where the vaccine is introduced before incidence rises.

- Findings are robust to assumptions of reduced VE in older populations.
Population-Wide Averted Deaths: Infection-Blocking Vaccine, Older Adults Receive Full Protection

<table>
<thead>
<tr>
<th>Vaccine Introduction Time</th>
<th>Deaths Averted by Vaccination (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before Incidence Rises</td>
<td>~4%</td>
</tr>
<tr>
<td>As Incidence Rises</td>
<td>~3%</td>
</tr>
<tr>
<td>As Incidence Falls</td>
<td>~1%</td>
</tr>
</tbody>
</table>

Initial Phase 1B Target:
- Age 65+
- High-Risk Adults
- Essential Workers

- Initially vaccinating age 65+ in Phase 1B averts approximately 1–4% more deaths, compared to targeting high-risk adults or essential workers.
  - As before, this difference is greatest in the scenario where the vaccine is introduced before incidence rises.
Population-Wide Averted Deaths: Infection-Blocking Vaccine, Older Adults Receive Half Protection

- The percentage of deaths averted changes if VE is reduced in older populations

- Initially vaccinating high-risk adults, age 65+, or essential workers in Phase 1B averts a similar percentage of deaths across the scenarios
Population-Wide Averted Deaths:
Disease-Blocking Vaccine, Older Adults Receive Full Protection

- Initially vaccinating age 65+ in Phase 1B averts approximately 2–11% more deaths, compared to targeting high-risk adults or essential workers
  - As before, this difference is greatest in the scenario where the vaccine is introduced before incidence rises
- Findings robust to assumptions of reduced VE in older populations but percentage averted drops
Conclusions
Limitations

- The efficacy and ability of the vaccine candidates to prevent transmission, as well as the time vaccine may become available, is currently unknown.
- Modeled epidemic trajectories are only for illustration and are not forecasts.
- Overall averted burden should be interpreted cautiously:
  - Sensitive to the future trajectory of the epidemic.
  - Findings reflect an idealized rollout, with minimal delays and 100% uptake.
  - The aim of this study was to demonstrate the relative impact of different initial vaccine allocation strategies.
Limitations

- The following inputs were assumed and will require reassessment as more information becomes available
  - All infections confer protective immunity
  - Immunity (either naturally- or vaccine-acquired) doesn’t wane significantly within a year of infection/immunization
  - Given exposure, younger age groups are just as likely to become infected as older age groups (susceptibility independent of age)
  - Individuals with comorbidities are just as likely as their peers to practice social distancing and other protective behaviors
  - No reduction in VE among those with high-risk medical conditions
Discussion

- Initially vaccinating adults 65+ in Phase 1B generally averts greatest % of **deaths**
  - Approximately 1 to 11% increase in averted deaths across the scenarios
- Initially vaccinating essential workers or high-risk adults in Phase 1B generally averts greatest % of **infections**
  - Approximately 1 to 5% increase in averted infections across the scenarios
- Earlier vaccine roll-out relative to increasing transmission, the greater the averted percentage and differences between the strategies
  - Differences not substantial in some scenarios
  - Emphasizes need to continue efforts to slow the spread
- Findings are consistent in sensitivity analyses where the % of the population infected prior to vaccine introduction was varied
Consistency with External Literature

- Reviewed peer-reviewed and pre-publication studies that model the impact of vaccination under different initial allocation strategies
- General agreement across the study results with results presented here
Questions