**Text S1.**

**1. Model description**

**The model is described by a set of differential equations for each age group (i=1 for infants age 0-1 years, i=2 for preschoolers age 2-4 years, i=3 for school children 5-14 years, and i=4 for adults age 15+ years):**



bi- birth rate, contributes to the infant group only (b1>0, bi=0 for i=2,3,4)

*ai* – maturation rates from group i to group i+1

ν1- vaccination rate

ν2- loss of vaccine immunity

γ*1,* γ*2*- recovery rates for cholera cases and asymptomatic infections

γ*3*- loss of natural immunity

*ξ1, ξ2* - excretion of *V. cholerae* by cholera cases and asymptomatically infected in water

*θ*- decay rate of *V. cholerae* in the environment

μi- natural death rate by age group

*p* – proportion of the infections of non-vaccinated which become cholera cases

*q* – proportion of the infections of vaccinated which become symptomatically infected

N – total population size

**2. Forces of infection**

The forces of infections () represent the risk of the susceptible and vaccinated individuals in age group i to acquire cholera including short cycle transmission through contacts with infected individuals and long cycle transmission through exposure to contaminated water:



where

*βH* – transmission rate from cholera cases to unvaccinated susceptible adults by direct contact (human-to-human)

βasymp – relative infectiousness of the asymptomatically infected.

- transmission rate to susceptibles adults due to the environment (water-to-human) outside of cholera season

δ1 (δ2) – seasonal multiplier for increased environmental riskduring spring (fall) seasons

δ3 – shift in the start of the season of elevated environmental risk (fall)

*βW* – transmission rate to susceptible adults from the environment (water-to-human)

si (i=1..4) – relative susceptibility of the group i. Adult group is used as a baseline (s4=1)

VES – vaccine efficacy in reducing susceptibility

**3. Modeling vaccination strategies**

All simulations are initiated with the population distributed among compartments based on the procedure described below. Simulations without vaccination are initiated with (V=0) and no transfers to the vaccinated compartment (ν1=0).The following vaccination strategies have been simulated with the model:

**One time vaccination campaign**. A proportion (coverage) of the targeted population is vaccinated once at the start of the simulation. Modeled by direct transfer of proportion k (coverage) of S and R compartments into V at the start (V(0)=kS(0)+kR(0)). The number of vaccinations is given by V(0).

**Periodic campaigns.** A proportion of the targeted population is vaccinated every three years. Modeled by direct transfer of proportion k (coverage) of S and R compartments into V at regular 5- or 3-year intervals. The individuals still remaining in the vaccinated compartment (V) immediately before the next campaign are also eligible for revaccination. The population distribution after each vaccination campaign (Snew, Rnew, Vnew) is related to the population distribution before the campaign (Sold, Rold, Vold) as follows (Vnew=Vold+kSold+kRold, Snew=(1-k)Sold, Rnew=(1-k)Rold). The number of vaccinations per campaign is given by kVold+kSold+kRold

**Continuous vaccination.** A proportion k of the targeted population is vaccinated initially (V(0)=kS(0)+kR(0)) and after the first year, a proportion of S and R are vaccinated at a fixed rate. Vaccination rate ν1 is set (ν1=0) for the first year and replaced with (ν1= ) afterward, where the value of ν1 is selected to balance the proportion of vaccinated who lose protection in one year if the vaccine is protective for an average of 3 and 5 years respectively. The total number of vaccinations over T years is given by .

The vaccination of one-year-olds in all scenarios is modeled by vaccinating half of the cohort younger than 2 years.