

Covstretch Function Summary

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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.

We begin with the fundamental epidemiological model. The associated system of differential equations is defined in **R/ode_2vaccines_v2.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.

$$\dot{S}_i(t) = -(\lambda_i(t) + \text{constantrisk})S_i(t) + \phi_i R_i(t) - (v_i^1(t)\delta_i^1 - v_i^2(t)\delta_i^2) \frac{S_i(t)}{S_i(t) + \text{vrf}R_i(t)} \quad (1)$$

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

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

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

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

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

$$\dot{N}_i^1(t) = v_i^1(t)\delta_i^1 \frac{(1 - e_i^1)S_i(t)}{S_i(t) + \text{vrf}R_i(t)} + \kappa_i^1 V_i^1(t) - (\lambda_i(t) + \text{constantrisk})N_i^1(t) \quad (7)$$

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

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

Questions:

- What is *constantrisk*?
- What is ϕ_i ?
- What is *vrf*?
- What are the exact definitions/interpretations of $\tilde{S}_i(t)$ and $\tilde{R}_i(t)$? They appear as $\frac{S_i(t)}{S_i(t) + \text{vrf}R_i(t)}$ in (1) and $\frac{\text{vrf}R_i(t)}{S_i(t) + R_i(t)}$ in (4), slightly different than in (8) and (9) of the PNAS paper's appendix. Why is the *vrf* not appearing in the denominator of the second expression?