Appendix

Title

Authors Jesse Knight[1,2] and Marie-Claude Boily[1,2]

[1] MRC Centre for Global Infectious Disease Analysis, Imperial College London
[2] HIV Prevention Trials Network Modelling Centre, Imperial College London

Date 2024-10-09

Contents

Appendix A

Simulation Model Details

A.1 Simulation Model Overview

The simulation model is a discrete-time, stochastic individual-based model representing an open population of approximately *N* sexual and gender minority (SGM) individuals aged 10–59 including men who have sex with men (MSM) and transgender women (TGW) in an illustrative Sub-Saharan African context. The model aims to represent the sexual life-course events of SGM with respect to the potential causal pathways in Figure A.1, with the approximate representation shown in Figure A.2:

i) exposure to SGM violence

ii) distal mediators, including: depression and hazardous drinking

iii) proximal determinants of HIV risk, including: sexual partnership dynamics and condom use

SGM violence is conceptualized as any verbal and/or physical violence on the basis of an individuals' gender and/or sexual identity.

Individuals enter the model in a "null state", reflecting no prior SGM violence, depression, hazardous drinking, or sexual activity. At each timestep, individuals in the model can then experience any combination of the following events: exposure to SGM violence, depression onset or recovery, hazardous drinking onset or recovery, non-heterosexual partnership formation or dissolution, and sex within modelled partnerships (including whether a condom is used). Rates of "downstream" events are influenced by the current and possibly past states of individuals' "upstream" variables, as described below in § A.2.2.

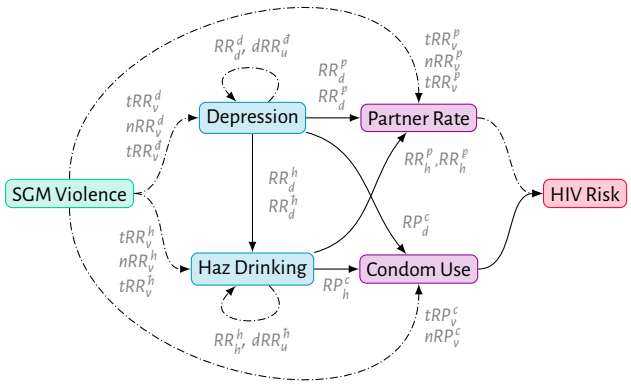


Figure A.1: Directed graph of the modelled causal pathways

Colours denote: green: structural factor; blue: distal mediators; purple: proximal determinants; red: outcome. *Lines* denote that the modelled effect depends on: solid: current state of upstream variable; dashed: current and past state of upstream variable. *RR* denote relative rates (see Table A.2 for definitions). Not shown: effect of age on all variables.

Table A.1: Notation reference

Symbol	Meaning
i	*index:* individual
k	*index:* partnership
z	*index:* timestep
t	*index:* time (days)
Δ_t	*duration:* one timestep
a	*status:* individual's age
v	*event:* SGM violence exposure
d	*event:* depression onset / *status:* current depression
d'	*status:* any previous depression
$đ$	*event:* depression recovery
h	*event:* hazardous drinking onset / *status:* current hazardous drinking
h'	*status:* any previous hazardous drinking
$ħ$	*event:* hazardous drinking recovery
u	*duration:* time since violence exposure or depression / hazardous drinking onset
p	*event:* sexual partnership formation
$ṗ$	*event:* sexual partnership dissolution
c	*event:* condom use
$\boldsymbol{R}_i^e$	overall rate of e for individual i
R_i^e	base rate of e for individual i
RR_x^e	rate ratio of e given x
tRR	transient rate ratio [1]
dRR	duration rate ratio [1]
τ	time scale of tRR and dRR [1]
iRR	initial value of tRR [1]
nRR	cumulative rate ratio [1]
η	count scale of nRR [1]
mRR	maximum / minimum value of nRR [1]

[1] See § A.2.2.2 for details.

