

epiworld

0.0-1

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1 Example: 00-hello-world	1
2 Benchmarking	3
3 Contributor Code of Conduct	5
4 epiworld c++ template library	7
4.1 Main features	7
4.2 Algorithm	7
4.3 Hello world (C++)	8
4.4 Surveillance simulation	8
4.4.1 Preliminary results	9
4.4.2 Cases detected	10
5 General parameters	11
5.1 Compartmental Models	11
5.1.1 SIR Model	11
5.1.2 SEIR Model	12
5.2 Agent-Based Model Approach	12
5.2.1 Mathematical preliminaries	13
5.2.2 Simulation study	13
5.3 Comparing ABM with Compartmental Models	13
5.3.1 SIR	13
5.3.2 SEIR	14
5.3.3 Rates	14
6 MIT License	15
7 model1	17
8 Mixing probabilities in connected model	19
8.1 Case 1: No grouping	19
8.2 Case 2: Grouping	20
9 EPI Simulator	21
9.1 Disease dynamics	21
9.2 Network dynamics	21
9.3 Contagion dynamics	21
9.4 Time dynamics	21
9.5 Updating agent's status	22
9.5.1 Other parameters	22
10 Namespace Index	23
10.1 Namespace List	23
11 Hierarchical Index	25

11.1 Class Hierarchy	25
12 Class Index	27
12.1 Class List	27
13 File Index	31
13.1 File List	31
14 Namespace Documentation	33
14.1 epiworld::sampler Namespace Reference	33
14.1.1 Detailed Description	33
14.1.2 Function Documentation	33
14.1.2.1 make_sample_virus_neighbors()	33
14.1.2.2 make_update_susceptible()	34
14.1.2.3 sample_virus_single()	34
14.2 sampler Namespace Reference	36
14.2.1 Detailed Description	36
14.2.2 Function Documentation	36
14.2.2.1 make_sample_virus_neighbors()	36
14.2.2.2 make_update_susceptible()	37
14.2.2.3 sample_virus_single()	37
15 Class Documentation	41
15.1 AdjList Class Reference	41
15.1.1 Constructor & Destructor Documentation	41
15.1.1.1 AdjList()	41
15.1.2 Member Function Documentation	42
15.1.2.1 read_edgelist()	42
15.2 epiworld::AdjList Class Reference	42
15.2.1 Constructor & Destructor Documentation	43
15.2.1.1 AdjList()	43
15.2.2 Member Function Documentation	43
15.2.2.1 read_edgelist()	43
15.3 Agent< TSeq > Class Template Reference	44
15.3.1 Detailed Description	46
15.3.2 Member Function Documentation	46
15.3.2.1 operator()()	46
15.3.2.2 swap_neighbors()	48
15.3.3 Friends And Related Function Documentation	48
15.3.3.1 default_rm_entity	48
15.4 epiworld::Agent< TSeq > Class Template Reference	49
15.4.1 Detailed Description	51
15.4.2 Member Function Documentation	51
15.4.2.1 operator()()	51

15.4.2.2 swap_neighbors()	52
15.4.3 Friends And Related Function Documentation	52
15.4.3.1 default_rm_entity	52
15.5 AgentsSample< TSeq > Class Template Reference	52
15.5.1 Detailed Description	53
15.5.2 Constructor & Destructor Documentation	53
15.5.2.1 AgentsSample()	53
15.6 epiworld::AgentsSample< TSeq > Class Template Reference	54
15.6.1 Detailed Description	54
15.6.2 Constructor & Destructor Documentation	55
15.6.2.1 AgentsSample()	55
15.7 DataBase< TSeq > Class Template Reference	55
15.7.1 Detailed Description	57
15.7.2 Member Function Documentation	58
15.7.2.1 generation_time()	58
15.7.2.2 get_transmissions()	58
15.7.2.3 operator==() [1/3]	58
15.7.2.4 operator==() [2/3]	59
15.7.2.5 operator==() [3/3]	59
15.7.2.6 record_virus()	59
15.7.2.7 reproductive_number()	60
15.7.2.8 transition_probability()	60
15.8 epiworld::DataBase< TSeq > Class Template Reference	61
15.8.1 Detailed Description	63
15.8.2 Member Function Documentation	63
15.8.2.1 generation_time()	63
15.8.2.2 get_transmissions()	63
15.8.2.3 operator==()	64
15.8.2.4 record_virus()	64
15.8.2.5 reproductive_number()	65
15.8.2.6 transition_probability()	65
15.9 Entities< TSeq > Class Template Reference	66
15.9.1 Detailed Description	66
15.10 epiworld::Entities< TSeq > Class Template Reference	66
15.10.1 Detailed Description	67
15.11 Entities_const< TSeq > Class Template Reference	67
15.11.1 Detailed Description	68
15.12 epiworld::Entities_const< TSeq > Class Template Reference	68
15.12.1 Detailed Description	68
15.13 Entity< TSeq > Class Template Reference	69
15.13.1 Constructor & Destructor Documentation	70
15.13.1.1 Entity()	70

15.13.2 Friends And Related Function Documentation	70
15.13.2.1 default_rm_entity	70
15.14 epiworld::Entity< TSeq > Class Template Reference	71
15.14.1 Constructor & Destructor Documentation	71
15.14.1.1 Entity()	71
15.14.2 Friends And Related Function Documentation	72
15.14.2.1 default_rm_entity	72
15.15 epiworld::Event< TSeq > Struct Template Reference	72
15.15.1 Detailed Description	72
15.15.2 Constructor & Destructor Documentation	73
15.15.2.1 Event()	73
15.16 Event< TSeq > Struct Template Reference	73
15.16.1 Detailed Description	74
15.16.2 Constructor & Destructor Documentation	75
15.16.2.1 Event()	75
15.17 epiworld::GlobalEvent< TSeq > Class Template Reference	75
15.17.1 Detailed Description	76
15.17.2 Constructor & Destructor Documentation	76
15.17.2.1 GlobalEvent()	76
15.18 GlobalEvent< TSeq > Class Template Reference	77
15.18.1 Detailed Description	77
15.18.2 Constructor & Destructor Documentation	77
15.18.2.1 GlobalEvent()	77
15.19 epiworld::LFMCMC< TData > Class Template Reference	78
15.19.1 Detailed Description	79
15.20 LFMCMC< TData > Class Template Reference	79
15.20.1 Detailed Description	80
15.21 epiworld::Model< TSeq > Class Template Reference	81
15.21.1 Detailed Description	89
15.21.2 Member Function Documentation	89
15.21.2.1 add_globlevent()	89
15.21.2.2 clone_ptr()	90
15.21.2.3 draw()	90
15.21.2.4 events_add()	90
15.21.2.5 events_run()	91
15.21.2.6 load_agents_entities_ties()	91
15.21.2.7 reset()	92
15.21.2.8 run_multiple()	92
15.21.2.9 set_agents_data()	92
15.21.2.10 set_name()	94
15.21.2.11 write_data()	94
15.21.3 Member Data Documentation	95

15.21.3.1 initial_states_fun	95
15.21.3.2 rbinomd	95
15.21.3.3 rexp	95
15.21.3.4 rgammad	95
15.21.3.5 rgeomd	96
15.21.3.6 rlognormald	96
15.21.3.7 rnbino	96
15.21.3.8 rnormd	96
15.21.3.9 rpoissd	96
15.21.3.10 runifd	97
15.21.3.11 time_elapsed	97
15.22 Model< TSeq > Class Template Reference	97
15.22.1 Detailed Description	105
15.22.2 Member Function Documentation	106
15.22.2.1 add_globlevent()	106
15.22.2.2 clone_ptr()	106
15.22.2.3 draw()	106
15.22.2.4 events_add()	107
15.22.2.5 events_run()	107
15.22.2.6 load_agents_entities_ties()	108
15.22.2.7 reset()	108
15.22.2.8 run_multiple()	109
15.22.2.9 set_agents_data()	109
15.22.2.10 set_name()	109
15.22.2.11 write_data()	110
15.22.3 Member Data Documentation	110
15.22.3.1 initial_states_fun	110
15.22.3.2 rbinomd	110
15.22.3.3 rexp	111
15.22.3.4 rgammad	111
15.22.3.5 rgeomd	111
15.22.3.6 rlognormald	111
15.22.3.7 rnbino	111
15.22.3.8 rnormd	112
15.22.3.9 rpoissd	112
15.22.3.10 runifd	112
15.22.3.11 time_elapsed	112
15.23 epiworld::ModelDiagram Class Reference	113
15.24 ModelDiagram Class Reference	113
15.25 epiworld::epimodels::ModelDiffNet< TSeq > Class Template Reference	113
15.25.1 Detailed Description	114
15.26 ModelDiffNet< TSeq > Class Template Reference	115

15.26.1 Detailed Description	116
15.27 epiworld::epimodels::ModelMeaslesQuarantine< TSeq > Class Template Reference	116
15.27.1 Detailed Description	118
15.27.2 Constructor & Destructor Documentation	119
15.27.2.1 ModelMeaslesQuarantine()	119
15.27.3 Member Function Documentation	120
15.27.3.1 clone_ptr()	120
15.27.3.2 quarantine_agents()	120
15.27.3.3 reset()	121
15.28 ModelMeaslesQuarantine< TSeq > Class Template Reference	121
15.28.1 Detailed Description	123
15.28.2 Constructor & Destructor Documentation	123
15.28.2.1 ModelMeaslesQuarantine()	124
15.28.3 Member Function Documentation	124
15.28.3.1 clone_ptr()	124
15.28.3.2 quarantine_agents()	125
15.28.3.3 reset()	125
15.29 epiworld::epimodels::ModelSEIR< TSeq > Class Template Reference	126
15.29.1 Detailed Description	127
15.29.2 Member Function Documentation	127
15.29.2.1 initial_states()	127
15.29.3 Member Data Documentation	128
15.29.3.1 update_exposed_seir	128
15.29.3.2 update_infected_seir	128
15.30 ModelSEIR< TSeq > Class Template Reference	129
15.30.1 Detailed Description	130
15.30.2 Member Function Documentation	130
15.30.2.1 initial_states()	130
15.30.3 Member Data Documentation	131
15.30.3.1 update_exposed_seir	131
15.30.3.2 update_infected_seir	131
15.31 epiworld::epimodels::ModelSEIRCONN< TSeq > Class Template Reference	131
15.31.1 Constructor & Destructor Documentation	132
15.31.1.1 ModelSEIRCONN()	133
15.31.2 Member Function Documentation	133
15.31.2.1 clone_ptr()	133
15.31.2.2 initial_states()	133
15.31.2.3 reset()	134
15.32 ModelSEIRCONN< TSeq > Class Template Reference	134
15.32.1 Constructor & Destructor Documentation	135
15.32.1.1 ModelSEIRCONN()	136
15.32.2 Member Function Documentation	136

15.32.2.1 clone_ptr()	136
15.32.2.2 initial_states()	136
15.32.2.3 reset()	137
15.33 epiworld::epimodels::ModelSEIRD< TSeq > Class Template Reference	137
15.33.1 Detailed Description	139
15.33.2 Constructor & Destructor Documentation	139
15.33.2.1 ModelSEIRD() [1/2]	139
15.33.2.2 ModelSEIRD() [2/2]	140
15.33.3 Member Data Documentation	140
15.33.3.1 update_exposed_seir	140
15.34 ModelSEIRD< TSeq > Class Template Reference	141
15.34.1 Detailed Description	142
15.34.2 Constructor & Destructor Documentation	142
15.34.2.1 ModelSEIRD() [1/2]	142
15.34.2.2 ModelSEIRD() [2/2]	143
15.34.3 Member Data Documentation	143
15.34.3.1 update_exposed_seir	143
15.35 epiworld::epimodels::ModelSEIRDCONN< TSeq > Class Template Reference	144
15.35.1 Constructor & Destructor Documentation	145
15.35.1.1 ModelSEIRDCONN()	145
15.35.2 Member Function Documentation	146
15.35.2.1 clone_ptr()	146
15.35.2.2 initial_states()	146
15.35.2.3 reset()	146
15.36 ModelSEIRDCONN< TSeq > Class Template Reference	147
15.36.1 Constructor & Destructor Documentation	148
15.36.1.1 ModelSEIRDCONN()	148
15.36.2 Member Function Documentation	149
15.36.2.1 clone_ptr()	149
15.36.2.2 initial_states()	149
15.36.2.3 reset()	150
15.37 epiworld::epimodels::ModelSEIRMixing< TSeq > Class Template Reference	150
15.37.1 Constructor & Destructor Documentation	151
15.37.1.1 ModelSEIRMixing() [1/2]	152
15.37.1.2 ModelSEIRMixing() [2/2]	152
15.37.2 Member Function Documentation	153
15.37.2.1 clone_ptr()	153
15.37.2.2 initial_states()	153
15.37.2.3 reset()	154
15.38 ModelSEIRMixing< TSeq > Class Template Reference	154
15.38.1 Constructor & Destructor Documentation	155
15.38.1.1 ModelSEIRMixing() [1/2]	155

15.38.1.2 ModelSEIRMixing() [2/2]	156
15.38.2 Member Function Documentation	156
15.38.2.1 clone_ptr()	157
15.38.2.2 initial_states()	157
15.38.2.3 reset()	157
15.39 epiworld::epimodels::ModelSIR< TSeq > Class Template Reference	158
15.39.1 Detailed Description	159
15.39.2 Member Function Documentation	159
15.39.2.1 initial_states()	159
15.40 ModelSIR< TSeq > Class Template Reference	159
15.40.1 Detailed Description	160
15.40.2 Member Function Documentation	161
15.40.2.1 initial_states()	161
15.41 epiworld::epimodels::ModelSIRCONN< TSeq > Class Template Reference	162
15.41.1 Constructor & Destructor Documentation	163
15.41.1.1 ModelSIRCONN()	163
15.41.2 Member Function Documentation	163
15.41.2.1 clone_ptr()	164
15.41.2.2 get_n_infected()	164
15.41.2.3 initial_states()	164
15.41.2.4 reset()	164
15.42 ModelSIRCONN< TSeq > Class Template Reference	165
15.42.1 Constructor & Destructor Documentation	166
15.42.1.1 ModelSIRCONN()	166
15.42.2 Member Function Documentation	167
15.42.2.1 clone_ptr()	167
15.42.2.2 get_n_infected()	167
15.42.2.3 initial_states()	167
15.42.2.4 reset()	168
15.43 epiworld::epimodels::ModelSIRD< TSeq > Class Template Reference	168
15.43.1 Detailed Description	169
15.43.2 Constructor & Destructor Documentation	169
15.43.2.1 ModelSIRD()	170
15.43.3 Member Function Documentation	171
15.43.3.1 initial_states()	171
15.44 ModelSIRD< TSeq > Class Template Reference	171
15.44.1 Detailed Description	172
15.44.2 Constructor & Destructor Documentation	173
15.44.2.1 ModelSIRD()	173
15.44.3 Member Function Documentation	173
15.44.3.1 initial_states()	173
15.45 epiworld::epimodels::ModelSIRDCONN< TSeq > Class Template Reference	174

15.45.1 Constructor & Destructor Documentation	175
15.45.1.1 ModelSIRDCONN()	175
15.45.2 Member Function Documentation	176
15.45.2.1 clone_ptr()	176
15.45.2.2 reset()	176
15.46 ModelSIRDCONN< TSeq > Class Template Reference	177
15.46.1 Constructor & Destructor Documentation	178
15.46.1.1 ModelSIRDCONN()	178
15.46.2 Member Function Documentation	178
15.46.2.1 clone_ptr()	178
15.46.2.2 reset()	179
15.47 epiworld::epimodels::ModelSIRLogit< TSeq > Class Template Reference	179
15.47.1 Detailed Description	180
15.47.2 Constructor & Destructor Documentation	181
15.47.2.1 ModelSIRLogit()	181
15.47.3 Member Function Documentation	182
15.47.3.1 clone_ptr()	182
15.47.3.2 reset()	182
15.48 ModelSIRLogit< TSeq > Class Template Reference	183
15.48.1 Detailed Description	184
15.48.2 Constructor & Destructor Documentation	184
15.48.2.1 ModelSIRLogit()	184
15.48.3 Member Function Documentation	185
15.48.3.1 clone_ptr()	185
15.48.3.2 reset()	185
15.49 epiworld::epimodels::ModelSIRMixing< TSeq > Class Template Reference	186
15.49.1 Constructor & Destructor Documentation	187
15.49.1.1 ModelSIRMixing() [1/2]	187
15.49.1.2 ModelSIRMixing() [2/2]	188
15.49.2 Member Function Documentation	188
15.49.2.1 clone_ptr()	189
15.49.2.2 initial_states()	189
15.49.2.3 reset()	189
15.50 ModelSIRMixing< TSeq > Class Template Reference	190
15.50.1 Constructor & Destructor Documentation	191
15.50.1.1 ModelSIRMixing() [1/2]	191
15.50.1.2 ModelSIRMixing() [2/2]	192
15.50.2 Member Function Documentation	192
15.50.2.1 clone_ptr()	192
15.50.2.2 initial_states()	192
15.50.2.3 reset()	193
15.51 epiworld::epimodels::ModelSIS< TSeq > Class Template Reference	193

