

Documentation for HIV-HSV2 co-infection model in SIMPACT

The implementation of the HIV-HSV2 co-infection model is available in GitHub:

<https://github.com/dmhendrickx/simpactcyan>

4.4.8. Diagnosis event

When a person gets infected with HIV, either by transmission of the virus or by seeding the population to get the epidemic started, a diagnosis event will get scheduled. When fired, the person is deemed to feel bad enough to go to a doctor and get diagnosed as being HIV-infected. Upon diagnosis, a monitoring event will be scheduled very shortly afterwards, to monitor the progression of the disease and to offer treatment if eligible.

This event is hazard-based, and the hazard is of the following form:

$$\begin{aligned} hazard = \exp(&baseline + agefactor \times (t - t_{birth}) + genderfactor \times G \\ &+ diagpartnersfactor \times P + isdiagnosedfactor \times D \\ &+ \beta(t - t_{infected}) + HSV2factor \times HSV2 \end{aligned}$$

Note that this is again a time dependent exponential hazard of the form

$$hazard = \exp(A + Bt)$$

In the formula, G is a value related to the gender of the person, 0 for a man and 1 for a woman. The number P represents the number of partners of the person that are both HIV infected and diagnosed. The value of D is an indication of whether the person was diagnosed previously: its value is 0 if this is the initial diagnosis event, or 1 if it's a re-diagnosis (after dropping out of treatment). The value HSV2 is an indication of whether the person is infected with HSV2. Its value is 0 if the person is not infected with HSV2 and 1 if the person is infected with HSV2.

Here is an overview of the relevant configuration options, their defaults (between parentheses), and their meaning:

diagnosis.baseline (0):

Controls the corresponding baseline value in the expression for the hazard.

diagnosis.agefactor (0):

Controls the corresponding agefactor value in the expression for the hazard. This allows one to let the age of a person influence the hazard.

diagnosis.genderfactor (0):

Controls the genderfactor parameter in the hazard. This allows you to have a different hazard depending on the gender of the person.

diagnosis.diagpartnersfactor (0):

Corresponds to the value of `diagpartnersfactor` in the expression for the hazard. The idea is to allow the number of partners that have already been diagnosed to have an effect on a person's diagnosis time: if a person is not feeling well and knows that some of the partners are infected with HIV, this can be an incentive to go to the doctor sooner.

`diagnosis.isdiagnosedfactor (0)`:

Using this `isdiagnosedfactor` value in the hazard, it is possible to have a different hazard if the person was diagnosed before. After dropping out of treatment, for example because a person is feeling better and no longer feels the need for treatment, a diagnosis event will be scheduled again. It is reasonable to think that a person may go to the doctor again sooner when he already knows about the HIV infection.

`diagnosis.beta (0)`:

Corresponds to the β factor in the hazard expression, allowing one to take the time since infection into account.

`diagnosis.HSV2factor (0)`:

Using the `HSV2factor`, it is possible to have a different hazard when the person is infected with HSV2.

`diagnosis.t_max (200)`:

As explained in the section about 'time limited' hazards, an exponential function needs some kind of threshold value (after which it stays constant) to be able to perform the necessary calculations. This configuration value is a measure of this threshold.

4.4.23. HIV transmission event

When a relationship is formed between two people of which one is HIV infected, or when a relationship between two uninfected people exists and one of them gets infected, an HIV transmission event is scheduled. The hazard for this event is the following:

$$\begin{aligned} hazard = \exp & (a + bV^{-c} + d_1P_{infected} + d_2P_{uninfected} \\ & + Wf_1 \exp(f_2(A_{woman}(t_{ry}) + A_{debut})) + e_1HSV2_{infected} \\ & + e_2HSV2_{uninfected}) \end{aligned}$$