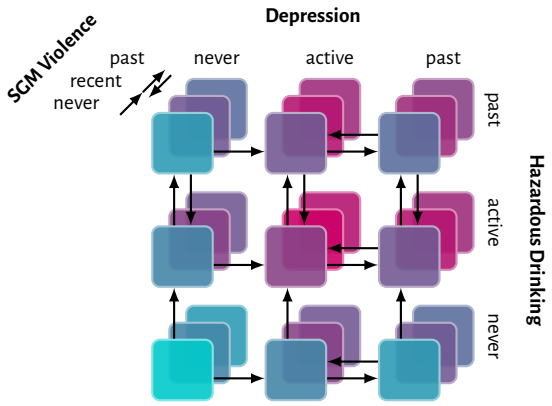


Figure A.2: Conceptual diagram of states related to SGM violence, depression, and hazardous drinking

Colours denote approximate HIV risk (mediated by sexual partnership turnover and condom use) where blue: lowest HIV risk, red: highest HIV risk. *Arrows* denote possible state transitions, where depression and hazardous drinking transitions are shown for first layer only, and SGM violence transitions are applied to all compartment stacks.

Implementation The model uses a fixed timestep of $\Delta_t = 7$ days,[1] reflecting a trade-off between temporal resolution and computational efficiency. Event-scheduling approaches were considered infeasible because multiple "upstream" events are modelled to have immediate effects on the rates of "downstream" events (e.g., exposure to SGM violence immediately increases the rate of depression onset); thus, "downstream" events cannot be scheduled. Instead, each timestep, the probability of each event occurring is computed for all individuals aged 10–59, using vectorized code. The model is implemented in R (v3.6.3), with code available online.[2] Table A.1 provides a notation reference.

A.2 Simulation Model Parameterization

Table A.2 summarizes the model parameters, while the details of the modelled processes are given below.

A.2.1 Active Population

The active population is defined as SGM individuals aged 10–59, which aims to capture the majority of sexual activity among SGM [**??**], plus exposure to SGM violence, depression, and hazardous drinking, including possibly prior to sexual activity. Individuals become sexually active at a randomly sampled age from the distribution given in Table A.3. Individuals exit the active population by reaching age 60, or through background mortality before age 60. Mortality rates are given in Table A.4, loosely reflecting ??

[1] One year is thus defined as $52\Delta_t$.
[2] github.com/jessexknight/shift

Table A.2: Overview of model parameters

Variable	Stratification	Symbol [1]	Value [2]
Active population size		N	10,000
Active population ages		—	[10, 60)
Age of starting sexual activity		—	Table A.3
Background rate of mortality	for age a	R_a^m	Table A.4
Base rate of violence exposure	*	R_i^v	??
Relative rate of violence exposure	for age a (years)	RR_a^v	Table A.4
Base rate of depression onset	*	R_i^d	??
Relative rates of depression onset	for age a (years)	RR_a^d	Table A.4
	if any previous depression	$RR_{d'}^d$	??
	for violence exposure u days ago	tRR_v^d	Table A.5
	per violence exposure (ever)	nRR_v^d	Table A.5
Base rate of depression recovery	*	$R_i^{\not d}$	??
Relative rate of depression recovery	for episode duration u days	$dRR_u^{\not d}$	Table A.5
	for violence exposure u days ago	$tRR_v^{\not d}$	Table A.5
Base rate of hazardous drinking onset	*	R_i^h	??
Relative rates of hazardous drinking onset	for age a (years)	RR_a^h	Table A.4
	if any previous hazardous drinking	$RR_{h'}^h$	??
	for violence exposure u days ago	tRR_v^h	Table A.5
	per violence exposure (ever)	nRR_v^h	Table A.5
	if current depression	RR_d^h	??
Base rate of hazardous drinking recovery	*	$R_i^{\not h}$	??
Relative rate of hazardous drinking recovery	for episode duration u days	$dRR_u^{\not h}$	Table A.5
	for violence exposure u days ago	$tRR_v^{\not h}$	Table A.5
	if current depression	$RR_d^{\not h}$	??
Maximum number of concurrent partners	*	M_i^p	§ A.2.2.5
Base rate of partnership formation	*	R_i^p	??
Relative rate of partnership formation	for age a (years)	RR_a^p	Table A.4
	for violence exposure u days ago	tRR_v^p	Table A.5
	per violence exposure (ever)	nRR_v^p	Table A.5
	if current depression	RR_d^p	??
	if current hazardous drinking	RR_h^p	??
Base rate of partnership dissolution	*	$R_i^{\not p}$	??
Relative rate of partnership dissolution	for age a (years)	$RR_a^{\not p}$	Table A.4
	for violence exposure u days ago	$tRR_v^{\not p}$	Table A.5
	if current depression	$RR_d^{\not p}$	??
	if current hazardous drinking	$RR_h^{\not p}$	??
Base probability of condom use per sex act	*	P_i^c	??
Relative probability of condom use	for age a (years)	RP_a^c	Table A.4
	for violence exposure u days ago	tRP_v^c	Table A.5
	per violence exposure (ever)	nRP_v^c	Table A.5
	if current depression	RP_d^c	??
	if current hazardous drinking	RP_h^c	??