15.51.1 Detailed Description	195
15.52 ModelSIS< TSeq > Class Template Reference	196
15.52.1 Detailed Description	197
15.53 epiworld::epimodels::ModelSISD< TSeq > Class Template Reference	197
15.53.1 Detailed Description	198
15.54 ModelSISD< TSeq > Class Template Reference	199
15.54.1 Detailed Description	200
15.55 epiworld::epimodels::ModelSURV< TSeq > Class Template Reference	200
15.55.1 Member Function Documentation	202
15.55.1.1 reset()	202
15.56 ModelSURV< TSeq > Class Template Reference	203
15.56.1 Member Function Documentation	204
15.56.1.1 reset()	205
15.57 Network< Nettype, Nodetype, Edgetype > Class Template Reference	205
15.58 epiworld::PersonTools< TSeq > Class Template Reference	205
15.59 PersonTools< TSeq > Class Template Reference	206
15.60 epiworld::Progress Class Reference	206
15.60.1 Detailed Description	206
15.61 Progress Class Reference	206
15.61.1 Detailed Description	206
15.62 epiworld::Queue< TSeq > Class Template Reference	207
15.62.1 Detailed Description	207
15.63 Queue< TSeq > Class Template Reference	207
15.63.1 Detailed Description	208
15.64 RandGraph Class Reference	208
15.65 epiworld::SAMPLETYPE Class Reference	209
15.66 SAMPLETYPE Class Reference	209
15.67 epiworld::Tool< TSeq > Class Template Reference	209
15.67.1 Detailed Description	210
15.68 Tool< TSeq > Class Template Reference	210
15.68.1 Detailed Description	212
15.69 epiworld::ToolFunctions< TSeq > Class Template Reference	212
15.69.1 Detailed Description	212
15.70 ToolFunctions< TSeq > Class Template Reference	213
15.70.1 Detailed Description	213
15.71 epiworld::Tools< TSeq > Class Template Reference	213
15.71.1 Detailed Description	213
15.72 Tools< TSeq > Class Template Reference	214
15.72.1 Detailed Description	214
15.73 epiworld::Tools_const< TSeq > Class Template Reference	215
15.73.1 Detailed Description	215
15.74 Tools_const< TSeq > Class Template Reference	215

15.74.1 Detailed Description	216
15.75 epiworld::UserData< TSeq > Class Template Reference	216
15.75.1 Detailed Description	217
15.75.2 Constructor & Destructor Documentation	218
15.75.2.1 UserData()	218
15.76 UserData< TSeq > Class Template Reference	218
15.76.1 Detailed Description	219
15.76.2 Constructor & Destructor Documentation	219
15.76.2.1 UserData()	219
15.77 epiworld::vecHasher< T > Struct Template Reference	220
15.77.1 Detailed Description	220
15.78 vecHasher< T > Struct Template Reference	220
15.78.1 Detailed Description	220
15.79 epiworld::Virus< TSeq > Class Template Reference	221
15.79.1 Detailed Description	222
15.80 Virus< TSeq > Class Template Reference	223
15.80.1 Detailed Description	225
15.81 epiworld::Viruses< TSeq > Class Template Reference	225
15.81.1 Detailed Description	225
15.82 Viruses< TSeq > Class Template Reference	226
15.82.1 Detailed Description	226
15.83 epiworld::Viruses_const< TSeq > Class Template Reference	227
15.83.1 Detailed Description	227
15.84 Viruses_const< TSeq > Class Template Reference	227
15.84.1 Detailed Description	228
15.85 epiworld::VirusFunctions< TSeq > Class Template Reference	228
15.86 VirusFunctions< TSeq > Class Template Reference	229
16 File Documentation	231
16.1 include/epiworld/agent-meat-state.hpp File Reference	231
16.1.1 Detailed Description	232
Index	233

Chapter 1

Example: 00-hello-world

Output from the program:

```
Running the model...
|||||
SIMULATION STUDY
Name of the model      : (none)
Population size        : 10000
Agents' data           : (none)
Number of entities    : 0
Days (duration)        : 100 (of 100)
Number of viruses      : 1
Last run elapsed t     : 17.00ms
Last run speed         : 56.33 million agents x day / second
Rewiring               : off
Global events:
  (none)
Virus(es):
  - covid 19
Tool(s):
  - vaccine
Model parameters:
  (none)
Distribution of the population at time 100:
  - (0) Susceptible : 9950 -> 0
  - (1) Exposed     : 50 -> 0
  - (2) Recovered   : 0 -> 9399
  - (3) Removed     : 0 -> 601
Transition Probabilities:
  - Susceptible 0.92 0.08 - -
  - Exposed - 0.85 0.14 0.01
  - Recovered - - 1.00 -
  - Removed - - - 1.00
```

Chapter 2

Benchmarking

Here we keep a list of scenarios where we compare epiworld with other ABM simulation engines. Although the comparison is made at the speed level, we also list features of capabilities and main differences between the engines.

Chapter 3

Contributor Code of Conduct

As contributors and maintainers of this project, we pledge to respect all people who contribute through reporting issues, posting feature requests, updating documentation, submitting pull requests or patches, and other activities.

We are committed to making participation in this project a harassment-free experience for everyone, regardless of level of experience, gender, gender identity and expression, sexual orientation, disability, personal appearance, body size, race, ethnicity, age, or religion.

Examples of unacceptable behavior by participants include the use of sexual language or imagery, derogatory comments or personal attacks, trolling, public or private harassment, insults, or other unprofessional conduct.

Project maintainers have the right and responsibility to remove, edit, or reject comments, commits, code, wiki edits, issues, and other contributions that are not aligned to this Code of Conduct. Project maintainers who do not follow the Code of Conduct may be removed from the project team.

Instances of abusive, harassing, or otherwise unacceptable behavior may be reported by opening an issue or contacting one or more of the project maintainers.

This Code of Conduct is adapted from the Contributor Covenant (<http://contributor-covenant.org>), version 1.0.0, available at <http://contributor-covenant.org/version/1/0/0/>

Chapter 4

epiworld c++ template library

4.1 Main features

This C++ template-header-only library provides a general framework for epidemiologic simulation. The main features of the library are:

1. Four key classes: `Model`, `Person`, `Tool`, and `Virus`.
2. The model features a social networks of `Persons`.
3. `Persons` can have multiple `Tools` as a defense system.
4. `Tools` can reduce contagion rate, transmissibility, death rates, and improve recovery rates.
5. `Viruses` can mutate (generating new variants).
6. `Models` can feature multiple states, e.g., `HEALTHY`, `SUSCEPTIBLE`, etc.
7. `Models` can have an arbitrary number of parameters.
8. **REALLY FAST** About 6.5 Million person/day simulations per second.

4.2 Algorithm

Setup

- Create viruses.
- Create tools (arbitrary).
- Set model parameters (arbitrary).
- Create global events (e.g., surveillance).
- Set up the population: small world network (default).
- Set up rewiring (optional).
- Set states (arbitrary number of them).

Run

1. Distribute the tool(s) and virus(es)
2. For each t in 1 -> Duration:
 - Update state for susceptible/infected/removed(?)
 - Mutate virus(es) (each individual)
 - Run Global events (e.g., surveillance)
 - Run rewiring algorithm

Along update:

- Contagion events are applied recorded.
- New variants are recorded.
- Optional user data is recorded.

4.3 Hello world (C++)

```
#include "include/epiworld/epiworld.hpp"
int main()
{
    // Creating a virus
    epiworld::Virus<> covid19("covid 19", .01, true);
    covid19.set_infectiousness(.8);

    // Creating a tool
    epiworld::Tool<> vax("vaccine", .5, true);
    vax.set_contagion_reduction(.95);
    // Creating a model
    epiworld::Model<> model;
    // Adding the tool and virus
    model.add_virus(covid19);
    model.add_tool(vax);
    // Generating a random pop
    model.population_from_adjlist(
        epiworld::rgraph_smallworld(1000, 5, .2)
    );
    // Initializing setting days and seed
    model.init(60, 123123);
    // Running the model
    model.run();
    model.print();
    return;
}
```

4.4 Surveillance simulation

- Incubation time of the disease $\sim \text{Gamma}(3, 1)$
- Duration of the disease $\sim \text{Gamma}(12, 1)$
- Probability of becoming symptomatic: 0.9
- Prob. of transmission: 1.0.
- Vaccinated population: 25%
- Vaccine efficacy: .9.
- Vaccine reduction on transmission: 0.5.
- Surveillance program of x% of the population at random.
- Individuals who test positive become isolated.

4.4.1 Preliminary results

```
# With low surveillance
pop_size <- 20e3
pop_seed <- pop_size * .01
s_levels <- c(0.0001, 0.002)
system(sprintf("./07-surveillance.o %i %i 100 %.04f 2>&1", pop_seed, pop_size, s_levels[1]), intern = TRUE)
|>
cat(sep = "\n")

## Running the model...
##
## | done.
##
##
## SIMULATION STUDY
##
## Population size      : 20000
## Days (duration)     : 200 (of 200)
## Number of variants  : 1
## Last run elapsed t  : 505.00ms
## Rewiring            : off
##
## Virus(es):
## - Covid19 (baseline prevalence: 100 seeds)
## Tool(s):
## - Vaccine (baseline prevalence: 25.00%)
##
## Model parameters:
## - Infect period      : 12.0000
## - Latent period      : 3.0000
## - Prob of symptoms   : 0.7000
## - Prob of transmission : 1.0000
## - Prob. death        : 0.0010
## - Prob. reinfect     : 0.1000
## - Surveillance prob. : 1.0e-04
## - Vax efficacy       : 0.9000
## - Vax redux transmission : 0.5000
##
## Distribution of the population at time 200:
## - Total susceptible (S) : 19900 -> 2106
## - Total recovered (S)   : 0 -> 17369
## - Total latent (I)      : 100 -> 109
## - Total symptomatic (I) : 0 -> 155
## - Total symptomatic isolated (I) : 0 -> 2
## - Total asymptomatic (I) : 0 -> 72
## - Total asymptomatic isolated (I) : 0 -> 0
## - Total removed (R)    : 0 -> 187
##
## (S): Susceptible, (I): Infected, (R): Recovered
##
hist1 <- read.csv("07-surveillance_hist.txt", sep = " ")
surv1 <- read.csv("07-surveillance_user_data.txt", sep = " ")
# With high surveillance
system(sprintf("./07-surveillance.o %i %i 100 %.04f 2>&1", pop_seed, pop_size, s_levels[2]), intern = TRUE)
|>
cat(sep = "\n")

## Running the model...
##
## | done.
##
##
## SIMULATION STUDY
##
## Population size      : 20000
## Days (duration)     : 200 (of 200)
## Number of variants  : 1
## Last run elapsed t  : 530.00ms
## Rewiring            : off
##
## Virus(es):
```

```
## - Covid19 (baseline prevalence: 100 seeds)
## Tool(s):
## - Vaccine (baseline prevalence: 25.00%)
##
## Model parameters:
## - Infect period      : 12.0000
## - Latent period      : 3.0000
## - Prob of symptoms   : 0.7000
## - Prob of transmission : 1.0000
## - Prob. death        : 0.0010
## - Prob. reinfect     : 0.1000
## - Surveillance prob. : 0.0020
## - Vax efficacy       : 0.9000
## - Vax redux transmission : 0.5000
##
## Distribution of the population at time 200:
## - Total susceptible (S)      : 19900 -> 2125
## - Total recovered (S)       : 0 -> 17325
## - Total latent (I)          : 100 -> 109
## - Total symptomatic (I)     : 0 -> 155
## - Total symptomatic isolated (I) : 0 -> 8
## - Total asymptomatic (I)    : 0 -> 76
## - Total asymptomatic isolated (I) : 0 -> 1
## - Total removed (R)        : 0 -> 201
##
## (S): Susceptible, (I): Infected, (R): Recovered
##
hist2 <- read.csv("07-surveillance_hist.txt", sep = " ")
surv2 <- read.csv("07-surveillance_user_data.txt", sep = " ")
hist_comb <- rbind(
  cbind(sim = as.character(s_levels[1]), hist1),
  cbind(sim = as.character(s_levels[2]), hist2)
)
ggplot(hist_comb, aes(x = date, y = counts + 1, colour = state, linetype=sim)) +
  geom_line() +
  # scale_y_log10() +
  labs(y = "Counts (log)")
```

4.4.2 Cases detected

```
survdat <- rbind(
  with(surv1, rbind(
    data.frame(Id = as.character(s_levels[1]), Date = date, Type = "N Sampled", n = nsampled),
    data.frame(Id = as.character(s_levels[1]), Date = date, Type = "N detected", n = ndetected),
    data.frame(Id = as.character(s_levels[1]), Date = date, Type = "N detected Asymp", n =
      ndetected_asymp),
    data.frame(Id = as.character(s_levels[1]), Date = date, Type = "N Asymp", n = nasymptomatic)
  )),
  with(surv2, rbind(
    data.frame(Id = as.character(s_levels[2]), Date = date, Type = "N Sampled", n = nsampled),
    data.frame(Id = as.character(s_levels[2]), Date = date, Type = "N detected", n = ndetected),
    data.frame(Id = as.character(s_levels[2]), Date = date, Type = "N detected Asymp", n =
      ndetected_asymp),
    data.frame(Id = as.character(s_levels[2]), Date = date, Type = "N Asymp", n = nasymptomatic)
  ))
)
ggplot(survdat, aes(x = Date, y = n + 1, colour = Type)) +
  geom_line() +
  facet_wrap(~Id) +
  scale_y_log10() +
  labs(y = "Counts (log)")
```


Chapter 5

General parameters

The following are parameters used for both ABM and Compartmental models.

```
EPI_BETA <- 0.75
EPI_GAMMA <- 0.33
EPI_LATENCY <- 1/0.33
EPI_N <- 10000
EPI_0 <- 0.01
EPI_NDAYS <- 50
Sys.setenv( # nolint
  EPI_BETA = EPI_BETA,
  EPI_GAMMA = EPI_GAMMA,
  EPI_LATENCY = EPI_LATENCY,
  EPI_N = EPI_N,
  EPI_0 = EPI_0,
  EPI_NDAYS = EPI_NDAYS
)
```

5.1 Compartmental Models

5.1.1 SIR Model

```
library(deSolve)
library(ggplot2)
library(data.table)
# Code from
# Chapter 2: SIR
# Book "Epidemics: Models and Data using R."
# By: Ottar N. Bjørnstad
sirmod <- function(t, y, parms) {
  # Pull state variables from the vector y
  S = y[1]
  I = y[2]
  R = y[3]

  # Pull parameter values from parms vector
  beta = parms["beta"]
  mu = parms["mu"]
  gamma = parms["gamma"]
  N = parms["N"]

  # Define equations
  dS = mu * (N - S) - beta * S * I/N
  dI = beta * S * I/N - (mu + gamma) * I
  dR = gamma * I - mu * R
  res = c(dS, dI, dR)

  # Return list of gradients
  list(res)
}
# Initial parameters
times <- seq(0, EPI_NDAYS, by = 1)
parms <- c(mu = 0, N = EPI_N, beta = EPI_BETA, gamma = EPI_GAMMA)
start <- c(S = EPI_N * (1 - EPI_0), I = EPI_N * EPI_0, R = 0)
out <- ode(y = start, times = times, func = sirmod, parms = parms)
out <- as.data.frame(out)
out <- rbind(
```

```

with(out, data.table(date = time, state = "Susceptible", counts = S)),
with(out, data.table(date = time, state = "Infected", counts = I)),
with(out, data.table(date = time, state = "Recovered", counts = R))
)

```

Now we visualize the model

```

ggplot(out, aes(x = date, y = counts)) +
  geom_line(aes(colour = state)) +
  labs(title = "Compartmental SIR")

```

5.1.2 SEIR Model

```

# Code adapted from
# Chapter 2: SIR
# Book "Epidemics: Models and Data using R"
# By: Ottar N. Bjørnstad
seirmod <- function(t, y, parms) {
  # Pull state variables from y vector
  S = y[1]
  E = y[2]
  I = y[3]
  R = y[4]

  # Pull parameter values from parms vector
  beta = parms["beta"]
  mu = parms["mu"]
  alpha = parms["alpha"]
  gamma = parms["gamma"]
  N = parms["N"]

  # Define equations
  dS = mu * (N - S) - beta * S * I/N - mu * S
  dE = beta * S * I/N - (mu + alpha) * E
  dI = alpha * E - (mu + gamma) * I
  dR = gamma * I - mu * R
  res = c(dS, dE, dI, dR)

  # Return list of gradients
  list(res)
}

# Initial parameters
parms <- c(
  mu = 0, N = EPI_N, beta = EPI_BETA,
  alpha = 1/EPI_LATENCY, gamma = EPI_GAMMA
)

start <- c(S = EPI_N * (1 - EPI_0), E = EPI_N * EPI_0, I = 0, R = 0)
out_seir <- ode(y = start, times = times, func = seirmod, parms = parms)
out_seir <- as.data.frame(out_seir)
out_seir <- rbind(
  with(out_seir, data.table(date = time, state = "Susceptible", counts = S)),
  with(out_seir, data.table(date = time, state = "Exposed", counts = E)),
  with(out_seir, data.table(date = time, state = "Infected", counts = I)),
  with(out_seir, data.table(date = time, state = "Recovered", counts = R))
)

```

Now we visualize the model

```

ggplot(out_seir, aes(x = date, y = counts)) +
  geom_line(aes(colour = state)) +
  labs(title = "Compartmental SEIR")

```

5.2 Agent-Based Model Approach

Calculation of the expected number of days in state S when prob of changing state equals α is $1/\alpha$

```

set.seed(712)
a <- .3
R <- matrix(runif(2e5 * 50), ncol = 50)
dat <- apply(R, 1, \ (x) {
  which.max(x < a)
})
mean(dat) - 1 / a

```

```
[1] -0.01049333
```

5.2.1 Mathematical preliminaries

That agent i becomes infected can be computed as follows:

At the same time, the probability of not becoming infected equals to the probability of no infected agent transmitting the infection. The probability that agent j infects i equals

In this case, β is parametrized such that its values are within $(0,1)$. Since transmission from the i infected agents happens independently, we finally have the following:

With the above equation, we can now calculate the change in the number of susceptible agents. In this case, it equals the expected number of new infections:

With the same parametrization in the canonical SIR model (Kermack and McKendrick), the instantaneous change in the number of susceptible agents equals $\frac{dS}{dt} = -S \beta I$. Given S and I , we can show that, as $\beta \rightarrow 0$, i.e., the population grows, both rates converge to the same number. Formally:

The same can be shown for the change in the number recovered.