In this hazard, the value of V is the current viral load of the person, which can differ from the set-point viral load. The number of partners of the person who is already HIV-infected is specified by $P_{infected}$, while the number of partners of the person who will become HIV-infected when the event fires, is $P_{uninfected}$. The value of W is 1 if the uninfected person is a woman, and 0 otherwise. By configuring the weights f_1 and f_2 , it becomes possible to change the susceptibility of a woman depending on her age. Note that this age is only specified approximately by using a reference time t_{ry} instead of the actual time t . This reference time can be updated using the reference year synchronization event. $HSV2_{infected}$ and $HSV2_{uninfected}$ specify if the HIV-infected resp. uninfected person is infected with HSV2. The value of

HSV2_{infected} resp. HSV2_{uninfected} is 1 if the HIV-infected resp. uninfected person is infected with HSV2, and 0 otherwise. The values a , b , c , d_1 , d_2 , e_1 , e_2 , f_1 and f_2 can be configured as specified below; the A_{debut} parameter is the debut age.

The form of this hazard was originally inspired by the article of [Hargrove et al]. The default parameters that are mentioned below are based on a fit to the data from the [Fraser et al] article.

Here is an overview of the relevant configuration options, their defaults (between parentheses), and their meaning:

hivtransmission.param.a (-1.3997):

This refers to the value of a in the expression for the hazard, providing a baseline value.

hivtransmission.param.b (-12.0220):

This refers to the value of b in the expression for the hazard. Together with the value of c , this specifies the influence of the current viral load of the infected person.

hivtransmission.param.c (0.1649):

This refers to the value of c in the expression for the hazard. Together with the value of b , this specifies the influence of the current viral load of the infected person.

hivtransmission.param.d1 (0):

This refers to the value of d_1 in the expression for the hazard, providing a weight based on the number of partners of the infected person.

hivtransmission.param.d2 (0):

This refers to the value of d_2 in the expression for the hazard, providing a weight based on the number of partners of the uninfected person.

hivtransmission.param.e1 (0):

This refers to the value of e_1 in the expression for the hazard and specifies the influence of the HIV-infected person being HSV2-infected.

hivtransmission.param.e2 (0):

This refers to the value of e_2 in the expression for the hazard and specifies the influence of the HIV-uninfected person being HSV2-infected.

hivtransmission.param.f1 (0):

This refers to the value of f_1 in the expression of the hazard.

hivtransmission.param.f2 (0):

This refers to the value of f_2 in the expression of the hazard.

hivtransmission.maxageref.diff (1):

As explained above, the hazard does not use the real time dependency t , but refers to a reference time t_{ry} that needs to be synchronized periodically using the synchronize reference year event. The program will abort if it detects that the last reference time synchronization was more than this amount of time ago, which by default is one year.

4.4.24. HSV2 transmission event

When a person is HSV2 infected and a relationship is formed, an HSV2 transmission event will be scheduled. A time dependent exponential hazard is used:

$$hazard = \exp(a_i + b(t - t_{HSV2-infected}) + cM_i + dH_i)$$

The value of a_i can be set using `person.hsv2.a.dist.type` from the HSV2 related person settings. This value is taken from the person that's already infected. The b value can be configured using `hsv2transmission.hazard.b`, and $t_{HSV2-infected}$ is the time at which the infected person acquired the HSV2 infection. M_i represents the gender effect and is taken from the person that's already HSV2-infected. It's value is 1 for male and 0 for female. The value H_i is an indicator for the HSV2-infected person being HIV-infected. It's value is 1 for HIV-infected and 0 for HIV-uninfected.

Here is an overview of the relevant configuration options, their defaults (between parentheses), and their meaning:

`hsv2transmission.hazard.b` (0):

This configures the value of b in the hazard above.

`hsv2transmission.hazard.c` (0):

This configures the value of c for the gender effect in the hazard above.

`hsv2transmission.hazard.d` (0):

This configures the value of d for the HIV effect in the hazard above.

`hsv2transmission.hazard.t_max` (200):

As explained in the section about 'time limited' hazards, an exponential function needs some kind of threshold value (after which it stays constant) to be able to perform the necessary calculations. This configuration value is a measure of this threshold.