[1] R_i: individual-level base rate; RR: population-level relative rate; tRR / nRR: transient / cumulative relative rates (see § A.2.2.2 for details);
[2] all durations in days; all rates in per-day

Table A.3: Ages of first sexual activity

Age	15	16	17	18	19	20	21	22	23	24
Proportion (%)	??	??	??	??	??	??	??	??	??	??
Cumulative Proportion (%)	??	??	??	??	??	??	??	??	??	100

Table A.4: Rates / relative rates of events by age

		Age (years) [1]						
Event	Symbol	10	15	20	30	40	50	60
Background mortality rate (per year)	R_a^m	??	??	??	??	??	??	??
RR SGM violence	RR_a^v	??	??	??	??	??	??	??
RR depression onset	RR_a^d	??	??	??	??	??	??	??
RR hazardous drinking onset	RR_a^d	??	??	??	??	??	??	??
RR sexual partnership formation	RR_a^p	??	??	??	??	??	??	??
RR sexual partnership dissolution	RR_a^p	??	??	??	??	??	??	??
RP condom use	RR_a^p	??	??	??	??	??	??	??

RR: relative rate; [1] Rates / RR were interpolated between these ages using monotonic cubic interpolation [1], with horizontal tangents enforced at ages 10 and 60; Figure A.3 illustrates these RR.

A.2.2 Event Rates

Event rates are modelled as a product of randomly sampled *individual-specific* base rates R_i and fixed *population-level* relative rates RR given an individual's current age, prior SGM violence exposure(s), depression status, and hazardous drinking status. The resulting rate of event e for individual i is denoted $\boldsymbol{R}_i^e$.

Some events are assumed to occur up to once per timestep per individual: depression onset, depression recovery, hazardous drinking onset, and hazardous drinking recovery. For these events, the probability of the event occurring to individual i during the timestep Δ_t is defined as:

$$P_i^e = 1 - \exp(-\boldsymbol{R}_i^e \Delta_t) \tag{A.1}$$

Other events are modelled to occur any number of times per timestep per individual: exposure to SGM violence, sexual partnership formation, and sex within partnerships. For these events, the number of events occurring to individual i during the timestep Δ_t is defined as:[3]

$$N_i^e \sim \text{Pois}(\boldsymbol{R}_i^e \Delta_t) \tag{A.2}$$

[3] Eq. (A.1) simply reflects the probability of $N_i^e > 0$ in Eq. (A.2).

[TODO]

Figure A.3: Relative rates of events by age

A.2.2.1 Exposure to SGM Violence

Individuals are modelled to have unique base rate of exposure to SGM violence (R_i^v), reflecting differences in family, friends, and the broader local community [**??**]. This base rate is modelled as fixed for each individual's lifetime and drawn from a population-level distribution (Figure **??**). A calibrated relative rate by age RR_a^v is also applied equally to all individuals. Thus, the rate of exposure to SGM violence for individual i is modelled as:

$$\boldsymbol{R}_i^v = R_i^v \cdot RR_a^v(a_i) \tag{A.3}$$

where a_i is the age of individual i. An individual's history of exposure to SGM violence is then represented by the set of times in which they were exposed: t_i^v, which can include duplicate values, if the individual was exposed more than once in any timestep — i.e., Eq. (A.2) > 1.

A.2.2.2 Effects of SGM Violence

Exposure to SGM violence is modelled to have two types of effects, both applied as relative rates of downstream events: transient ($tRR(t_i^v)$, where t_i^v is the set of times of recent exposures for individual i), and cumulative ($nRR(n_i^v)$, where n_i^v is the total number of lifetime exposures for individual i).