5.2.2 Simulation study

Now, what happens with `epiworld`.

```
system("./09-sir-connected.o -n $EPI_N -b $EPI_BETA -d $EPI_NDAYS -p $EPI_0 -r $EPI_GAMMA -i 1.0 -s555599")
library(ggplot2)
epiworld <- data.table::fread("total_hist.txt")
ggplot(epiworld, aes(x = date, y = counts)) +
  geom_line(aes(colour = state)) +
  labs(title = "ABM SIR")
system("./09-seir-connected.o -n $EPI_N -b $EPI_BETA -d $EPI_NDAYS -p $EPI_0 -r $EPI_GAMMA -i 1.0 -s555599 -l $EPI_LATENCY")
library(ggplot2)
epiworld <- data.table::fread("total_hist.txt")
ggplot(epiworld, aes(x = date, y = counts)) +
  geom_line(aes(colour = state)) +
  labs(title = "ABM SEIR")
```

5.3 Comparing ABM with Compartmental Models

To this end, we will compare the results of the first run of the Compartmental model with 100 runs of the ABM, compute the confidence interval, and see how likely is the compartmental model to fall within the trajectory of the ABM simulation.

5.3.1 SIR

```
system("./09-sir-connected.o -n $EPI_N -b $EPI_BETA -d $EPI_NDAYS -p $EPI_0 -r $EPI_GAMMA -i 1.0 -s555599 -e 100")
library(ggplot2)
library(data.table)
epiworld <- data.table::fread("09-sir-connected-experiments.csv")
epiworld <- epiworld[, .(
  min = quantile(counts, probs = .025),
  mean = mean(counts),
  max = quantile(counts, probs = .975)), by = .(date, state)]
# Merging Compartmental
epiworld <- merge(
  epiworld,
  out[, .(date = date, state = state, compartmental = counts)],
  by = c("date", "state")
)
setorder(epiworld, state, date)
ggplot(epiworld, aes(x = date, y = mean)) +
  geom_ribbon(aes(ymin = min, ymax = max, colour = state), alpha = 0.1) +
  geom_line(aes(x = date, y = compartmental, colour = sprintf("%s (compt)", state)))
```

It seems that, although both yield the same equilibria, compartmental models reach the highest point of the simulation earlier. This makes sense as within a single day of the ABM simulation, compartmental models have more events taking place. Nonetheless, as predicted, as $\beta \rightarrow 0$, the differences become lesser. Furthermore, we could use the fact that the transition rates are known to compute an adjustment.

5.3.2 SEIR

```
system("./09-seir-connected.o -n $EPI_N -b $EPI_BETA -d $EPI_NDAYS -p $EPI_0 -r $EPI_GAMMA -i 1.0 -s555599
-e 100 -l $EPI_LATENCY")
library(ggplot2)
library(data.table)
epiworld_seir <- data.table::fread("09-seir-connected-experiments.csv")
epiworld_seir <- epiworld_seir[, .(
  min = quantile(counts, probs = .025),
  mean = mean(counts),
  max = quantile(counts, probs = .975)), by = .(date, state)]
# Merging Compartmental
epiworld_seir <- merge(
  epiworld_seir,
  out_seir[, .(date = date, state = state, compartmental = counts)],
  by = c("date", "state")
)
setorder(epiworld_seir, state, date)
ggplot(epiworld_seir, aes(x = date, y = mean)) +
  geom_ribbon(aes(ymin = min, ymax = max, colour = state), alpha = 0.1) +
  geom_line(aes(x = date, y = compartmental, colour = sprintf("%s (compt)", state)))
```

5.3.3 Rates

```
S <- 1000
rate_comp <- function(I,B) S * B * I
rate_abm <- function(I,B) S * (1 - (1 - B)^I)
op <- par(mfrow = c(3, 2))
for (i in c(1, 10, 100)) {
  curve(rate_comp(i, x), from = .01, to = 0.05)
  curve(rate_abm(i, x), from = .01, to = 0.05, add = FALSE, lty = 2)
}
par(op)
```

Chapter 6

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Chapter 7

model1

The dynamics of the simulation process are:

1. Discrete Markov process.
2. The simulation has the following parameters:
 - a. New variant emergence at rate X .
 - b. For each variant k :
 - Unvaccinated individuals become sick rate $C(k)$,
 - Mortality rate $D(k)$,
 - Recovery rate $H(k)$,
 - Vaccines have an efficacy rate $E(v, k)$ and pseudo vaccines (recovered) have efficacy rate $E(r, k) < E(v, k)$. In general, the probability of i acquiring the disease k from j will be equal to

$$P(i \text{ gets the disease from } j \mid \text{their states}) = C(k) * (1 - E(i, k)) * (1 - E(j, k))$$

where $(i, j) \in (u, v, r)$. Efficacy rate for unvaccinated is zero.

- Vaccinated individuals have a reduced mortality rate $D(k, v) > D(k)$, and recovered individuals $D(k, r) \in (D(k, v), D(k))$
- Vaccinated individuals have an increased recovery rate $H(k, v) > H(k)$, whereas recovered's rate $H(k, r) \in (H(k), H(k, v))$.

The sum of mortality and recovery rates is less than one since the difference represents no change.

- c. Each country vaccinates citizens at rate V function of A (availability) and B (citizens' acceptance rate.)
- d. In each country i , the entire population $N(i)$ distributes between the following states:

- Healthy unvaccinated ($N(i, t, u)$),
- Healthy vaccinated ($N(i, t, v)$),
- Deceased ($N(i, t, d)$),
- Recovered ($N(i, t, r)$),
- Unvaccinated and sick with variant ($N(i, t, s, k|u)$) k ., and
- Vaccinated and sick with variant ($N(i, t, s, k|v)$) k .

$$\text{Total sick are } N(i, t, k, s) = \sum_{g \in \{u, v\}} N(i, t, k, s|g)$$

Globally, we keep track of the prevalence of new variants. Variants can disappear if no more individuals port the variant, i.e., the prevalence rate $P(k, t) = \sum_i N(i, s, k)$ equals zero.

- d. Vaccines are manufactured at each country at rates $M(i)$ and uniformly shared with other countries at rate $S(i)$.
- c. Population flows between each country pair (i, j) at a rate $F(i, j)$. Flows between countries do not change Population and are symmetric.

3. The simulation process is as follows:

- (a) Countries are initialized with a total population $N(i)$.
- (b) Variant zero initializes at a random location i , with an initial prevalence $P(k, t) = N(i, t, k)$.
- (c) For time t in $(0, T)$ do:
 - a. Unvaccinated individuals can become sick of variant k with probability:

$$\Pr(h \rightarrow s | i, t, k, u) \sim \sum(g \in \{u, v\}) (N(i, t-1, s, k | g) + \sum(j \neq i) F(i, j) * N(j, t-1, s, k | g)) * C(k) / (N(i) + \sum(j \neq i) N(j))$$
 - b. Vaccinated individuals can become sick of variant k with probability: $\Pr(v \rightarrow s | i, t, k, v) \sim \Pr(h \rightarrow s | i, t, k) * (1 - E(v, k))$.
 - b. Recovered individuals can become sick of variant k with probability: $\Pr(v \rightarrow s | i, t, k, r) \sim \Pr(h \rightarrow s | i, t, k) * (1 - E(r, k))$.
 - c. Sick individuals with variant k die with probability $D(k)$ or recover with probability $H(k)$, otherwise they stay infected; with the rates depending on their vaccination status v or n .
 - d. Unvaccinated individuals vaccinate in country i with probability $P(u \rightarrow v) \sim V(A(i, t), B(i))$.
 - e. The country vaccine supply changes.

Chapter 8

Mixing probabilities in connected model

George G. Vega Yon, Ph.D. 2024-04-25

8.1 Case 1: No grouping

We will look into the probability of drawing infected individuals to simplify the algorithm. There are I infected individuals at any time in the simulation; thus, instead of drawing from $\text{Bern}(c/N, N)$, we will be drawing from $\text{Bern}(c/N, I)$. The next step is to check which infected individuals should be drawn. Let's compare the distributions using the hypergeometric as an example:

```
set.seed(132)
nsims <- 1e4
N <- 400
rate <- 5
p <- rate/N
I <- 10
sim_complex <- parallel::mclapply(1:nsims, \(i) {
  nsamples <- rbinom(N, N, p)
  sum(rbinom(N, size = nsamples, prob = I/N) > 0)
}, mc.cores = 4L) |> unlist()
sim_simple <- parallel::mclapply(1:nsims, \(i) {
  sum(rbinom(N, I, p) > 0)
}, mc.cores = 4L) |> unlist()
op <- par(mfrow = c(1,2))
MASS::truehist(sim_complex)
MASS::truehist(sim_simple)
par(op)
quantile(sim_complex)
```

0%	25%	50%	75%	100%
27	43	47	51	71

```
quantile(sim_simple)
```

0%	25%	50%	75%	100%
23	43	47	51	71

```
plotter(sim_complex, sim_simple)
```

These two approaches are equivalent, but the second one is more efficient from the computational perspective.

8.2 Case 2: Grouping

This explores the case when we have mixing across groups. The question is if we can replicate the effect at the group level.

```
set.seed(123133)
ngroups <- 3
mixing <- matrix(
  c(0.1, 0.2, 0.3, 0.2, 0.1, 0.2, 0.3, 0.2, 0.1),
  nrow = ngroups,
  ncol = ngroups
)
mixing <- mixing/rowSums(mixing)
mixing

      [,1]      [,2]      [,3]
[1,] 0.1666667 0.3333333 0.5000000
[2,] 0.4000000 0.2000000 0.4000000
[3,] 0.5000000 0.3333333 0.1666667

N <- 500
sizes <- c(100, 150, 250)
rate <- 5
p <- rate/N
I <- c(10, 30, 20)
ids <- rep.int(1:ngroups, times = sizes)
nsims <- 1e4
sim_complex <- parallel::mclapply(1:nsims, \(i) {
  # Sampling group first
  sapply(1:ngroups, \(g) {
    # How many each individual will sample from the groups
    ans <- rbinom(
      n = N, size = sizes[g], prob = mixing[ids,][g] * p
    ) |> sum()
    # Sampling with replacement
    rbinom(ans, size = 1, prob = I[g]/sizes[g]) |> sum()
  }) |> sum()
}, mc.cores = 4L) |> unlist()
```

Using the alternative method in which we directly weight the probabilities:

```
sim_simple <- parallel::mclapply(1:nsims, \(i) {
  # Sampling group first
  sapply(1:ngroups, \(g) {
    rbinom(
      n = N, size = I[g], prob = mixing[cbind(ids,g)] * p
    ) |> sum()
  }) |> sum()
}, mc.cores = 4L) |> unlist()
op <- par(mfrow = c(1,2))
MASS::truehist(sim_complex)
MASS::truehist(sim_simple)
par(op)
quantile(sim_complex)
```

```
0% 25% 50% 75% 100%
57  88  94 101 131
```

```
quantile(sim_simple)
```

```
0% 25% 50% 75% 100%
58  87  94 101 135
```

```
plotter(sim_complex, sim_simple)
```

Chapter 9

EPI Simulator

9.1 Disease dynamics

Diseases continuously evolve in time. Changes in their genetic sequence make them more or less resistant to the particular version of the vaccine. Mutations also affect the transmissibility level and mortality rate of the disease. Using this approach allows making vaccination efficacy a function of compatibility between the variant and the vaccine.

When an individual becomes infected, the disease accumulates mutations in the new host. Ultimately, there is no single version of the disease present in the model, but rather an infinite number of them, each slightly different from the other.

9.2 Network dynamics

We can assume that the Population is organized in fully connected blocks for the first version of the model. Block sizes and the number of connections between blocks are Poisson random variables. Individuals interact with all the members of their blocks, and bridging individuals allow the disease to move across blocks.

9.3 Contagion dynamics

The transmission of the disease will be governed by the number of vaccinated, infected, and recovered within each block. Transmission between blocks will be treated in the same way, although individuals bridging the block will only interact with others within the block and their direct connections across the blocks.

9.4 Time dynamics

Time dynamics has two components, how biology evolves and how agents react.

The model develops as a continuous-time Markov process. Each block of individuals takes action at rates $L(i|N(i))$ function of the local number of infections. This way, if

9.5 Updating agent's status

Like most other components, updating agents' states can be personalized. A naive approach allows agents to get infected with a single virus or stay as-is. The probability of this event is conditional on acquiring at most one virus. Since these are independent events, the conditional probability is computed as follows:

$$\begin{aligned} P(\text{Variant } k | \text{at most 1}) &= P(\text{at most 1} | \text{Variant } k) * P(\text{Variant } k) / P(\text{at most 1}) \\ &= P(\text{only variant } k) / P(\text{variant } k) * P(\text{Variant } k) / P(\text{at most 1}) \\ &= P(\text{only variant } k) / P(\text{at most 1}) \end{aligned}$$

Where

$$\begin{aligned} P(\text{only variant } k) &= P(k) * \text{Prod}(m \neq v) (1 - P(m)) \\ P(\text{at most 1}) &= P(\text{None}) + \text{Sum}(v \text{ in variants}) P(v) * \text{Prod}(m \neq v) (1 - P(m)) \\ P(\text{None}) &= \text{Prod}(v \text{ in variants}) (1 - P(v)) \end{aligned}$$

Furthermore, the (Variant, Person) pairs are treated independently.

9.5.1 Other parameters

- Who did you get the infection from.
- Omicron is 1.5 more infectious than delta.
- Surveillance:
 - Pull people to be tested at random.
 - Or at symptoms.
 - A mix of the two.
- Define a class for passing extra functions and datasets, for example, testing surveillance.
- Exposed people become infectious after k days.
- [Network](#) changes the can be a function of an ERGM. Apply K steps throughout time.
- Add progress bar.

Chapter 10

Namespace Index

10.1 Namespace List

Here is a list of all documented namespaces with brief descriptions:

epiworld::sampler	Functions for sampling viruses	33
sampler	Functions for sampling viruses	36

Chapter 11

Hierarchical Index

11.1 Class Hierarchy

This inheritance list is sorted roughly, but not completely, alphabetically:

AdjList	41
epiworld::AdjList	42
Agent< TSeq >	44
epiworld::Agent< TSeq >	49
Agent< EPI_DEFAULT_TSEQ >	44
AgentsSample< TSeq >	52
epiworld::AgentsSample< TSeq >	54
DataBase< TSeq >	55
epiworld::DataBase< TSeq >	61
Entities< TSeq >	66
epiworld::Entities< TSeq >	66
Entities_const< TSeq >	67
epiworld::Entities_const< TSeq >	68
Entity< TSeq >	69
epiworld::Entity< TSeq >	71
Entity< EPI_DEFAULT_TSEQ >	69
epiworld::Event< TSeq >	72
Event< TSeq >	73
epiworld::GlobalEvent< TSeq >	75
GlobalEvent< TSeq >	77
epiworld::LFMCMC< TData >	78
LFMCMC< TData >	79
epiworld::Model< TSeq >	81
Model< TSeq >	97
ModelMeaslesQuarantine< TSeq >	121
epiworld::Model< EPI_DEFAULT_TSEQ >	81
ModelDiffNet< TSeq >	115
ModelSEIR< TSeq >	129
ModelSEIRCONN< TSeq >	134
ModelSEIRD< TSeq >	141
ModelSEIRDCONN< TSeq >	147
ModelSEIRMixing< TSeq >	154
ModelSIR< TSeq >	159
ModelSIRCONN< TSeq >	165
ModelSIRD< TSeq >	171

