Modeling typhoid vaccination in Nepal: TCV impact and booster dose strategy

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Typhoid vaccination in Nepal

- TCV was introduced into the National Immunization Program of Nepal in April 2012
  - Routine vaccination at 15 months
  - Catch-up campaign to 15 years of age
- Data from TyVAC randomized controlled trial demonstrated high VE (79%) through 2 yrs of follow-up
- Key question: Will booster doses of TCV be needed to sustain protection among school-aged children?
  - What is the most cost-effective vaccination strategy?
Translating vaccine efficacy into impact

\[ \text{VE}_0 \times \text{coverage}_a \times S_1 \]

\[ (1-\text{VE}_0) \times c_a \times S_1 \]

\[ (1-\text{VE}_0) \times c_a \times R \]

\[ \omega_v V_1 \]

\[ \omega_v V_2 \]

\[ \text{VE}_0 \times \text{booster}_a \times R_V \]
Waning of vaccine effectiveness

Based on data from Malawi:

Routine vaccination doses (<2 yrs)

- $VE_0 = 81\%$ (71-97\%)
- Median duration = 46.8 yrs (5.6 to 97 yrs)

Campaign & booster doses (2-15 yrs)

- $VE_0 = 84\%$ (77-93\%)
- Median duration = 59.8 yrs (20 to 98 yrs)
We modeled the following vaccination strategies:

- Routine vaccination at 15m + campaign 15m – 15y (Base case)
- Routine 15m + campaign 15m-15y + booster at 5y (in year 5)
- Routine 15m + campaign 15m-15y + booster at 10y (in year 10)
- Routine 15m + campaign 15m-15y + boosters at 5y & 10y (in years 5 & 10)
- No vaccination
Predicted vaccine impact

A

- 0-4 years old
- 5-9 years old
- 10-14 years old
- 15-29 years old
- 30+ years old

Total Incidence per 100,000 person-years

Year

 Base Case  No Vaccine
Predicted vaccine impact

**Graph A**

- **0-4 years old**
- **5-9 years old**
- **10-14 years old**
- **15-29 years old**
- **30+ years old**

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Cases averted

• The current vaccination strategy (base case) is predicted to avert ~10,000 cases per 100k population over 20 years.
• Including a **booster dose** is predicted to avert an additional 650 to 1,900 cases per 100k.
Cost-effectiveness of booster strategies

• The current vaccination strategy is preferred (most cost-effective) at a willingness-to-pay (WTP) equal to 1xGDP per capita
• Including a booster dose at age 5 years is cost-effective at a WTP threshold of $1300 per DALY averted
Limitations and next steps

- Model was fitted to adjusted typhoid incidence in Kathmandu (STRATAA study)
  - may not be representative of entire country
- Need additional data on the delivery costs and coverage achievable for booster dose strategies
- Update with data from TyVAC-Nepal and TyVOID study on medium-term VE in Kathmandu
  - explore factors underlying differences in waning of VE between settings
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Waning of vaccine effectiveness (fast waning)

Routine vaccination doses (<2 yrs)

- \( \text{VE}_0 = 81\% \) (70-99\%)
- Median duration = 8.4 yrs (2.5 to 65 yrs)

Campaign & booster doses (2-15 yrs)

- \( \text{VE}_0 = 90\% \) (72-100\%)
- Median duration = 14.6 yrs (8 to 82 yrs)

Based on data from Bangladesh:
Qadri et al (Lancet, 2021) and in prep
Cost-effectiveness analysis: our approach

• Predict the impact of vaccination on the incidence of typhoid fever using a transmission dynamic model
• Estimate disability-adjusted life-years (DALYs) and treatment costs due to typhoid under each strategy
  – 20-year time horizon
• Estimate the cost of vaccination
• Calculate net monetary benefit:
  \[ \Delta NB = (\text{DALYs averted}) \times WTP - \Delta \text{Costs} \]
  (incorporates uncertainty in the model inputs)
Sampled 1,000 times from input parameters (incidence, vaccine efficacy and duration, treatment costs, vaccine delivery costs, CFR, etc)

Calculated net monetary benefit:
\[ NB = (\text{DALYs averted}) \times \text{WTP} - \Delta \text{Costs} \]

Examined the proportion of simulations in which the strategy that yielded the highest average net benefit was preferred for a given willingness-to-pay value