Transient Effects Transient effects of SGM violence are applied as relative rates of: depression onset (tRR_v^d), depression recovery ($tRR_v^{\bar{d}}$), hazardous drinking onset (tRR_v^h), hazardous drinking recovery ($tRR_v^{\bar{h}}$), partnership formation (tRR_v^p), and partnership dissolution ($tRR_v^{\bar{p}}$), plus a relative *probability* of condom use (tRP_v^c).[4] These relative rates are modelled to wane exponentially towards $RR = 1$ (i.e., no effect) with time since the most recent exposure $u_i^v = t - t_i^v$. The transient effects of the most recent exposure is thus specified as follows:

$$tRR(u_i^v) = 1 + (iRR - 1)\exp(-u_i^v/\tau) \tag{A.4}$$

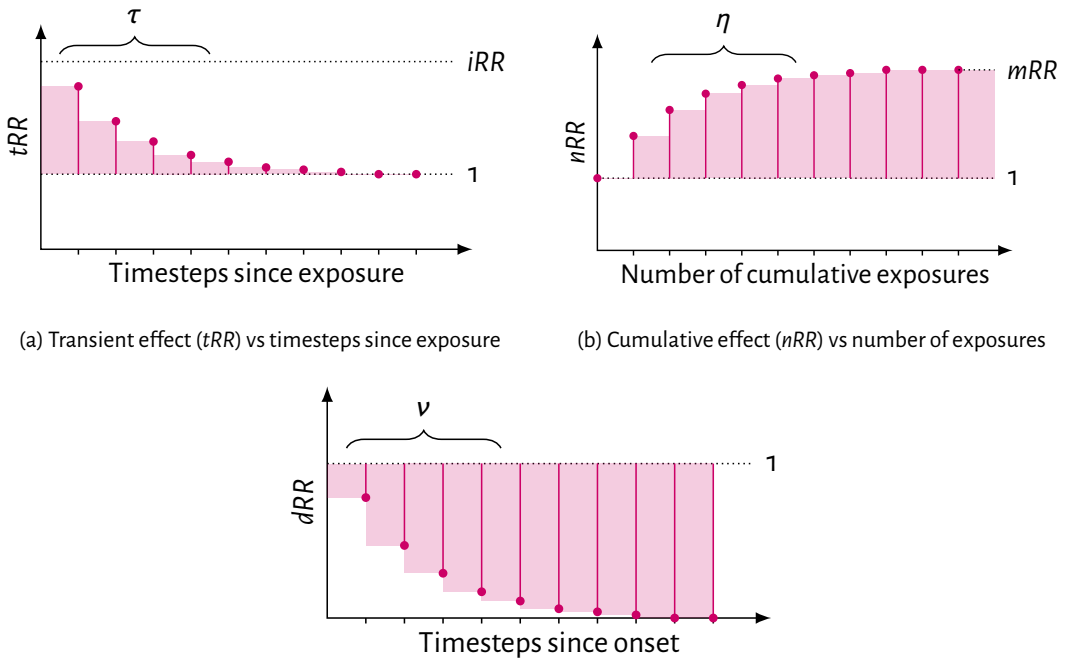
where: iRR is an initial relative rate, and τ is a scale parameter controlling the duration of effect.[5]

When considering discrete timesteps (indexed z, with length Δ_t), we replace t above with $z\,\Delta_t$ and t_i^v with z_i^v. Transient effects of violence are further assumed to only begin during the timestep following exposure, and thus only define tRR for $u_i^v > 0$. Figure A.4a illustrates an example transient effect $tRR(u_i^v)$ given by Eq. (A.4).

Cumulative Effects Cumulative effects of SGM violence are applied as relative rates of depression onset (nRR_v^d), hazardous drinking onset (nRR_v^h), and partnership formation (nRR_v^p), plus a relative *probability* of condom use (nRP_v^c). These relative rates are modelled to accumulate exponentially with each additional

[4] To ensure this probability remains bounded $\in [0, 1]$, we model either $RP \leq 1$ of condom use, or $RP \leq 1$ of condom non-use.

[5] For example, tRR decays to $\approx 0.37\ iRR$ by $t = \tau$.