ModelSIRDCONN< TSeq >	177
ModelSIRLogit< TSeq >	183
ModelSIRMixing< TSeq >	190
ModelSIS< TSeq >	196
ModelISD< TSeq >	199
ModelSURV< TSeq >	203
epiworld::epimodels::ModelDiffNet< TSeq >	113
epiworld::epimodels::ModelMeaslesQuarantine< TSeq >	116
epiworld::epimodels::ModelSEIR< TSeq >	126
epiworld::epimodels::ModelSEIRCONN< TSeq >	131
epiworld::epimodels::ModelSEIRD< TSeq >	137
epiworld::epimodels::ModelSEIRDCONN< TSeq >	144
epiworld::epimodels::ModelSEIRMixing< TSeq >	150
epiworld::epimodels::ModelSIR< TSeq >	158
epiworld::epimodels::ModelSIRCONN< TSeq >	162
epiworld::epimodels::ModelSIRD< TSeq >	168
epiworld::epimodels::ModelSIRDCONN< TSeq >	174
epiworld::epimodels::ModelSIRLogit< TSeq >	179
epiworld::epimodels::ModelSIRMixing< TSeq >	186
epiworld::epimodels::ModelSIS< TSeq >	193
epiworld::epimodels::ModelISD< TSeq >	197
epiworld::epimodels::ModelSURV< TSeq >	200
epiworld::ModelDiagram	113
ModelDiagram	113
Network< Nettype, Nodetype, Edgetype >	205
epiworld::PersonTools< TSeq >	205
PersonTools< TSeq >	206
epiworld::Progress	206
Progress	206
epiworld::Queue< TSeq >	207
Queue< TSeq >	207
RandGraph	208
epiworld::SAMPLETYPE	209
SAMPLETYPE	209
epiworld::Tool< TSeq >	209
Tool< TSeq >	210
epiworld::ToolFunctions< TSeq >	212
ToolFunctions< TSeq >	213
epiworld::Tools< TSeq >	213
Tools< TSeq >	214
epiworld::Tools_const< TSeq >	215
Tools_const< TSeq >	215
epiworld::UserData< TSeq >	216
UserData< TSeq >	218
epiworld::vecHasher< T >	220
vecHasher< T >	220
epiworld::Virus< TSeq >	221
Virus< TSeq >	223
epiworld::Viruses< TSeq >	225
Viruses< TSeq >	226
epiworld::Viruses_const< TSeq >	227
Viruses_const< TSeq >	227
epiworld::VirusFunctions< TSeq >	228
VirusFunctions< TSeq >	229

Chapter 12

Class Index

12.1 Class List

Here are the classes, structs, unions and interfaces with brief descriptions:

AdjList	41
epiworld::AdjList	42
Agent< TSeq >	
Agent (agents)	44
epiworld::Agent< TSeq >	
Agent (agents)	49
AgentsSample< TSeq >	
Sample of agents	52
epiworld::AgentsSample< TSeq >	
Sample of agents	54
DataBase< TSeq >	
Statistical data about the process	55
epiworld::DataBase< TSeq >	
Statistical data about the process	61
Entities< TSeq >	
Set of Entities (useful for building iterators)	66
epiworld::Entities< TSeq >	
Set of Entities (useful for building iterators)	66
Entities_const< TSeq >	
Set of Entities (const) (useful for iterators)	67
epiworld::Entities_const< TSeq >	
Set of Entities (const) (useful for iterators)	68
Entity< TSeq >	69
epiworld::Entity< TSeq >	71
epiworld::Event< TSeq >	
Event data for update an agent	72
Event< TSeq >	
Event data for update an agent	73
epiworld::GlobalEvent< TSeq >	
Template for a Global Event	75
GlobalEvent< TSeq >	
Template for a Global Event	77
epiworld::LFMCMC< TData >	
Likelihood-Free Markov Chain Monte Carlo	78
LFMCMC< TData >	
Likelihood-Free Markov Chain Monte Carlo	79

epiworld::Model< TSeq >	
Core class of epiworld	81
Model< TSeq >	
Core class of epiworld	97
epiworld::ModelDiagram	113
ModelDiagram	113
epiworld::epimodels::ModelDiffNet< TSeq >	
Template for a Network Diffusion Model	113
ModelDiffNet< TSeq >	
Template for a Network Diffusion Model	115
epiworld::epimodels::ModelMeaslesQuarantine< TSeq >	
Template for a Measles model with quarantine	116
ModelMeaslesQuarantine< TSeq >	
Template for a Measles model with quarantine	121
epiworld::epimodels::ModelSEIR< TSeq >	
Template for a Susceptible-Exposed-Infected-Removed (SEIR) model	126
ModelSEIR< TSeq >	
Template for a Susceptible-Exposed-Infected-Removed (SEIR) model	129
epiworld::epimodels::ModelSEIRCONN< TSeq >	131
ModelSEIRCONN< TSeq >	134
epiworld::epimodels::ModelSEIRD< TSeq >	
Template for a Susceptible-Exposed-Infected-Removed-Deceased (SEIRD) model	137
ModelSEIRD< TSeq >	
Template for a Susceptible-Exposed-Infected-Removed-Deceased (SEIRD) model	141
epiworld::epimodels::ModelSEIRDCONN< TSeq >	144
ModelSEIRDCONN< TSeq >	147
epiworld::epimodels::ModelSEIRMixing< TSeq >	150
ModelSEIRMixing< TSeq >	154
epiworld::epimodels::ModelSIR< TSeq >	
Template for a Susceptible-Infected-Removed (SIR) model	158
ModelSIR< TSeq >	
Template for a Susceptible-Infected-Removed (SIR) model	159
epiworld::epimodels::ModelSIRCONN< TSeq >	162
ModelSIRCONN< TSeq >	165
epiworld::epimodels::ModelSIRD< TSeq >	
Template for a Susceptible-Infected-Removed-Deceased (SIRD) model	168
ModelSIRD< TSeq >	
Template for a Susceptible-Infected-Removed-Deceased (SIRD) model	171
epiworld::epimodels::ModelSIRDCONN< TSeq >	174
ModelSIRDCONN< TSeq >	177
epiworld::epimodels::ModelSIRLogit< TSeq >	
Template for a Susceptible-Infected-Removed (SIR) model	179
ModelSIRLogit< TSeq >	
Template for a Susceptible-Infected-Removed (SIR) model	183
epiworld::epimodels::ModelSIRMixing< TSeq >	186
ModelSIRMixing< TSeq >	190
epiworld::epimodels::ModelSIS< TSeq >	
Template for a Susceptible-Infected-Susceptible (SIS) model	193
ModelSIS< TSeq >	
Template for a Susceptible-Infected-Susceptible (SIS) model	196
epiworld::epimodels::ModelSISD< TSeq >	
Template for a Susceptible-Infected-Susceptible-Deceased (SISD) model	197
ModelSISD< TSeq >	
Template for a Susceptible-Infected-Susceptible-Deceased (SISD) model	199
epiworld::epimodels::ModelSURV< TSeq >	200
ModelSURV< TSeq >	203
Network< Nettype, Nodetype, Edgetype >	205
epiworld::PersonTools< TSeq >	205

PersonTools< TSeq >	206
epiworld::Progress	
A simple progress bar	206
Progress	
A simple progress bar	206
epiworld::Queue< TSeq >	
Controls which agents are verified at each step	207
Queue< TSeq >	
Controls which agents are verified at each step	207
RandGraph	208
epiworld::SAMPLETYPE	209
SAMPLETYPE	209
epiworld::Tool< TSeq >	
Tools for defending the agent against the virus	209
Tool< TSeq >	
Tools for defending the agent against the virus	210
epiworld::ToolFunctions< TSeq >	
Helper class to store the functions avoiding multiple shared_pointers (we have only one for the four of these)	212
ToolFunctions< TSeq >	
Helper class to store the functions avoiding multiple shared_pointers (we have only one for the four of these)	213
epiworld::Tools< TSeq >	
Set of tools (useful for building iterators)	213
Tools< TSeq >	
Set of tools (useful for building iterators)	214
epiworld::Tools_const< TSeq >	
Set of Tools (const) (useful for iterators)	215
Tools_const< TSeq >	
Set of Tools (const) (useful for iterators)	215
epiworld::UserData< TSeq >	
Personalized data by the user	216
UserData< TSeq >	
Personalized data by the user	218
epiworld::vecHasher< T >	
Vector hasher	220
vecHasher< T >	
Vector hasher	220
epiworld::Virus< TSeq >	
Virus	221
Virus< TSeq >	
Virus	223
epiworld::Viruses< TSeq >	
Set of viruses (useful for building iterators)	225
Viruses< TSeq >	
Set of viruses (useful for building iterators)	226
epiworld::Viruses_const< TSeq >	
Set of Viruses (const) (useful for iterators)	227
Viruses_const< TSeq >	
Set of Viruses (const) (useful for iterators)	227
epiworld::VirusFunctions< TSeq >	228
VirusFunctions< TSeq >	229

Chapter 13

File Index

13.1 File List

Here is a list of all documented files with brief descriptions:

epiworld.hpp	??
include/epiworld/ adjlist-bones.hpp	??
include/epiworld/ adjlist-meat.hpp	??
include/epiworld/ agent-bones.hpp	??
include/epiworld/ agent-events-meat.hpp	??
include/epiworld/ agent-meat-state.hpp	??
Sampling functions are getting big, so we keep them in a separate file	231
include/epiworld/ agent-meat-virus-sampling.hpp	??
include/epiworld/ agent-meat.hpp	??
include/epiworld/ agentssample-bones.hpp	??
include/epiworld/ config.hpp	??
include/epiworld/ database-bones.hpp	??
include/epiworld/ database-meat.hpp	??
include/epiworld/ entities-bones.hpp	??
include/epiworld/ entity-bones.hpp	??
include/epiworld/ entity-distribute-meat.hpp	??
include/epiworld/ entity-meat.hpp	??
include/epiworld/ epiworld-macros.hpp	??
include/epiworld/ epiworld.hpp	??
include/epiworld/ globalevent-bones.hpp	??
include/epiworld/ globalevent-meat.hpp	??
include/epiworld/ misc.hpp	??
include/epiworld/ model-bones.hpp	??
include/epiworld/ model-meat-print.hpp	??
include/epiworld/ model-meat.hpp	??
include/epiworld/ modeldiagram-bones.hpp	??
include/epiworld/ modeldiagram-meat.hpp	??
include/epiworld/ network-bones.hpp	??
include/epiworld/ progress.hpp	??
include/epiworld/ queue-bones.hpp	??
include/epiworld/ randgraph.hpp	??
include/epiworld/ random_graph.hpp	??
include/epiworld/ seq_processing.hpp	??
include/epiworld/ tool-bones.hpp	??
include/epiworld/ tool-distribute-meat.hpp	??

include/epiworld/ tool-meat.hpp	??
include/epiworld/ tools-bones.hpp	??
include/epiworld/ userdata-bones.hpp	??
include/epiworld/ userdata-meat.hpp	??
include/epiworld/ virus-bones.hpp	??
include/epiworld/ virus-distribute-meat.hpp	??
include/epiworld/ virus-meat.hpp	??
include/epiworld/ viruses-bones.hpp	??
include/epiworld/math/ distributions.hpp	??
include/epiworld/math/ lfmcmc.hpp	??
include/epiworld/math/lfmcmc/ lfmcmc-bones.hpp	??
include/epiworld/math/lfmcmc/ lfmcmc-meat-print.hpp	??
include/epiworld/math/lfmcmc/ lfmcmc-meat.hpp	??
include/epiworld/models/ diffnet.hpp	??
include/epiworld/models/ globalevents.hpp	??
include/epiworld/models/ init-functions.hpp	??
include/epiworld/models/ measlesquarantine.hpp	??
include/epiworld/models/ models.hpp	??
include/epiworld/models/ seir.hpp	??
include/epiworld/models/ seirconnected.hpp	??
include/epiworld/models/ seird.hpp	??
include/epiworld/models/ seirdconnected.hpp	??
include/epiworld/models/ seirmixing.hpp	??
include/epiworld/models/ sir.hpp	??
include/epiworld/models/ sirconnected.hpp	??
include/epiworld/models/ sird.hpp	??
include/epiworld/models/ sirdconnected.hpp	??
include/epiworld/models/ sirlogit.hpp	??
include/epiworld/models/ sirmixing.hpp	??
include/epiworld/models/ sis.hpp	??
include/epiworld/models/ sisd.hpp	??
include/epiworld/models/ surveillance.hpp	??
tests/ tests.hpp	??

Chapter 14

Namespace Documentation

14.1 epiworld::sampler Namespace Reference

Functions for sampling viruses.

Functions

- `template<typename TSeq = EPI_DEFAULT_TSEQ>`
`std::function< void(Agent< TSeq > *, Model< TSeq > *)> make_update_susceptible (std::vector< epiworld_fast_uint > exclude={})`
Make a function to sample from neighbors.
- `template<typename TSeq = EPI_DEFAULT_TSEQ>`
`std::function< Virus< TSeq > *(Agent< TSeq > *, Model< TSeq > *)> make_sample_virus_neighbors (std::vector< epiworld_fast_uint > exclude={})`
Make a function to sample from neighbors.
- `template<typename TSeq = EPI_DEFAULT_TSEQ>`
`Virus< TSeq > * sample_virus_single (Agent< TSeq > *p, Model< TSeq > *m)`
Sample from neighbors pool of viruses (at most one)

14.1.1 Detailed Description

Functions for sampling viruses.

14.1.2 Function Documentation

14.1.2.1 `make_sample_virus_neighbors()`

```
template<typename TSeq = EPI_DEFAULT_TSEQ>
std::function<Virus<TSeq>*(Agent<TSeq>*,Model<TSeq>*)> epiworld::sampler::make_sample_virus_neighbors (
    std::vector< epiworld_fast_uint > exclude = {} ) [inline]
```

Make a function to sample from neighbors.

This is akin to the function `default_update_susceptible`, with the difference that it will create a function that supports excluding states from the sampling frame. For example, individuals who have acquired a virus can be excluded if in incubation state.

Template Parameters

<i>TSeq</i>	
-------------	--

Parameters

<i>exclude</i>	unsigned vector of states that need to be excluded from the sampling
----------------	----------------------------------------------------------------------

Returns

Virus<TSeq>* of the selected virus. If none selected (or none available,) returns a nullptr;

14.1.2.2 make_update_susceptible()

```
template<typename TSeq = EPI_DEFAULT_TSEQ>
std::function<void (Agent<TSeq>*, Model<TSeq>*)> epiworld::sampler::make_update_susceptible (
    std::vector< epiworld_fast_uint > exclude = {} ) [inline]
```

Make a function to sample from neighbors.

This is akin to the function default_update_susceptible, with the difference that it will create a function that supports excluding states from the sampling frame. For example, individuals who have acquired a virus can be excluded if in incubation state.

Template Parameters

<i>TSeq</i>	
-------------	--

Parameters

<i>exclude</i>	unsigned vector of states that need to be excluded from the sampling
----------------	----------------------------------------------------------------------

Returns

Virus<TSeq>* of the selected virus. If none selected (or none available,) returns a nullptr;

14.1.2.3 sample_virus_single()

```
template<typename TSeq = EPI_DEFAULT_TSEQ>
Virus<TSeq>* epiworld::sampler::sample_virus_single (
    Agent< TSeq > * p,
    Model< TSeq > * m ) [inline]
```

Sample from neighbors pool of viruses (at most one)

This function samples at most one virus from the pool of viruses from its neighbors. If no virus is selected, the function returns a `nullptr`, otherwise it returns a pointer to the selected virus.

This can be used to build a new update function (EPI_NEW_UPDATEFUN.)

Template Parameters

<i>TSeq</i>	
-------------	--

Parameters

<i>p</i>	Pointer to person
<i>m</i>	Pointer to the model

Returns

Virus<TSeq>* of the selected virus. If none selected (or none available,) returns a nullptr;

14.2 sampler Namespace Reference

Functions for sampling viruses.

Functions

- `template<typename TSeq = EPI_DEFAULT_TSEQ>`
`std::function< void(Agent< TSeq > *, Model< TSeq > *)> make_update_susceptible (std::vector< epiworld_fast_uint > exclude={})`
Make a function to sample from neighbors.
- `template<typename TSeq = EPI_DEFAULT_TSEQ>`
`std::function< Virus< TSeq > *(Agent< TSeq > *, Model< TSeq > *)> make_sample_virus_neighbors (std::vector< epiworld_fast_uint > exclude={})`
Make a function to sample from neighbors.
- `template<typename TSeq = EPI_DEFAULT_TSEQ>`
`Virus< TSeq > * sample_virus_single (Agent< TSeq > *p, Model< TSeq > *m)`
Sample from neighbors pool of viruses (at most one)

14.2.1 Detailed Description

Functions for sampling viruses.

14.2.2 Function Documentation

14.2.2.1 [make_sample_virus_neighbors\(\)](#)

```
template<typename TSeq = EPI_DEFAULT_TSEQ>
std::function<Virus<TSeq>*(Agent<TSeq>*,Model<TSeq>*)> sampler::make_sample_virus_neighbors
(
    std::vector< epiworld_fast_uint > exclude = {} ) [inline]
```

Make a function to sample from neighbors.

This is akin to the function `default_update_susceptible`, with the difference that it will create a function that supports excluding states from the sampling frame. For example, individuals who have acquired a virus can be excluded if in incubation state.

Template Parameters

<i>TSeq</i>	
-------------	--

Parameters

<i>exclude</i>	unsigned vector of states that need to be excluded from the sampling
----------------	----------------------------------------------------------------------

Returns

Virus<TSeq>* of the selected virus. If none selected (or none available,) returns a nullptr;

14.2.2.2 make_update_susceptible()

```
template<typename TSeq = EPI_DEFAULT_TSEQ>
std::function<void (Agent<TSeq>*, Model<TSeq>*)> sampler::make_update_susceptible (
    std::vector< epiworld_fast_uint > exclude = {} ) [inline]
```

Make a function to sample from neighbors.

This is akin to the function `default_update_susceptible`, with the difference that it will create a function that supports excluding states from the sampling frame. For example, individuals who have acquired a virus can be excluded if in incubation state.

Template Parameters

<i>TSeq</i>	
-------------	--

Parameters

<i>exclude</i>	unsigned vector of states that need to be excluded from the sampling
----------------	----------------------------------------------------------------------

Returns

Virus<TSeq>* of the selected virus. If none selected (or none available,) returns a nullptr;

14.2.2.3 sample_virus_single()

```
template<typename TSeq = EPI_DEFAULT_TSEQ>
Virus<TSeq>* sampler::sample_virus_single (
    Agent< TSeq > * p,
    Model< TSeq > * m ) [inline]
```

Sample from neighbors pool of viruses (at most one)

This function samples at most one virus from the pool of viruses from its neighbors. If no virus is selected, the function returns a `nullptr`, otherwise it returns a pointer to the selected virus.

