Covstretch Function Summary

Leonardo Wang

This note will summarize main functions for simulation and optimization from the **covstretch** repository that can potentially be utilized by the new theoretical paper on optimal doze stretching.

Epidemiological Model

We begin with the fundamental epidemiological model. The associated system of differential equations is defined originally in **R/ode_2vaccines_v2.R**, now moved to **review/setup/epi_models.R**, and can be formally written as below. The model assumes two vaccine types with different efficacies, which can be interpreted as full and fractional doses.

$$\dot{S}_i(t) = -\lambda_i(t)S_i(t) + \phi_i R_i(t) - (v_i^1(t)\delta_t^1 - v_i^2(t)\delta_t^2)\frac{S_i(t)}{S_i(t)+R_i(t)} \tag{1}$$

$$\dot{E}_i(t) = \lambda_i(t)(S_i(t) + N_i^1(t) + N_i^2(t)) - \gamma_i^{EI}E_i(t) \tag{2}$$

$$\dot{I}_i(t) = \gamma_i^{EI}E_i(t) - \gamma_i^{IRD}I_i(t) \tag{3}$$

$$\dot{R}_i(t) = (1-p_i)\gamma_i^{IRD}I_i(t) - \phi_i R_i(t) - (v_i^1\delta_i^1 + v_i^2\delta_i^2)\frac{R_i(t)}{S_i(t)+R_i(t)} \tag{4}$$

$$\dot{D}_i(t) = p_i\gamma_i^{IRD}I_i(t) \tag{5}$$

$$\dot{V}_i^1(t) = v_i^1(t)\delta_i^1\frac{e_i^1S_i(t)+R_i(t)}{S_i(t)+R_i(t)} - \kappa_i^1V_i^1(t) \tag{6}$$

$$\dot{N}_i^1(t) = v_i^1(t)\delta_i^1\frac{(1-e_i^1)S_i(t)}{S_i(t)+vrfR_i(t)} + \kappa_i^1V_i^1(t) - \lambda_i(t)N_i^1(t) \tag{7}$$

$$\dot{V}_i^2(t) = v_i^2(t)\delta_i^2\frac{e_i^2S_i(t)+R_i(t)}{S_i(t)+R_i(t)} - \kappa_i^2V_i^2(t) \tag{8}$$

$$\dot{N}_i^2(t) = v_i^2(t)\delta_i^2\frac{(1-e_i^2)S_i(t)}{S_i(t)+R_i(t)} + \kappa_i^2V_i^2(t) - \lambda_i(t)N_i^2(t) \tag{9}$$

where the definitions can be found in the appendix to the PNAS paper. Note that ϕ_i denotes loss of immunity.

Parameters