(a) Transient effect (*tRR*) vs timesteps since exposure

(b) Cumulative effect (*nRR*) vs number of exposures

(c) Duration effect (*nRR*) vs duration since onset

Figure A.4: Illustration of transient, cumulative, and duration effects as relative rates

exposure, up to a maximum value:

$$nRR(n_i^v) = 1 + (mRR - 1)(1 - \exp(-n_i^v/\eta)) \tag{A.5}$$

where n_i^v reflects the cumulative number of exposures to SGM violence for individual i. Cumulative effects are thus also specified via 2 parameters: a maximum relative rate mRR, and a scale parameter η.[6] Figure A.4b illustrates the general shape of nRR with an increasing number of cumulative exposures. Like transient effects, cumulative effects are also assumed to begin the next timestep following exposure.

A.2.2.3 Depression

Although depression is likely a complex and dynamic system [2], for simplicity, we conceptualize depression as binary, using a working definition of PHQ-9 score $\geq$ 10 [3]. Depression status is denoted: $d_i = 1$ if individual i is currently depressed and $d_i = 0$ otherwise; plus $d'_i = 1$ if individual i was ever previously depressed and $d'_i = 0$ otherwise. Each individual is initialized with a base rate of depression onset (R_i^d) and a base rate of depression recovery ($R_i^{\hat{d}}$), reflecting differences in susceptibility to depression [4].

[6] Specifically, $nRR \approx 1 + 0.63(mRR - 1)$ after $n = \eta$ cumulative exposures.

Table A.5: Summary of modelled non-linear effects (relative rates) due to exposure to SGM violence and duration of depression/hazardous drinking episodes

Affected Rate [1]	Parameter values [2]			Example *RR*				
Transient effects of violence	Initial RR (*iRR*)	Time scale (τ)	u:	1	3	10	30	100
tRR_v^d: depression onset	??	??		??	??	??	??	??
$tRR_v^{\hat{d}}$: depression recovery	??	??		??	??	??	??	??
tRR_v^h: hazardous drinking onset	??	??		??	??	??	??	??
$tRR_v^{\hat{h}}$: hazardous drinking recovery	??	??		??	??	??	??	??
tRR_v^p: partnership formation	??	??		??	??	??	??	??
$tRR_v^{\hat{p}}$: partnership dissolution	??	??		??	??	??	??	??
tRP_v^c: condom use	??	??		??	??	??	??	??
Cumulative effects of violence	Max RR (*mRR*)	Count scale (η)	n:	1	3	10	30	100
nRR_v^d: depression onset	??	??		??	??	??	??	??
nRR_v^h: hazardous drinking onset	??	??		??	??	??	??	??
nRR_v^p: partnership formation	??	??		??	??	??	??	??
nRP_v^c: condom use	??	??		??	??	??	??	??
Effects of episode duration		Time scale (τ)	u:	1	3	10	30	100
dRR_d^u: depression recovery		??		??	??	??	??	??
dRR_h^u: hazardous drinking recovery		??		??	??	??	??	??

[1] All durations in days; all rates in per-day. [2] See Eqs. (A.4–**??**), (**??**) for parameter details.

Depression Onset Individuals are modelled to be at risk of depression onset from age 10 and not before [5]. The rate of depression onset is modelled to increase over ages 10–20 and decline after age 30 (RR_a^d, Table A.4, Figure A.3) [4–6]. The rate of depression onset is also modelled to increase by $RR_{d'}^d$ with any previous depression [7], and increase with exposure to SGM violence via transient (tRR_v^d) and cumulative (nRR_v^d) effects, as described in § A.2.2.2. Thus, the rate of depression onset for individual i (who is not currently depressed) is given by

$$\boldsymbol{R}_i^d = R_i^d \cdot RR_a^d(a_i) \cdot RR_{d'}^d(d'_i) \cdot tRR_v^d(t_i^v) \cdot nRR_v^d(n_i^v) \tag{A.6}$$

In a small abuse of notation, let $RR(x)$ denote $1 + x{\cdot}(RR - 1)$ when $x \in \{0, 1\}$ — i.e., $\{RR \text{ if } x = 1 \text{ else } 1\}$.