This can be used to build a new update function (`EPI_NEW_UPDATEFUN.`)

Template Parameters

<i>TSeq</i>	
-------------	--

Parameters

<i>p</i>	Pointer to person
<i>m</i>	Pointer to the model

Returns

Virus<TSeq>* of the selected virus. If none selected (or none available,) returns a nullptr;

Chapter 15

Class Documentation

15.1 AdjList Class Reference

Public Member Functions

- [AdjList](#) (const std::vector< int > &source, const std::vector< int > &target, int size, bool directed)
Construct a new Adj List object.
- **AdjList** ([AdjList](#) &&a)
- **AdjList** (const [AdjList](#) &a)
- [AdjList](#) & **operator=** (const [AdjList](#) &a)
- void [read_edgelist](#) (std::string fn, int size, int skip=0, bool directed=true)
Read an edgelist.
- std::map< int, int > **operator()** (epiworld_fast_uint i) const
- void **print** (epiworld_fast_uint limit=20u) const
- size_t [vcount](#) () const
Number of vertices/nodes in the network.
- size_t [ecount](#) () const
Number of edges/arcs/ties in the network.
- std::vector< std::map< int, int > > & **get_dat** ()
- bool [is_directed](#) () const
true if the network is directed.

15.1.1 Constructor & Destructor Documentation

15.1.1.1 AdjList()

```
AdjList::AdjList (
    const std::vector< int > & source,
    const std::vector< int > & target,
    int size,
    bool directed ) [inline]
```

Construct a new Adj List object.

Ids in the network are assume to range from 0 to size - 1.

Parameters

<i>source</i>	Unsigned int vector with the source
<i>target</i>	Unsigned int vector with the target
<i>size</i>	Number of vertices in the network.
<i>directed</i>	Bool true if the network is directed

15.1.2 Member Function Documentation

15.1.2.1 read_edgelist()

```
void AdjList::read_edgelist (
    std::string fn,
    int size,
    int skip = 0,
    bool directed = true ) [inline]
```

Read an edgelist.

Ids in the network are assume to range from 0 to `size - 1`.

Parameters

<i>fn</i>	Path to the file
<i>skip</i>	Number of lines to skip (e.g., 1 if there's a header)
<i>directed</i>	true if the network is directed
<i>size</i>	Number of vertices in the network.

The documentation for this class was generated from the following files:

- include/epiworld/adjlist-bones.hpp
- include/epiworld/adjlist-meat.hpp

15.2 epiworld::AdjList Class Reference

Public Member Functions

- [AdjList](#) (const std::vector< int > &source, const std::vector< int > &target, int size, bool directed)
Construct a new Adj List object.
- [AdjList](#) ([AdjList](#) &&a)
- [AdjList](#) (const [AdjList](#) &a)
- [AdjList](#) & [operator=](#) (const [AdjList](#) &a)
- void [read_edgelist](#) (std::string fn, int size, int skip=0, bool directed=true)
Read an edgelist.

- `std::map< int, int > operator()` (`epiworld_fast_uint i`) `const`
- `void print` (`epiworld_fast_uint limit=20u`) `const`
- `size_t vcount` () `const`
Number of vertices/nodes in the network.
- `size_t ecount` () `const`
Number of edges/arcs/ties in the network.
- `std::vector< std::map< int, int > > & get_dat` ()
- `bool is_directed` () `const`
true if the network is directed.

15.2.1 Constructor & Destructor Documentation

15.2.1.1 AdjList()

```
AdjList::AdjList (
    const std::vector< int > & source,
    const std::vector< int > & target,
    int size,
    bool directed ) [inline]
```

Construct a new Adj List object.

Ids in the network are assume to range from 0 to `size - 1`.

Parameters

<i>source</i>	Unsigned int vector with the source
<i>target</i>	Unsigned int vector with the target
<i>size</i>	Number of vertices in the network.
<i>directed</i>	Bool true if the network is directed

15.2.2 Member Function Documentation

15.2.2.1 read_edgelist()

```
void AdjList::read_edgelist (
    std::string fn,
    int size,
    int skip = 0,
    bool directed = true ) [inline]
```

Read an edgelist.

Ids in the network are assume to range from 0 to `size - 1`.

Parameters

<i>fn</i>	Path to the file
<i>skip</i>	Number of lines to skip (e.g., 1 if there's a header)
<i>directed</i>	<code>true</code> if the network is directed
<i>size</i>	Number of vertices in the network.

The documentation for this class was generated from the following file:

- `epiworld.hpp`

15.3 Agent< TSeq > Class Template Reference

[Agent](#) (agents)

```
#include <agent-bones.hpp>
```

Public Member Functions

- **Agent** ([Agent](#)< TSeq > &&p)
- **Agent** (const [Agent](#)< TSeq > &p)
- [Agent](#)< TSeq > & **operator=** (const [Agent](#)< TSeq > &other_agent)
- int **get_id** () const
Id of the individual.
- VirusPtr< TSeq > & **get_virus** ()
- const VirusPtr< TSeq > & **get_virus** () const
- ToolPtr< TSeq > & **get_tool** (int i)
- [Tools](#)< TSeq > **get_tools** ()
- const [Tools_const](#)< TSeq > **get_tools** () const
- size_t **get_n_tools** () const noexcept
- void **mutate_virus** ()
- void **add_neighbor** ([Agent](#)< TSeq > &p, bool check_source=true, bool check_target=true)
- void **swap_neighbors** ([Agent](#)< TSeq > &other, size_t n_this, size_t n_other)
Swaps neighbors between the current agent and agent other
- std::vector< [Agent](#)< TSeq > * > **get_neighbors** ()
- size_t **get_n_neighbors** () const
- void **change_state** ([Model](#)< TSeq > *model, epiworld_fast_uint new_state, epiworld_fast_int queue=0)
- const unsigned int & **get_state** () const
- void **reset** ()
- bool **has_tool** (epiworld_fast_uint t) const
- bool **has_tool** (std::string name) const
- bool **has_tool** (const [Tool](#)< TSeq > &t) const
- bool **has_virus** (epiworld_fast_uint t) const
- bool **has_virus** (std::string name) const
- bool **has_virus** (const [Virus](#)< TSeq > &v) const
- bool **has_entity** (epiworld_fast_uint t) const
- bool **has_entity** (std::string name) const
- void **print** ([Model](#)< TSeq > *model, bool compressed=false) const
- [Entities](#)< TSeq > **get_entities** ()
- const [Entities_const](#)< TSeq > **get_entities** () const

- const [Entity](#)< TSeq > & **get_entity** (size_t i) const
- [Entity](#)< TSeq > & **get_entity** (size_t i)
- size_t **get_n_entities** () const
- bool **operator==** (const [Agent](#)< TSeq > &other) const
- bool **operator!=** (const [Agent](#)< TSeq > &other) const

Add/Remove Virus/Tool

Any of these is ultimately reflected at the end of the iteration.

Parameters

tool	Tool to add
virus	Virus to add
state_new	state after the change
queue	

- void **add_tool** (ToolPtr< TSeq > tool, [Model](#)< TSeq > *model, epiworld_fast_int state_new=-99, epiworld_fast_int queue=-99)
- void **add_tool** ([Tool](#)< TSeq > tool, [Model](#)< TSeq > *model, epiworld_fast_int state_new=-99, epiworld_fast_int queue=-99)
- void **set_virus** (VirusPtr< TSeq > virus, [Model](#)< TSeq > *model, epiworld_fast_int state_new=-99, epiworld_fast_int queue=-99)
- void **set_virus** ([Virus](#)< TSeq > virus, [Model](#)< TSeq > *model, epiworld_fast_int state_new=-99, epiworld_fast_int queue=-99)
- void **add_entity** ([Entity](#)< TSeq > &entity, [Model](#)< TSeq > *model, epiworld_fast_int state_new=-99, epiworld_fast_int queue=-99)
- void **rm_tool** (epiworld_fast_uint tool_idx, [Model](#)< TSeq > *model, epiworld_fast_int state_new=-99, epiworld_fast_int queue=-99)
- void **rm_tool** (ToolPtr< TSeq > &tool, [Model](#)< TSeq > *model, epiworld_fast_int state_new=-99, epiworld_fast_int queue=-99)
- void **rm_virus** ([Model](#)< TSeq > *model, epiworld_fast_int state_new=-99, epiworld_fast_int queue=-99)
- void **rm_entity** (epiworld_fast_uint entity_idx, [Model](#)< TSeq > *model, epiworld_fast_int state_new=-99, epiworld_fast_int queue=-99)
- void **rm_entity** ([Entity](#)< TSeq > &entity, [Model](#)< TSeq > *model, epiworld_fast_int state_new=-99, epiworld_fast_int queue=-99)
- void **rm_agent_by_virus** ([Model](#)< TSeq > *model, epiworld_fast_int state_new=-99, epiworld_fast_int queue=-99)

[Agent](#) removed by virus.

Get the rates (multipliers) for the agent

Parameters

v	A pointer to a virus.
---	-----------------------

Returns

epiworld_double

- epiworld_double **get_susceptibility_reduction** (VirusPtr< TSeq > v, [Model](#)< TSeq > *model)
- epiworld_double **get_transmission_reduction** (VirusPtr< TSeq > v, [Model](#)< TSeq > *model)
- epiworld_double **get_recovery_enhancer** (VirusPtr< TSeq > v, [Model](#)< TSeq > *model)
- epiworld_double **get_death_reduction** (VirusPtr< TSeq > v, [Model](#)< TSeq > *model)

- double & [operator\(\)](#) (size_t j)
Access the j-th column of the agent.
- double & **operator[]** (size_t j)
- double **operator()** (size_t j) const
- double **operator[]** (size_t j) const

Friends

- class **Model**< TSeq >
- class **Virus**< TSeq >
- class **Tool**< TSeq >
- class **Tools**< TSeq >
- class **Tools_const**< TSeq >
- class **Queue**< TSeq >
- class **Entities**< TSeq >
- class **AgentsSample**< TSeq >
- void **default_add_virus** ([Event](#)< TSeq > &a, [Model](#)< TSeq > *m)
- void **default_add_tool** ([Event](#)< TSeq > &a, [Model](#)< TSeq > *m)
- void **default_add_entity** ([Event](#)< TSeq > &a, [Model](#)< TSeq > *m)
- void **default_rm_virus** ([Event](#)< TSeq > &a, [Model](#)< TSeq > *m)
- void **default_rm_tool** ([Event](#)< TSeq > &a, [Model](#)< TSeq > *m)
- void **default_rm_entity** ([Event](#)< TSeq > &a, [Model](#)< TSeq > *m)
- void **default_change_state** ([Event](#)< TSeq > &a, [Model](#)< TSeq > *m)

15.3.1 Detailed Description

```
template<typename TSeq>
class Agent< TSeq >
```

[Agent](#) (agents)

Template Parameters

<i>TSeq</i>	Sequence type (should match TSeq across the model)
-------------	----------------------------------------------------

15.3.2 Member Function Documentation

15.3.2.1 operator()()

```
template<typename TSeq >
double & Agent< TSeq >::operator() (
    size_t j ) [inline]
```

Access the j-th column of the agent.

If an external array has been specified, then these two functions can be used to access additional agent's features not included in the model.

The `operator[]` method is with no boundary check, whereas the `operator()` method checks boundaries. The former can result in a segfault.

Parameters

<i>j</i>	
----------	--

Returns

double&

15.3.2.2 swap_neighbors()

```
template<typename TSeq >
void Agent< TSeq >::swap_neighbors (
    Agent< TSeq > & other,
    size_t n_this,
    size_t n_other ) [inline]
```

Swaps neighbors between the current agent and agent *other*

Parameters

<i>other</i>	
<i>n_this</i>	
<i>n_other</i>	

15.3.3 Friends And Related Function Documentation**15.3.3.1 default_rm_entity**

```
template<typename TSeq >
void default_rm_entity (
    Event< TSeq > & a,
    Model< TSeq > * m ) [friend]
```

< Last entity of the agent

< Last agent of the entity

The documentation for this class was generated from the following files:

- include/epiworld/agent-bones.hpp
- include/epiworld/agent-meat.hpp

15.4 epiworld::Agent< TSeq > Class Template Reference

[Agent](#) (agents)

```
#include <epiworld.hpp>
```

Public Member Functions

- **Agent** ([Agent](#)< TSeq > &&p)
- **Agent** (const [Agent](#)< TSeq > &p)
- [Agent](#)< TSeq > & **operator=** (const [Agent](#)< TSeq > &other_agent)
- int **get_id** () const
Id of the individual.
- VirusPtr< TSeq > & **get_virus** ()
- const VirusPtr< TSeq > & **get_virus** () const
- ToolPtr< TSeq > & **get_tool** (int i)
- [Tools](#)< TSeq > **get_tools** ()
- const [Tools_const](#)< TSeq > **get_tools** () const
- size_t **get_n_tools** () const noexcept
- void **mutate_virus** ()
- void **add_neighbor** ([Agent](#)< TSeq > &p, bool check_source=true, bool check_target=true)
- void **swap_neighbors** ([Agent](#)< TSeq > &other, size_t n_this, size_t n_other)
Swaps neighbors between the current agent and agent other
- std::vector< [Agent](#)< TSeq > * > **get_neighbors** ()
- size_t **get_n_neighbors** () const
- void **change_state** ([Model](#)< TSeq > *model, epiworld_fast_uint new_state, epiworld_fast_int queue=0)
- const unsigned int & **get_state** () const
- void **reset** ()
- bool **has_tool** (epiworld_fast_uint t) const
- bool **has_tool** (std::string name) const
- bool **has_tool** (const [Tool](#)< TSeq > &t) const
- bool **has_virus** (epiworld_fast_uint t) const
- bool **has_virus** (std::string name) const
- bool **has_virus** (const [Virus](#)< TSeq > &v) const
- bool **has_entity** (epiworld_fast_uint t) const
- bool **has_entity** (std::string name) const
- void **print** ([Model](#)< TSeq > *model, bool compressed=false) const
- [Entities](#)< TSeq > **get_entities** ()
- const [Entities_const](#)< TSeq > **get_entities** () const
- const [Entity](#)< TSeq > & **get_entity** (size_t i) const
- [Entity](#)< TSeq > & **get_entity** (size_t i)
- size_t **get_n_entities** () const
- bool **operator==** (const [Agent](#)< TSeq > &other) const
- bool **operator!=** (const [Agent](#)< TSeq > &other) const

Add/Remove Virus/Tool

Any of these is ultimately reflected at the end of the iteration.

Parameters

tool	<i>Tool to add</i>
virus	<i>Virus to add</i>
state_new	<i>state after the change</i>
Generated by Doxygen	

- void **add_tool** (ToolPtr< TSeq > tool, [Model](#)< TSeq > *model, epiworld_fast_int state_new=-99, epiworld_fast_int queue=-99)
- void **add_tool** ([Tool](#)< TSeq > tool, [Model](#)< TSeq > *model, epiworld_fast_int state_new=-99, epiworld_fast_int queue=-99)
- void **set_virus** (VirusPtr< TSeq > virus, [Model](#)< TSeq > *model, epiworld_fast_int state_new=-99, epiworld_fast_int queue=-99)
- void **set_virus** ([Virus](#)< TSeq > virus, [Model](#)< TSeq > *model, epiworld_fast_int state_new=-99, epiworld_fast_int queue=-99)
- void **add_entity** ([Entity](#)< TSeq > &entity, [Model](#)< TSeq > *model, epiworld_fast_int state_new=-99, epiworld_fast_int queue=-99)
- void **rm_tool** (epiworld_fast_uint tool_idx, [Model](#)< TSeq > *model, epiworld_fast_int state_new=-99, epiworld_fast_int queue=-99)
- void **rm_tool** (ToolPtr< TSeq > &tool, [Model](#)< TSeq > *model, epiworld_fast_int state_new=-99, epiworld_fast_int queue=-99)
- void **rm_virus** ([Model](#)< TSeq > *model, epiworld_fast_int state_new=-99, epiworld_fast_int queue=-99)
- void **rm_entity** (epiworld_fast_uint entity_idx, [Model](#)< TSeq > *model, epiworld_fast_int state_new=-99, epiworld_fast_int queue=-99)
- void **rm_entity** ([Entity](#)< TSeq > &entity, [Model](#)< TSeq > *model, epiworld_fast_int state_new=-99, epiworld_fast_int queue=-99)
- void **rm_agent_by_virus** ([Model](#)< TSeq > *model, epiworld_fast_int state_new=-99, epiworld_fast_int queue=-99)

[Agent](#) removed by virus.

Get the rates (multipliers) for the agent

Parameters

v	A pointer to a virus.
---	-----------------------

Returns

epiworld_double

- epiworld_double **get_susceptibility_reduction** (VirusPtr< TSeq > v, [Model](#)< TSeq > *model)
- epiworld_double **get_transmission_reduction** (VirusPtr< TSeq > v, [Model](#)< TSeq > *model)
- epiworld_double **get_recovery_enhancer** (VirusPtr< TSeq > v, [Model](#)< TSeq > *model)
- epiworld_double **get_death_reduction** (VirusPtr< TSeq > v, [Model](#)< TSeq > *model)

- double & [operator](#)() (size_t j)

Access the j-th column of the agent.

- double & **operator[]** (size_t j)
- double **operator()** (size_t j) const
- double **operator[]** (size_t j) const

Friends

- class [Model](#)< TSeq >
- class [Virus](#)< TSeq >
- class [Tool](#)< TSeq >
- class [Tools](#)< TSeq >
- class [Tools_const](#)< TSeq >
- class [Queue](#)< TSeq >
- class [Entities](#)< TSeq >

- class **AgentsSample**< TSeq >
- void **default_add_virus** ([Event](#)< TSeq > &a, [Model](#)< TSeq > *m)
- void **default_add_tool** ([Event](#)< TSeq > &a, [Model](#)< TSeq > *m)
- void **default_add_entity** ([Event](#)< TSeq > &a, [Model](#)< TSeq > *m)
- void **default_rm_virus** ([Event](#)< TSeq > &a, [Model](#)< TSeq > *m)
- void **default_rm_tool** ([Event](#)< TSeq > &a, [Model](#)< TSeq > *m)
- void **default_rm_entity** ([Event](#)< TSeq > &a, [Model](#)< TSeq > *m)
- void **default_change_state** ([Event](#)< TSeq > &a, [Model](#)< TSeq > *m)

15.4.1 Detailed Description

```
template<typename TSeq>
class epiworld::Agent< TSeq >
```

[Agent](#) (agents)

Template Parameters

<i>TSeq</i>	Sequence type (should match TSeq across the model)
-------------	----------------------------------------------------

15.4.2 Member Function Documentation

15.4.2.1 operator()()

```
template<typename TSeq >
double & Agent< TSeq >::operator() (
    size_t j ) [inline]
```

Access the j-th column of the agent.

If an external array has been specified, then these two functions can be used to access additional agent's features not included in the model.

The `operator[]` method is with no boundary check, whereas the `operator()` method checks boundaries. The former can result in a segfault.

Parameters

<i>j</i>	
----------	--

Returns

double&

15.4.2.2 swap_neighbors()

```
template<typename TSeq >
void Agent< TSeq >::swap_neighbors (
    Agent< TSeq > & other,
    size_t n_this,
    size_t n_other ) [inline]
```

Swaps neighbors between the current agent and agent `other`

Parameters

<i>other</i>	
<i>n_this</i>	
<i>n_other</i>	

15.4.3 Friends And Related Function Documentation

15.4.3.1 default_rm_entity

```
template<typename TSeq >
void default_rm_entity (
    Event< TSeq > & a,
    Model< TSeq > * m ) [friend]
```

< Last entity of the agent

< Last agent of the entity

The documentation for this class was generated from the following file:

- epiworld.hpp

15.5 AgentsSample< TSeq > Class Template Reference

Sample of agents.

```
#include <agentssample-bones.hpp>
```

Public Member Functions

- [AgentsSample](#) ()=delete
Default constructor.
- [AgentsSample](#) (const [AgentsSample](#)< TSeq > &a)=delete
Copy constructor.
- [AgentsSample](#) ([AgentsSample](#)< TSeq > &&a)=delete
Move constructor.
- **AgentsSample** ([Model](#)< TSeq > &model_, size_t n, std::vector< size_t > states_={}, bool truncate=false)
- **AgentsSample** ([Model](#)< TSeq > *model, [Entity](#)< TSeq > &entity_, size_t n, std::vector< size_t > states_←_={}, bool truncate=false)
- [AgentsSample](#) ([Model](#)< TSeq > *model, [Agent](#)< TSeq > &agent_, size_t n, std::vector< size_t > states_←_={}, bool truncate=false)
Sample from the agent's entities.
- std::vector< [Agent](#)< TSeq > * >::iterator **begin** ()
- std::vector< [Agent](#)< TSeq > * >::iterator **end** ()
- [Agent](#)< TSeq > * **operator[]** (size_t n)
- [Agent](#)< TSeq > * **operator()** (size_t n)
- size_t **size** () const noexcept

15.5.1 Detailed Description

```
template<typename TSeq>
class AgentsSample< TSeq >
```

Sample of agents.

This class allows sampling agents from Entity<TSeq> and Model<TSeq>.

Template Parameters

<i>TSeq</i>	
-------------	--

15.5.2 Constructor & Destructor Documentation

15.5.2.1 AgentsSample()

```
template<typename TSeq >
AgentsSample< TSeq >::AgentsSample (
    Model< TSeq > * model,
    Agent< TSeq > & agent_,
    size_t n,
    std::vector< size_t > states_ = {},
    bool truncate = false ) [inline]
```

Sample from the agent's entities.

For example, how many individuals the agent contacts in a given point in time.

Template Parameters

<i>TSeq</i>	
-------------	--

Parameters

<i>agent</i> ↔	
—	
<i>n</i>	Sample size
<i>truncate</i>	If the agent has fewer than <i>n</i> connections, then <i>truncate</i> = true will automatically reduce the number of possible samples. Otherwise, if false, then it returns an error.

The documentation for this class was generated from the following file:

- include/epiworld/agentssample-bones.hpp

15.6 epiworld::AgentsSample< TSeq > Class Template Reference

Sample of agents.

```
#include <epiworld.hpp>
```

Public Member Functions

- [AgentsSample](#) ()=delete
Default constructor.
- [AgentsSample](#) (const [AgentsSample](#)< TSeq > &a)=delete
Copy constructor.
- [AgentsSample](#) ([AgentsSample](#)< TSeq > &&a)=delete
Move constructor.
- [AgentsSample](#) ([Model](#)< TSeq > &model_, size_t n, std::vector< size_t > states_={}, bool truncate=false)
- [AgentsSample](#) ([Model](#)< TSeq > *model, [Entity](#)< TSeq > &entity_, size_t n, std::vector< size_t > states_↔_={}, bool truncate=false)
- [AgentsSample](#) ([Model](#)< TSeq > *model, [Agent](#)< TSeq > &agent_, size_t n, std::vector< size_t > states_↔_={}, bool truncate=false)
Sample from the agent's entities.
- std::vector< [Agent](#)< TSeq > * >::iterator **begin** ()
- std::vector< [Agent](#)< TSeq > * >::iterator **end** ()
- [Agent](#)< TSeq > * **operator[]** (size_t n)
- [Agent](#)< TSeq > * **operator()** (size_t n)
- size_t **size** () const noexcept

15.6.1 Detailed Description

```
template<typename TSeq>
class epiworld::AgentsSample< TSeq >
```

Sample of agents.

This class allows sampling agents from [Entity](#)<TSeq> and [Model](#)<TSeq>.

Template Parameters

<i>TSeq</i>	
-------------	--

15.6.2 Constructor & Destructor Documentation

15.6.2.1 AgentsSample()

```
template<typename TSeq >
AgentsSample< TSeq >::AgentsSample (
    Model< TSeq > * model,
    Agent< TSeq > & agent_,
    size_t n,
    std::vector< size_t > states_ = {},
    bool truncate = false ) [inline]
```

Sample from the agent's entities.

For example, how many individuals the agent contacts in a given point in time.

Template Parameters

<i>TSeq</i>	
-------------	--

Parameters

<i>agent</i> ↔	
<i>n</i>	Sample size
<i>truncate</i>	If the agent has fewer than <i>n</i> connections, then <i>truncate</i> = true will automatically reduce the number of possible samples. Otherwise, if false, then it returns an error.

The documentation for this class was generated from the following file:

- epiworld.hpp

15.7 DataBase< TSeq > Class Template Reference

Statistical data about the process.

```
#include <database-bones.hpp>
```

Public Member Functions

- **DataBase** ([Model](#)< TSeq > &m)
- **DataBase** (const [DataBase](#)< TSeq > &db)
- void [record_virus](#) ([Virus](#)< TSeq > &v)
 - Registering a new variant.*
- void [record_tool](#) ([Tool](#)< TSeq > &t)
- void [set_seq_hasher](#) (std::function< std::vector< int >(TSeq)> fun)
- void [reset](#) ()
- [Model](#)< TSeq > * [get_model](#) ()
- void [record](#) ()
- const std::vector< TSeq > & [get_sequence](#) () const
- const std::vector< int > & [get_nexposed](#) () const
- size_t [size](#) () const
- void [write_data](#) (std::string fn_virus_info, std::string fn_virus_hist, std::string fn_tool_info, std::string fn_↵
_tool_hist, std::string fn_total_hist, std::string fn_transmission, std::string fn_transition, std::string fn_↵
reproductive_number, std::string fn_generation_time) const
- void [record_transmission](#) (int i, int j, int virus, int i_expo_date)
- size_t [get_n_viruses](#) () const
 - Get the number of viruses.*
- size_t [get_n_tools](#) () const
 - Get the number of tools.*
- void [set_user_data](#) (std::vector< std::string > names)
- void [add_user_data](#) (std::vector< epiworld_double > x)
- void [add_user_data](#) (epiworld_fast_uint j, epiworld_double x)
- [UserData](#)< TSeq > & [get_user_data](#) ()
- std::vector< epiworld_double > [transition_probability](#) (bool print=true, bool normalize=true) const
 - Calculates the transition probabilities.*
- bool [operator==](#) (const [DataBase](#)< TSeq > &other) const
- bool [operator!=](#) (const [DataBase](#)< TSeq > &other) const
- bool [operator==](#) (const [DataBase](#)< std::vector< int >> &other) const
- bool [operator==](#) (const [DataBase](#)< std::vector< int >> &other) const

Get recorded information from the model

Parameters

what	<i>std::string, The state, e.g., 0, 1, 2, ...</i>
------	---------------------------------------------------

Returns

In [get_today_total](#), the current counts of what.

In [get_today_virus](#), the current counts of what for each virus.

In [get_hist_total](#), the time series of what

In [get_hist_virus](#), the time series of what for each virus.

In [get_hist_total_date](#) and [get_hist_virus_date](#) the corresponding date

- int [get_today_total](#) (std::string what) const
- int [get_today_total](#) (epiworld_fast_uint what) const
- void [get_today_total](#) (std::vector< std::string > *state=nullptr, std::vector< int > *counts=nullptr) const
- void [get_today_virus](#) (std::vector< std::string > &state, std::vector< int > &id, std::vector< int > &counts) const
- void [get_today_transition_matrix](#) (std::vector< int > &counts) const
- void [get_hist_total](#) (std::vector< int > *date, std::vector< std::string > *state, std::vector< int > *counts) const

- void **get_hist_virus** (std::vector< int > &date, std::vector< int > &id, std::vector< std::string > &state, std::vector< int > &counts) const
 - void **get_hist_tool** (std::vector< int > &date, std::vector< int > &id, std::vector< std::string > &state, std::vector< int > &counts) const
 - void **get_hist_transition_matrix** (std::vector< std::string > &state_from, std::vector< std::string > &state_to, std::vector< int > &date, std::vector< int > &counts, bool skip_zeros) const
-
- void **get_transmissions** (std::vector< int > &date, std::vector< int > &source, std::vector< int > &target, std::vector< int > &virus, std::vector< int > &source_exposure_date) const
Get the transmissions object.
 - void **get_transmissions** (int *date, int *source, int *target, int *virus, int *source_exposure_date) const
-
- MapVec_type< int, int > **reproductive_number** () const
Computes the reproductive number of each case.
 - void **reproductive_number** (std::string fn) const
-
- void **generation_time** (std::vector< int > &agent_id, std::vector< int > &virus_id, std::vector< int > &time, std::vector< int > &gentime) const
Get the generation time.
 - void **generation_time** (std::string fn) const
Write the generation time to a file.

Friends

- class **Model**< TSeq >
- void **default_add_virus** (Event< TSeq > &a, Model< TSeq > *m)
- void **default_add_tool** (Event< TSeq > &a, Model< TSeq > *m)
- void **default_rm_virus** (Event< TSeq > &a, Model< TSeq > *m)
- void **default_rm_tool** (Event< TSeq > &a, Model< TSeq > *m)
- void **default_change_state** (Event< TSeq > &a, Model< TSeq > *m)

15.7.1 Detailed Description

```
template<typename TSeq>
class DataBase< TSeq >
```

Statistical data about the process.

Template Parameters

<i>TSeq</i>	
-------------	--

15.7.2 Member Function Documentation

15.7.2.1 generation_time()

```
template<typename TSeq >
void DataBase< TSeq >::generation_time (
    std::vector< int > & agent_id,
    std::vector< int > & virus_id,
    std::vector< int > & time,
    std::vector< int > & gentime ) const [inline]
```

Get the generation time.

Calculates the generating time

Parameters

<i>agent_id, virus_id, time, gentime</i>	vectors where to save the values
------------------------------------------	----------------------------------

The generation time is the time between the infection of the source and the infection of the target.

15.7.2.2 get_transmissions()

```
template<typename TSeq >
void DataBase< TSeq >::get_transmissions (
    std::vector< int > & date,
    std::vector< int > & source,
    std::vector< int > & target,
    std::vector< int > & virus,
    std::vector< int > & source_exposure_date ) const [inline]
```

Get the transmissions object.

Parameters

<i>date</i>	
<i>source</i>	
<i>target</i>	
<i>virus</i>	
<i>source_exposure_date</i>	

15.7.2.3 operator==() [1/3]

```
bool DataBase< std::vector< int > >::operator== (
    const DataBase< std::vector< int >> & other ) const [inline]
```


< Date of the transmission eve,

< Id of the sour,

< Id of the targ,

< Id of the varia,

< Date when the source acquired the varia,

15.7.2.4 operator==() [2/3]

```
bool DataBase< std::vector< int > >::operator== (
    const DataBase< std::vector< int >> & other ) const [inline]
```

< Date of the transmission eve,

< Id of the sour,

< Id of the targ,

< Id of the varia,

< Date when the source acquired the varia,

15.7.2.5 operator==() [3/3]

```
template<typename TSeq >
bool DataBase< TSeq >::operator== (
    const DataBase< TSeq > & other ) const [inline]
```

< Date of the transmission eve

< Id of the sour

< Id of the targ

< Id of the varia

< Date when the source acquired the varia

15.7.2.6 record_virus()

```
template<typename TSeq >
void DataBase< TSeq >::record_virus (
    Virus< TSeq > & v ) [inline]
```

Registering a new variant.

Parameters

<i>v</i>	Pointer to the new virus. Since viruses are originated in the agent, the numbers simply move around. From the parent virus to the new virus. And the total number of infected does not change.
----------	------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

15.7.2.7 reproductive_number()

```
template<typename TSeq >
MapVec_type< int, int > DataBase< TSeq >::reproductive_number [inline]
```

Computes the reproductive number of each case.

By definition, whereas it computes R_0 (basic reproductive number) or R_t/R (the effective reproductive number) will depend on whether the virus is allowed to circulate naïvely or not, respectively.

Parameters

<i>fn</i>	File where to write out the reproductive number.
-----------	--------------------------------------------------

In the case of `MapVec_type<int, int>`, the key is a vector of 3 integers:

- [Virus](#) id
- Source id
- Date when the source was infected

15.7.2.8 transition_probability()

```
template<typename TSeq >
std::vector< epiworld_double > DataBase< TSeq >::transition_probability (
    bool print = true,
    bool normalize = true ) const [inline]
```

Calculates the transition probabilities.

Parameters

<i>print</i>	Print the transition matrix.
<i>normalize</i>	Normalize the transition matrix. Otherwise, it returns raw counts.

The transition matrix is the matrix of the counts of transitions from one state to another. So the ij -th element of the matrix is the number of transitions from state i to state j (when not normalized), or the probability of transitioning from state i to state j (when normalized).

Returns

std::vector< epiworld_double >

The documentation for this class was generated from the following files:

- include/epiworld/database-bones.hpp
- include/epiworld/database-meat.hpp

15.8 epiworld::DataBase< TSeq > Class Template Reference

Statistical data about the process.

```
#include <epiworld.hpp>
```

Public Member Functions

- **DataBase** ([Model](#)< TSeq > &m)
- **DataBase** (const [DataBase](#)< TSeq > &db)
- void **record_virus** ([Virus](#)< TSeq > &v)
Registering a new variant.
- void **record_tool** ([Tool](#)< TSeq > &t)
- void **set_seq_hasher** (std::function< std::vector< int >(TSeq)> fun)
- void **reset** ()
- [Model](#)< TSeq > * **get_model** ()
- void **record** ()
- const std::vector< TSeq > & **get_sequence** () const
- const std::vector< int > & **get_nexposed** () const
- size_t **size** () const
- void **write_data** (std::string fn_virus_info, std::string fn_virus_hist, std::string fn_tool_info, std::string fn_tool_hist, std::string fn_total_hist, std::string fn_transmission, std::string fn_transition, std::string fn_reproductive_number, std::string fn_generation_time) const
- void **record_transmission** (int i, int j, int virus, int i_expo_date)
- size_t **get_n_viruses** () const
Get the number of viruses.
- size_t **get_n_tools** () const
Get the number of tools.
- void **set_user_data** (std::vector< std::string > names)
- void **add_user_data** (std::vector< epiworld_double > x)
- void **add_user_data** (epiworld_fast_uint j, epiworld_double x)
- [UserData](#)< TSeq > & **get_user_data** ()
- std::vector< epiworld_double > **transition_probability** (bool print=true, bool normalize=true) const
Calculates the transition probabilities.
- bool **operator==** (const [DataBase](#)< TSeq > &other) const
- bool **operator!=** (const [DataBase](#)< TSeq > &other) const

Get recorded information from the model

Parameters

what	<i>std::string, The state, e.g., 0, 1, 2, ...</i>
------	---------------------------------------------------

Returns

In `get_today_total`, the current counts of what.

In `get_today_virus`, the current counts of what for each virus.