Depression Recovery Individuals are modelled to potentially recover from depression ($\hat{d}$) in the timestep immediately after onset, although the minimum duration of symptoms in clinical criteria for depression is 2 weeks [8]. The relative rate of depression recovery is modelled to decline with longer and longer duration depressed during this episode $u_i^{\hat{d}}$, as suggested by prior empirical modelling [9] . This effect is thus modelled to wane exponentially from 1 to 0:

$$dRR(u_i^{\hat{d}}) = \exp(-u_i^{\hat{d}}/\tau) \tag{A.7}$$

where: τ is a scale parameter as before. Figure A.4c illustrates an example transient effect $dRR(u_i^{\hat{d}})$ given by Eq. (A.7). The rate of depression recovery is also modelled to transiently decrease with exposure to SGM

violence ($tRR_v^{\dot{d}}$), as described in § A.2.2.2. Effects of age on recovery are not considered. Thus, the rate of depression recovery for depressed individual i is given by:

$$\boldsymbol{R}_i^{\dot{d}} = R_i^{\dot{d}} \cdot dRR_u^{\dot{d}}(u_i^d) \cdot tRR_v^{\dot{d}}(t_i^v) \tag{A.8}$$

A.2.2.4 Hazardous Drinking

Hazardous drinking is also conceptualized as binary, using the working definition of AUDIT-C score ≥ 4 [10]. It is modelled almost identically to depression (with different parameter values), except that effects of current depression status (d) on hazardous drinking onset and recovery are also considered, per the hypothesized causal pathway (Figure A.1).

Hazardous Drinking Onset Thus, the rate of hazardous drinking onset for individual i is modelled as the product of an individual-specific base rate R_i^h, relative rates for age (RR_a^h), current depression (RR_d^h), and any previous hazardous drinking ($RR_{h'}^h$), plus transient and cumulative relative rates for exposures to SGM violence (tRR_v^h, nRR_v^h) :

$$\boldsymbol{R}_i^h = R_i^h \cdot RR_a^h(a_i) \cdot RR_{h'}^h(h_i') \cdot RR_d^h(d_i) \cdot tRR_v^h(t_i^v) \cdot nRR_v^h(n_i^v) \tag{A.9}$$

Hazardous Drinking Recovery Likewise, the rate of hazardous drinking recovery for individual i is modelled as the product of an individual-specific base rate $R_i^{\dot{h}}$, relative rates for duration drinking hazardously ($dRR_u^{\dot{h}}$), and current depression ($RR_d^{\dot{h}}$), plus a transient relative rate for exposure to SGM violence ($tRR_v^{\dot{h}}$):

$$\boldsymbol{R}_i^{\dot{h}} = R_i^{\dot{h}} \cdot RR_d^{\dot{h}}(d_i) \cdot dRR_u^{\dot{h}}(u_i^h) \cdot tRR_v^{\dot{h}}(t_i^v) \tag{A.10}$$

A.2.2.5 Sexual Partnerships

Only sexual partnerships formed within the modelled SGM population are considered. That is, no "external" or heterosexual partnerships are modelled, and all sexual partnerships formed by individuals in the modelled population are assumed to be formed with other individuals in the modelled population.

Sexual Partnership Formation Each individual is modelled to have two unchanging characteristics that influence their rate of sexual partnership formation: a maximum number of concurrent partners M_i^p, and a base rate of sexual partnership formation R_i^p (while having fewer than M_i^p partners).

Relative rates of sexual partnership formation are also implemented for individuals' age (RR_a^p), exposure to SGM violence (tRR_v^p, nRR_v^p), current depression status (RR_d^p), and current hazardous drinking status (RR_h^p). Thus, the rate of sexual partnership formation for individual i (who has fewer than M_i^p current partners) is given by:

$$\boldsymbol{R}_i^p = R_i^p \cdot RR_a^p(a_i) \cdot tRR_v^p(t_i^v) \cdot nRR_v^p(n_i^v) \cdot RR_d^p(d_i) \cdot RR_h^p(h_i) \tag{A.11}$$

Individuals may form multiple new sexual partnership per timestep via Eq. (A.2).