In `get_hist_total`, the time series of what

In `get_hist_virus`, the time series of what for each virus.

In `get_hist_total_date` and `get_hist_virus_date` the corresponding date

- `int get_today_total (std::string what) const`
 - `int get_today_total (epiworld_fast_uint what) const`
 - `void get_today_total (std::vector< std::string > *state=nullptr, std::vector< int > *counts=nullptr) const`
 - `void get_today_virus (std::vector< std::string > &state, std::vector< int > &id, std::vector< int > &counts) const`
 - `void get_today_transition_matrix (std::vector< int > &counts) const`
 - `void get_hist_total (std::vector< int > *date, std::vector< std::string > *state, std::vector< int > *counts) const`
 - `void get_hist_virus (std::vector< int > &date, std::vector< int > &id, std::vector< std::string > &state, std::vector< int > &counts) const`
 - `void get_hist_tool (std::vector< int > &date, std::vector< int > &id, std::vector< std::string > &state, std::vector< int > &counts) const`
 - `void get_hist_transition_matrix (std::vector< std::string > &state_from, std::vector< std::string > &state_to, std::vector< int > &date, std::vector< int > &counts, bool skip_zeros) const`
-
- `void get_transmissions (std::vector< int > &date, std::vector< int > &source, std::vector< int > &target, std::vector< int > &virus, std::vector< int > &source_exposure_date) const`
Get the transmissions object.
 - `void get_transmissions (int *date, int *source, int *target, int *virus, int *source_exposure_date) const`
-
- `MapVec_type< int, int > reproductive_number () const`
Computes the reproductive number of each case.
 - `void reproductive_number (std::string fn) const`
-
- `void generation_time (std::vector< int > &agent_id, std::vector< int > &virus_id, std::vector< int > &time, std::vector< int > &gentime) const`
Get the generation time.
 - `void generation_time (std::string fn) const`
Write the generation time to a file.

Friends

- class **Model**< TSeq >
- void **default_add_virus** ([Event](#)< TSeq > &a, [Model](#)< TSeq > *m)
- void **default_add_tool** ([Event](#)< TSeq > &a, [Model](#)< TSeq > *m)
- void **default_rm_virus** ([Event](#)< TSeq > &a, [Model](#)< TSeq > *m)
- void **default_rm_tool** ([Event](#)< TSeq > &a, [Model](#)< TSeq > *m)
- void **default_change_state** ([Event](#)< TSeq > &a, [Model](#)< TSeq > *m)

15.8.1 Detailed Description

```
template<typename TSeq>
class epiworld::DataBase< TSeq >
```

Statistical data about the process.

Template Parameters

<i>TSeq</i>	
-------------	--

15.8.2 Member Function Documentation

15.8.2.1 generation_time()

```
template<typename TSeq >
void DataBase< TSeq >::generation_time (
    std::vector< int > & agent_id,
    std::vector< int > & virus_id,
    std::vector< int > & time,
    std::vector< int > & gentime ) const [inline]
```

Get the generation time.

Calculates the generating time

Parameters

<i>agent_id, virus_id, time, gentime</i>	vectors where to save the values
------------------------------------------	----------------------------------

The generation time is the time between the infection of the source and the infection of the target.

15.8.2.2 get_transmissions()

```
template<typename TSeq >
void DataBase< TSeq >::get_transmissions (
```

```

std::vector< int > & date,
std::vector< int > & source,
std::vector< int > & target,
std::vector< int > & virus,
std::vector< int > & source_exposure_date ) const [inline]

```

Get the transmissions object.

Parameters

<i>date</i>	
<i>source</i>	
<i>target</i>	
<i>virus</i>	
<i>source_exposure_date</i>	

15.8.2.3 operator==()

```

template<typename TSeq >
bool DataBase< TSeq >::operator== (
    const DataBase< TSeq > & other ) const [inline]

```

< Date of the transmission eve

< Id of the sour

< Id of the targ

< Id of the varia

< Date when the source acquired the varia

15.8.2.4 record_virus()

```

template<typename TSeq >
void DataBase< TSeq >::record_virus (
    Virus< TSeq > & v ) [inline]

```

Registering a new variant.

Parameters

<i>v</i>	Pointer to the new virus. Since viruses are originated in the agent, the numbers simply move around. From the parent virus to the new virus. And the total number of infected does not change.
----------	------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

15.8.2.5 reproductive_number()

```
template<typename TSeq >
MapVec_type< int, int > DataBase< TSeq >::reproductive_number [inline]
```

Computes the reproductive number of each case.

By definition, whereas it computes R_0 (basic reproductive number) or R_t/R (the effective reproductive number) will depend on whether the virus is allowed to circulate naïvely or not, respectively.

Parameters

<i>fn</i>	File where to write out the reproductive number.
-----------	--------------------------------------------------

In the case of `MapVec_type<int, int>`, the key is a vector of 3 integers:

- Virus id
- Source id
- Date when the source was infected

15.8.2.6 transition_probability()

```
template<typename TSeq >
std::vector< epiworld_double > DataBase< TSeq >::transition_probability (
    bool print = true,
    bool normalize = true ) const [inline]
```

Calculates the transition probabilities.

Parameters

<i>print</i>	Print the transition matrix.
<i>normalize</i>	Normalize the transition matrix. Otherwise, it returns raw counts.

The transition matrix is the matrix of the counts of transitions from one state to another. So the ij -th element of the matrix is the number of transitions from state i to state j (when not normalized), or the probability of transitioning from state i to state j (when normalized).

Returns

`std::vector< epiworld_double >`

The documentation for this class was generated from the following file:

- epiworld.hpp

15.9 Entities< TSeq > Class Template Reference

Set of [Entities](#) (useful for building iterators)

```
#include <entities-bones.hpp>
```

Public Member Functions

- **Entities** ([Agent](#)< TSeq > &p)
- std::vector< [Entity](#)< TSeq > * >::iterator **begin** ()
- std::vector< [Entity](#)< TSeq > * >::iterator **end** ()
- [Entity](#)< TSeq > & **operator()** (size_t i)
- [Entity](#)< TSeq > & **operator[]** (size_t i)
- size_t **size** () const noexcept
- bool **operator==** (const [Entities](#)< TSeq > &other) const

Friends

- class [Entity](#)< TSeq >
- class [Agent](#)< TSeq >

15.9.1 Detailed Description

```
template<typename TSeq>
class Entities< TSeq >
```

Set of [Entities](#) (useful for building iterators)

Template Parameters

<i>TSeq</i>	
-------------	--

The documentation for this class was generated from the following files:

- include/epiworld/agent-bones.hpp
- include/epiworld/entities-bones.hpp

15.10 epiworld::Entities< TSeq > Class Template Reference

Set of [Entities](#) (useful for building iterators)

```
#include <epiworld.hpp>
```


Public Member Functions

- **Entities** ([Agent](#)< TSeq > &p)
- std::vector< [Entity](#)< TSeq > * >::iterator **begin** ()
- std::vector< [Entity](#)< TSeq > * >::iterator **end** ()
- [Entity](#)< TSeq > & **operator()** (size_t i)
- [Entity](#)< TSeq > & **operator[]** (size_t i)
- size_t **size** () const noexcept
- bool **operator==** (const [Entities](#)< TSeq > &other) const

Friends

- class **Entity**< TSeq >
- class **Agent**< TSeq >

15.10.1 Detailed Description

```
template<typename TSeq>
class epiworld::Entities< TSeq >
```

Set of [Entities](#) (useful for building iterators)

Template Parameters

<i>TSeq</i>	
-------------	--

The documentation for this class was generated from the following file:

- epiworld.hpp

15.11 Entities_const< TSeq > Class Template Reference

Set of [Entities](#) (const) (useful for iterators)

```
#include <entities-bones.hpp>
```

Public Member Functions

- **Entities_const** (const [Agent](#)< TSeq > &p)
- std::vector< [Entity](#)< TSeq > * >::const_iterator **begin** ()
- std::vector< [Entity](#)< TSeq > * >::const_iterator **end** ()
- const [Entity](#)< TSeq > & **operator()** (size_t i)
- const [Entity](#)< TSeq > & **operator[]** (size_t i)
- size_t **size** () const noexcept
- bool **operator==** (const [Entities_const](#)< TSeq > &other) const

Friends

- class **Virus**< TSeq >
- class **Agent**< TSeq >

15.11.1 Detailed Description

```
template<typename TSeq>
class Entities_const< TSeq >
```

Set of [Entities](#) (const) (useful for iterators)

Template Parameters

<i>TSeq</i>	
-------------	--

The documentation for this class was generated from the following file:

- include/epiworld/entities-bones.hpp

15.12 epiworld::Entities_const< TSeq > Class Template Reference

Set of [Entities](#) (const) (useful for iterators)

```
#include <epiworld.hpp>
```

Public Member Functions

- **Entities_const** (const [Agent](#)< TSeq > &p)
- std::vector< [Entity](#)< TSeq > * >::const_iterator **begin** ()
- std::vector< [Entity](#)< TSeq > * >::const_iterator **end** ()
- const [Entity](#)< TSeq > & **operator()** (size_t i)
- const [Entity](#)< TSeq > & **operator[]** (size_t i)
- size_t **size** () const noexcept
- bool **operator==** (const [Entities_const](#)< TSeq > &other) const

Friends

- class **Virus**< TSeq >
- class **Agent**< TSeq >

15.12.1 Detailed Description

```
template<typename TSeq>
class epiworld::Entities_const< TSeq >
```

Set of [Entities](#) (const) (useful for iterators)

Template Parameters

<i>TSeq</i>	
-------------	--

The documentation for this class was generated from the following file:

- epiworld.hpp

15.13 Entity< TSeq > Class Template Reference

Public Member Functions

- [Entity](#) (std::string name, EntityToAgentFun< TSeq > fun=nullptr)
Constructs an [Entity](#) object.
- void **add_agent** ([Agent](#)< TSeq > &p, [Model](#)< TSeq > *model)
- void **add_agent** ([Agent](#)< TSeq > *p, [Model](#)< TSeq > *model)
- void **rm_agent** (size_t idx, [Model](#)< TSeq > *model)
- size_t **size** () const noexcept
- void **set_location** (std::vector< epiworld_double > loc)
- std::vector< epiworld_double > & **get_location** ()
- std::vector< [Agent](#)< TSeq > * >::iterator **begin** ()
- std::vector< [Agent](#)< TSeq > * >::iterator **end** ()
- std::vector< [Agent](#)< TSeq > * >::const_iterator **begin** () const
- std::vector< [Agent](#)< TSeq > * >::const_iterator **end** () const
- size_t **operator[]** (size_t i)
- int **get_id** () const noexcept
- const std::string & **get_name** () const noexcept
- void **set_state** (epiworld_fast_int init, epiworld_fast_int post)
- void **set_queue** (epiworld_fast_int init, epiworld_fast_int post)
- void **get_state** (epiworld_fast_int *init, epiworld_fast_int *post)
- void **get_queue** (epiworld_fast_int *init, epiworld_fast_int *post)
- void **reset** ()
- bool **operator==** (const [Entity](#)< TSeq > &other) const
- bool **operator!=** (const [Entity](#)< TSeq > &other) const

Entity distribution

These functions are used for distributing agents among entities. The idea is to have a flexible way of distributing agents among entities.

- void **distribute** ([Model](#)< TSeq > *model)
- std::vector< size_t > & **get_agents** ()
- void **print** () const
- void **set_distribution** (EntityToAgentFun< TSeq > fun)

Friends

- class [Agent](#)< TSeq >
- class [AgentsSample](#)< TSeq >
- class [Model](#)< TSeq >
- void **default_add_entity** ([Event](#)< TSeq > &a, [Model](#)< TSeq > *m)
- void **default_rm_entity** ([Event](#)< TSeq > &a, [Model](#)< TSeq > *m)

15.13.1 Constructor & Destructor Documentation

15.13.1.1 Entity()

```
template<typename TSeq >
Entity< TSeq >::Entity (
    std::string name,
    EntityToAgentFun< TSeq > fun = nullptr ) [inline]
```

Constructs an [Entity](#) object.

This constructor initializes an [Entity](#) object with the specified parameters.

Parameters

<i>name</i>	The name of the entity.
<i>fun</i>	A function pointer to a function that maps the entity to an agent.

15.13.2 Friends And Related Function Documentation

15.13.2.1 default_rm_entity

```
template<typename TSeq >
void default_rm_entity (
    Event< TSeq > & a,
    Model< TSeq > * m ) [friend]
```

< Last entity of the agent

< Last agent of the entity

< Last entity of the agent

< Last agent of the entity

The documentation for this class was generated from the following files:

- include/epiworld/agent-bones.hpp
- include/epiworld/entity-bones.hpp
- include/epiworld/entity-meat.hpp

15.14 epiworld::Entity< TSeq > Class Template Reference

Public Member Functions

- [Entity](#) (std::string name, EntityToAgentFun< TSeq > fun=nullptr)
Constructs an [Entity](#) object.
- void **add_agent** ([Agent](#)< TSeq > &p, [Model](#)< TSeq > *model)
- void **add_agent** ([Agent](#)< TSeq > *p, [Model](#)< TSeq > *model)
- void **rm_agent** (size_t idx, [Model](#)< TSeq > *model)
- size_t **size** () const noexcept
- void **set_location** (std::vector< epiworld_double > loc)
- std::vector< epiworld_double > & **get_location** ()
- std::vector< [Agent](#)< TSeq > * >::iterator **begin** ()
- std::vector< [Agent](#)< TSeq > * >::iterator **end** ()
- std::vector< [Agent](#)< TSeq > * >::const_iterator **begin** () const
- std::vector< [Agent](#)< TSeq > * >::const_iterator **end** () const
- size_t **operator[]** (size_t i)
- int **get_id** () const noexcept
- const std::string & **get_name** () const noexcept
- void **set_state** (epiworld_fast_int init, epiworld_fast_int post)
- void **set_queue** (epiworld_fast_int init, epiworld_fast_int post)
- void **get_state** (epiworld_fast_int *init, epiworld_fast_int *post)
- void **get_queue** (epiworld_fast_int *init, epiworld_fast_int *post)
- void **reset** ()
- bool **operator==** (const [Entity](#)< TSeq > &other) const
- bool **operator!=** (const [Entity](#)< TSeq > &other) const

Entity distribution

These functions are used for distributing agents among entities. The idea is to have a flexible way of distributing agents among entities.

- void **distribute** ([Model](#)< TSeq > *model)
- std::vector< size_t > & **get_agents** ()
- void **print** () const
- void **set_distribution** (EntityToAgentFun< TSeq > fun)

Friends

- class [Agent](#)< TSeq >
- class [AgentsSample](#)< TSeq >
- class [Model](#)< TSeq >
- void **default_add_entity** ([Event](#)< TSeq > &a, [Model](#)< TSeq > *m)
- void **default_rm_entity** ([Event](#)< TSeq > &a, [Model](#)< TSeq > *m)

15.14.1 Constructor & Destructor Documentation

15.14.1.1 Entity()

```
template<typename TSeq >
epiworld::Entity< TSeq >::Entity (
    std::string name,
    EntityToAgentFun< TSeq > fun = nullptr ) [inline]
```

Constructs an [Entity](#) object.

This constructor initializes an [Entity](#) object with the specified parameters.

Parameters

<i>name</i>	The name of the entity.
<i>fun</i>	A function pointer to a function that maps the entity to an agent.

15.14.2 Friends And Related Function Documentation

15.14.2.1 default_rm_entity

```
template<typename TSeq >
void default_rm_entity (
    Event< TSeq > & a,
    Model< TSeq > * m ) [friend]
```

< Last entity of the agent

< Last agent of the entity

The documentation for this class was generated from the following file:

- epiworld.hpp

15.15 epiworld::Event< TSeq > Struct Template Reference

[Event](#) data for update an agent.

```
#include <epiworld.hpp>
```

Public Member Functions

- [Event](#) ([Agent](#)< TSeq > *agent_, VirusPtr< TSeq > virus_, ToolPtr< TSeq > tool_, [Entity](#)< TSeq > *entity_, epiworld_fast_int new_state_, epiworld_fast_int queue_, EventFun< TSeq > call_, int idx_agent_, int idx_object_)
Construct a new [Event](#) object.

Public Attributes

- [Agent](#)< TSeq > * **agent**
- VirusPtr< TSeq > **virus**
- ToolPtr< TSeq > **tool**
- [Entity](#)< TSeq > * **entity**
- epiworld_fast_int **new_state**
- epiworld_fast_int **queue**
- EventFun< TSeq > **call**
- int **idx_agent**
- int **idx_object**

15.15.1 Detailed Description

```
template<typename TSeq = EPI_DEFAULT_TSEQ>
struct epiworld::Event< TSeq >
```

[Event](#) data for update an agent.

Template Parameters

<i>TSeq</i>	
-------------	--

15.15.2 Constructor & Destructor Documentation

15.15.2.1 Event()

```
template<typename TSeq = EPI_DEFAULT_TSEQ>
epiworld::Event< TSeq >::Event (
    Agent< TSeq > * agent_,
    VirusPtr< TSeq > virus_,
    ToolPtr< TSeq > tool_,
    Entity< TSeq > * entity_,
    epiworld_fast_int new_state_,
    epiworld_fast_int queue_,
    EventFun< TSeq > call_,
    int idx_agent_,
    int idx_object_ ) [inline]
```

Construct a new [Event](#) object.

All the parameters are rather optional.