Sexual Partnership Dissolution Sexual partnerships are modelled to dissolve at a rate influenced equally by the characteristics of both partners (denoted i, j). A base rate is modelled as the mean of individual-specific base rates: $\frac{1}{2}(R_i^p + R_j^p)$. This base rate is then multiplied by relative rates for *each* partner's age (RR_a^p), recent exposure to SGM violence (tRR_v^p), current depression status (RR_d^p), and current hazardous drinking status (RR_h^p), to obtain the overall rate:

$$\begin{aligned} \boldsymbol{R}_i^p = \tfrac{1}{2}(R_i^p + R_j^p) \cdot RR_a^p(a_i) \cdot tRR_v^p(t_i^v) \cdot RR_d^p(d_i) \cdot RR_h^p(h_i) \\ \cdot RR_a^p(a_j) \cdot tRR_v^p(z_j^v) \cdot RR_d^p(d_j) \cdot RR_h^p(h_j) \end{aligned} \tag{A.12}$$

All partnerships are modelled to last at least 1 timestep (7 days).

A.2.2.6 Anal Sex & Condom Use

[TODO]

A.2.2.7 Correlated Parameters

[TODO]

A.2.2.8 Summary

In total, 29 relative rates (RR) or relative probabilities (RP) are considered in the simulation model (Table A.2, Figure A.1), including:

- 6 RR associated with individuals' ages
- 11 RR due to SGM violence exposure (7 transient and 4 cumulative)
- 7 RR due to depression status/history (1 for any previous depression, 1 for current depression episode duration, and 5 for current depression status)
- 5 RR due to hazardous drinking status/history (1 for any previous hazardous drinking, 1 for current hazardous drinking episode duration, and 3 for current hazardous drinking status).

A.2.3 Sexual Mixing

Sexual mixing refers to non-random formation of sexual partnerships according to individuals' characteristics. Among individuals who are determined to form new sexual partnerships within a given timestep (see § A.2.2.5), sexual mixing is currently assumed to be fully random.

References

[1] F. N. Fritsch and R. E. Carlson. "Monotone Piecewise Cubic Interpolation". *SIAM Journal on Numerical Analysis* 17.2 (1980), pp. 238–246. URL: https://doi.org/10.1137/0717021.

[2] Angélique O. J. Cramer et al. "Major Depression as a Complex Dynamic System". *PLOS ONE* 11.12 (2016), e0167490. URL: https://doi.org/10.1371/journal.pone.0167490.

[3] Kurt Kroenke, Robert L. Spitzer, and Janet B. W. Williams. "The PHQ-9: Validity of a Brief Depression Severity Measure". *Journal of General Internal Medicine* 16.9 (2001), pp. 606–613. URL: https://doi.org/10.1046/j.1525-1497.2001.016009606.x.

[4] Benjamin L. Hankin et al. "Depression from childhood into late adolescence: Influence of gender, development, genetic susceptibility, and peer stress". *Journal of Abnormal Psychology* 124.4 (2015), pp. 803–816. URL: https://doi.org/10.1037/abn0000089.

[5] Marco Solmi et al. "Age at onset of mental disorders worldwide: large-scale meta-analysis of 192 epidemiological studies". *Molecular Psychiatry* 27.1 (2022), pp. 281–295. URL: https://doi.org/10.1038/s41380-021-01161-7.

[6] Scott B. Patten, Lee Gordon-Brown, and Graham Meadows. "Simulation studies of age-specific lifetime major depression prevalence". *BMC Psychiatry* 10.1 (2010), p. 85. URL: https://doi.org/10.1186/1471-244X-10-85.

[7] Kenneth S. Kendler and Charles O. Gardner. "Dependent Stressful Life Events and Prior Depressive Episodes in the Prediction of Major Depression: The Problem of Causal Inference in Psychiatric Epidemiology". *Archives of General Psychiatry* 67.11 (2010), pp. 1120–1127. URL: https://doi.org/10.1001/archgenpsychiatry.2010.136.

[8] American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders*. 5th ed. Washington, DC, 2013. URL: https://doi.org/10.1176/appi.books.9780890425787.

[9] Scott B. Patten. "Markov models of major depression for linking psychiatric epidemiology to clinical practice". *Clinical Practice and Epidemiology in Mental Health* 1.1 (2005), p. 2. URL: https://doi.org/10.1186/1745-0179-1-2.

[10] Kristen Bush et al. "The AUDIT Alcohol Consumption Questions (AUDIT-C): An Effective Brief Screening Test for Problem Drinking". *Archives of Internal Medicine* 158.16 (1998), pp. 1789–1795. URL: https://doi.org/10.1001/archinte.158.16.1789.