Parameters

<i>agent_</i>	Agent over who the action will happen
<i>virus_</i>	Virus to add
<i>tool_</i>	Tool to add
<i>virus_idx</i>	Index of virus to be removed (if needed)
<i>tool_idx</i>	Index of tool to be removed (if needed)
<i>new_↔ state_</i>	Next state
<i>queue_</i>	Effect on the queue
<i>call_</i>	The action call (if needed)
<i>idx_↔ agent_</i>	Location of agent in object.
<i>idx_↔ object_</i>	Location of object in agent.

The documentation for this struct was generated from the following file:

- epiworld.hpp

15.16 Event< TSeq > Struct Template Reference

[Event](#) data for update an agent.

```
#include <config.hpp>
```

Collaboration diagram for Event< TSeq >:



Public Member Functions

- [Event](#) ([Agent](#)< TSeq > *agent_, [VirusPtr](#)< TSeq > virus_, [ToolPtr](#)< TSeq > tool_, [Entity](#)< TSeq > *entity_, epiworld_fast_int new_state_, epiworld_fast_int queue_, [EventFun](#)< TSeq > call_, int idx_agent_, int idx_object_)

Construct a new [Event](#) object.

Public Attributes

- [Agent](#)< TSeq > * **agent**
- [VirusPtr](#)< TSeq > **virus**
- [ToolPtr](#)< TSeq > **tool**
- [Entity](#)< TSeq > * **entity**
- epiworld_fast_int **new_state**
- epiworld_fast_int **queue**
- [EventFun](#)< TSeq > **call**
- int **idx_agent**
- int **idx_object**

15.16.1 Detailed Description

```
template<typename TSeq = EPI_DEFAULT_TSEQ>
struct Event< TSeq >
```

[Event](#) data for update an agent.

Template Parameters

<i>TSeq</i>	
-------------	--

15.16.2 Constructor & Destructor Documentation

15.16.2.1 Event()

```
template<typename TSeq = EPI_DEFAULT_TSEQ>
Event< TSeq >::Event (
    Agent< TSeq > * agent_,
    VirusPtr< TSeq > virus_,
    ToolPtr< TSeq > tool_,
    Entity< TSeq > * entity_,
    epiworld_fast_int new_state_,
    epiworld_fast_int queue_,
    EventFun< TSeq > call_,
    int idx_agent_,
    int idx_object_ ) [inline]
```

Construct a new [Event](#) object.

All the parameters are rather optional.

Parameters

<i>agent_</i>	Agent over who the action will happen
<i>virus_</i>	Virus to add
<i>tool_</i>	Tool to add
<i>virus_idx</i>	Index of virus to be removed (if needed)
<i>tool_idx</i>	Index of tool to be removed (if needed)
<i>new_↔ state_</i>	Next state
<i>queue_</i>	Effect on the queue
<i>call_</i>	The action call (if needed)
<i>idx_↔ agent_</i>	Location of agent in object.
<i>idx_↔ object_</i>	Location of object in agent.

The documentation for this struct was generated from the following files:

- include/epiworld/agent-bones.hpp
- include/epiworld/config.hpp

15.17 epiworld::GlobalEvent< TSeq > Class Template Reference

Template for a Global [Event](#).

```
#include <epiworld.hpp>
```

Public Member Functions

- [GlobalEvent](#) (GlobalFun< TSeq > fun, std::string name, int day=-99)
Construct a new Global [Event](#) object.
- void **operator()** ([Model](#)< TSeq > *m, int day)
- void **set_name** (std::string name)
- std::string **get_name** () const
- void **set_day** (int day)
- int **get_day** () const
- void **print** () const
- bool **operator==** (const [GlobalEvent](#)< TSeq > &other) const
- bool **operator!=** (const [GlobalEvent](#)< TSeq > &other) const

15.17.1 Detailed Description

```
template<typename TSeq>
class epiworld::GlobalEvent< TSeq >
```

Template for a Global [Event](#).

Global events are functions that `Model<TSeq>` executes at the end of a day.

15.17.2 Constructor & Destructor Documentation

15.17.2.1 GlobalEvent()

```
template<typename TSeq >
GlobalEvent< TSeq >::GlobalEvent (
    GlobalFun< TSeq > fun,
    std::string name,
    int day = -99 ) [inline]
```

Construct a new Global [Event](#) object.

Parameters

<i>fun</i>	A function that takes a <code>Model<TSeq> *</code> as argument and returns void.
<i>name</i>	A descriptive name for the action.
<i>day</i>	The day when the action will be executed. If negative, it will be executed every day.

The documentation for this class was generated from the following file:

- epiworld.hpp

15.18 GlobalEvent< TSeq > Class Template Reference

Template for a Global [Event](#).

```
#include <globalevent-bones.hpp>
```

Public Member Functions

- [GlobalEvent](#) (GlobalFun< TSeq > fun, std::string name, int day=-99)
Construct a new Global [Event](#) object.
- void **operator()** ([Model](#)< TSeq > *m, int day)
- void **set_name** (std::string name)
- std::string **get_name** () const
- void **set_day** (int day)
- int **get_day** () const
- void **print** () const
- bool **operator==** (const [GlobalEvent](#)< TSeq > &other) const
- bool **operator!=** (const [GlobalEvent](#)< TSeq > &other) const

15.18.1 Detailed Description

```
template<typename TSeq>
class GlobalEvent< TSeq >
```

Template for a Global [Event](#).

Global events are functions that [Model](#)<TSeq> executes at the end of a day.

15.18.2 Constructor & Destructor Documentation

15.18.2.1 GlobalEvent()

```
template<typename TSeq >
GlobalEvent< TSeq >::GlobalEvent (
    GlobalFun< TSeq > fun,
    std::string name,
    int day = -99 ) [inline]
```

Construct a new Global [Event](#) object.

Parameters

<i>fun</i>	A function that takes a Model <TSeq> * as argument and returns void.
<i>name</i>	A descriptive name for the action.
<i>day</i>	The day when the action will be executed. If negative, it will be executed every day.

The documentation for this class was generated from the following files:

- include/epiworld/globalevent-bones.hpp
- include/epiworld/globalevent-meat.hpp

15.19 epiworld::LFMCMC< TData > Class Template Reference

Likelihood-Free Markov Chain Monte Carlo.

```
#include <epiworld.hpp>
```

Public Member Functions

- void **run** (std::vector< epiworld_double > params_init_, size_t n_samples_, epiworld_double epsilon_, int seed=-1)
- **LFMCMC** (const TData &observed_data_)
- void **set_observed_data** (const TData &observed_data_)
- void **set_proposal_fun** (LFMCMCProposalFun< TData > fun)
- void **set_simulation_fun** (LFMCMCSimFun< TData > fun)
- void **set_summary_fun** (LFMCMCSummaryFun< TData > fun)
- void **set_kernel_fun** (LFMCMCKernelFun< TData > fun)
- void **set_params_names** (std::vector< std::string > names)
- void **set_stats_names** (std::vector< std::string > names)
- size_t **get_n_samples** () const
- size_t **get_n_stats** () const
- size_t **get_n_params** () const
- epiworld_double **get_epsilon** () const
- const std::vector< epiworld_double > & **get_initial_params** () const
- const std::vector< epiworld_double > & **get_current_proposed_params** () const
- const std::vector< epiworld_double > & **get_current_accepted_params** () const
- const std::vector< epiworld_double > & **get_current_proposed_stats** () const
- const std::vector< epiworld_double > & **get_current_accepted_stats** () const
- const std::vector< epiworld_double > & **get_observed_stats** () const
- const std::vector< epiworld_double > & **get_all_sample_params** () const
- const std::vector< epiworld_double > & **get_all_sample_stats** () const
- const std::vector< bool > & **get_all_sample_acceptance** () const
- const std::vector< epiworld_double > & **get_all_sample_drawn_prob** () const
- const std::vector< epiworld_double > & **get_all_sample_kernel_scores** () const
- const std::vector< epiworld_double > & **get_all_accepted_params** () const
- const std::vector< epiworld_double > & **get_all_accepted_stats** () const
- const std::vector< epiworld_double > & **get_all_accepted_kernel_scores** () const
- std::vector< TData > * **get_simulated_data** () const
- std::vector< epiworld_double > **get_mean_params** ()
- std::vector< epiworld_double > **get_mean_stats** ()
- **LFMCMC**< TData > & **verbose_off** ()
- **LFMCMC**< TData > & **verbose_on** ()
- void **print** (size_t burnin=0u) const

Random number generation

Parameters

eng	
-----	--

- void **set_rand_engine** (std::shared_ptr< std::mt19937 > &eng)
- std::shared_ptr< std::mt19937 > & **get_rand_engine** ()
- void **seed** (epiworld_fast_uint s)
- void **set_rand_gamma** (epiworld_double alpha, epiworld_double beta)
- epiworld_double **runif** ()
- epiworld_double **rnorm** ()
- epiworld_double **rgamma** ()
- epiworld_double **runif** (epiworld_double lb, epiworld_double ub)
- epiworld_double **rnorm** (epiworld_double mean, epiworld_double sd)
- epiworld_double **rgamma** (epiworld_double alpha, epiworld_double beta)

15.19.1 Detailed Description

```
template<typename TData>
class epiworld::LFMCMC< TData >
```

Likelihood-Free Markov Chain Monte Carlo.

Template Parameters

<i>TData</i>	Type of data that is generated
--------------	--------------------------------

The documentation for this class was generated from the following file:

- epiworld.hpp

15.20 LFMCMC< TData > Class Template Reference

Likelihood-Free Markov Chain Monte Carlo.

```
#include <lfmcmc-bones.hpp>
```

Public Member Functions

- void **run** (std::vector< epiworld_double > params_init_, size_t n_samples_, epiworld_double epsilon_, int seed=-1)
- **LFMCMC** (const TData &observed_data_)
- void **set_observed_data** (const TData &observed_data_)
- void **set_proposal_fun** (LFMCMCProposalFun< TData > fun)
- void **set_simulation_fun** (LFMCMCSimFun< TData > fun)
- void **set_summary_fun** (LFMCMCSummaryFun< TData > fun)
- void **set_kernel_fun** (LFMCMCKernelFun< TData > fun)
- void **set_params_names** (std::vector< std::string > names)
- void **set_stats_names** (std::vector< std::string > names)
- size_t **get_n_samples** () const

- `size_t get_n_stats () const`
- `size_t get_n_params () const`
- `epiworld_double get_epsilon () const`
- `const std::vector< epiworld_double > & get_initial_params () const`
- `const std::vector< epiworld_double > & get_current_proposed_params () const`
- `const std::vector< epiworld_double > & get_current_accepted_params () const`
- `const std::vector< epiworld_double > & get_current_proposed_stats () const`
- `const std::vector< epiworld_double > & get_current_accepted_stats () const`
- `const std::vector< epiworld_double > & get_observed_stats () const`
- `const std::vector< epiworld_double > & get_all_sample_params () const`
- `const std::vector< epiworld_double > & get_all_sample_stats () const`
- `const std::vector< bool > & get_all_sample_acceptance () const`
- `const std::vector< epiworld_double > & get_all_sample_drawn_prob () const`
- `const std::vector< epiworld_double > & get_all_sample_kernel_scores () const`
- `const std::vector< epiworld_double > & get_all_accepted_params () const`
- `const std::vector< epiworld_double > & get_all_accepted_stats () const`
- `const std::vector< epiworld_double > & get_all_accepted_kernel_scores () const`
- `std::vector< TData > * get_simulated_data () const`
- `std::vector< epiworld_double > get_mean_params ()`
- `std::vector< epiworld_double > get_mean_stats ()`
- `LFMCMC< TData > & verbose_off ()`
- `LFMCMC< TData > & verbose_on ()`
- `void print (size_t burnin=0u) const`

Random number generation

Parameters

eng	
-----	--

- `void set_rand_engine (std::shared_ptr< std::mt19937 > &eng)`
- `std::shared_ptr< std::mt19937 > & get_rand_engine ()`
- `void seed (epiworld_fast_uint s)`
- `void set_rand_gamma (epiworld_double alpha, epiworld_double beta)`
- `epiworld_double runif ()`
- `epiworld_double rnorm ()`
- `epiworld_double rgamma ()`
- `epiworld_double runif (epiworld_double lb, epiworld_double ub)`
- `epiworld_double rnorm (epiworld_double mean, epiworld_double sd)`
- `epiworld_double rgamma (epiworld_double alpha, epiworld_double beta)`

15.20.1 Detailed Description

```
template<typename TData>
class LFMCMC< TData >
```

Likelihood-Free Markov Chain Monte Carlo.

Template Parameters

<i>TData</i>	Type of data that is generated
--------------	--------------------------------

The documentation for this class was generated from the following files:

- include/epiworld/math/lfmcmc/lfmcmc-bones.hpp
- include/epiworld/math/lfmcmc/lfmcmc-meat-print.hpp
- include/epiworld/math/lfmcmc/lfmcmc-meat.hpp

15.21 epiworld::Model< TSeq > Class Template Reference

Core class of epiworld.

```
#include <epiworld.hpp>
```

Collaboration diagram for epiworld::Model< TSeq >:



Public Member Functions

- [DataBase](#)< TSeq > & **get_db** ()
- const [DataBase](#)< TSeq > & **get_db** () const
- epiworld_double & **operator()** (std::string pname)
- size_t **size** () const
- void **load_agents_entities_ties** (std::string fn, int skip)
Associate agents-entities from a file.
- void **load_agents_entities_ties** (const std::vector< int > &agents_ids, const std::vector< int > &entities_ids)
Associate agents-entities from data.
- void **load_agents_entities_ties** (const int *agents_id, const int *entities_id, size_t n)
- size_t **get_n_viruses** () const
Number of viruses in the model.
- size_t **get_n_tools** () const
Number of tools in the model.
- epiworld_fast_uint **get_ndays** () const
- epiworld_fast_uint **get_n_replicates** () const
- void **set_ndays** (epiworld_fast_uint ndays)
- bool **get_verbose** () const
- [Model](#)< TSeq > & **verbose_off** ()
- [Model](#)< TSeq > & **verbose_on** ()
- int **today** () const

The current time of the model.

- void **write_data** (std::string fn_virus_info, std::string fn_virus_hist, std::string fn_tool_info, std::string fn_tool_hist, std::string fn_total_hist, std::string fn_transmission, std::string fn_transition, std::string fn_reproductive_number, std::string fn_generation_time) const

Wrapper of DataBase::write_data

- std::map< std::string, epiworld_double > & **params** ()
- virtual void **reset** ()

Reset the model.

- const **Model**< TSeq > & **print** (bool lite=false) const
- void **get_elapsed** (std::string unit="auto", epiworld_double *last_elapsed=nullptr, epiworld_double *total_elapsed=nullptr, std::string *unit_abbr=nullptr, bool print=true) const
- void **add_globlevent** (std::function< void(**Model**< TSeq > *)> fun, std::string name="A global action", int date=-99)

Set a global action.

- void **add_globlevent** (**GlobalEvent**< TSeq > action)
- **GlobalEvent**< TSeq > & **get_globlevent** (std::string name)

Retrieve a global action by name.

- **GlobalEvent**< TSeq > & **get_globlevent** (size_t i)

Retrieve a global action by index.

- void **rm_globlevent** (std::string name)

Remove a global action by name.

- void **rm_globlevent** (size_t i)

Remove a global action by index.

- void **run_globalevents** ()
- void **clear_state_set** ()
- const std::vector< **VirusPtr**< TSeq > > & **get_viruses** () const
- const std::vector< **ToolPtr**< TSeq > > & **get_tools** () const
- **Virus**< TSeq > & **get_virus** (size_t id)
- **Tool**< TSeq > & **get_tool** (size_t id)
- void **set_agents_data** (double *data_, size_t ncols_)

Set the agents data object.

- double * **get_agents_data** ()
- size_t **get_agents_data_ncols** () const
- void **set_name** (std::string name)

Set the name object.

- std::string **get_name** () const
- bool **operator==** (const **Model**< TSeq > &other) const
- bool **operator!=** (const **Model**< TSeq > &other) const
- void **events_run** ()

Executes the stored action.

- void **draw** (const std::string &fn_output="", bool self=false)

Draws a mermaid diagram of the model.

Set the backup object

backup can be used to restore the entire object after a run. This can be useful if the user wishes to have individuals start with the same network from the beginning.

- void **set_backup** ()

Random number generation

Parameters

eng	<i>Random number generator</i>
s	<i>Seed</i>

- void **set_rand_engine** (std::shared_ptr< std::mt19937 > &eng)
- std::shared_ptr< std::mt19937 > & **get_rand_engine** ()
- void **seed** (size_t s)
- void **set_rand_norm** (epiworld_double mean, epiworld_double sd)
- void **set_rand_unif** (epiworld_double a, epiworld_double b)
- void **set_rand_exp** (epiworld_double lambda)
- void **set_rand_gamma** (epiworld_double alpha, epiworld_double beta)
- void **set_rand_lognormal** (epiworld_double mean, epiworld_double shape)
- void **set_rand_binom** (int n, epiworld_double p)
- void **set_rand_nbinom** (int n, epiworld_double p)
- void **set_rand_geom** (epiworld_double p)
- void **set_rand_pois** (epiworld_double lambda)
- epiworld_double **runif** ()
- epiworld_double **runif** (epiworld_double a, epiworld_double b)
- epiworld_double **rnorm** ()
- epiworld_double **rnorm** (epiworld_double mean, epiworld_double sd)
- epiworld_double **rgamma** ()
- epiworld_double **rgamma** (epiworld_double alpha, epiworld_double beta)
- epiworld_double **rexp** ()
- epiworld_double **rexp** (epiworld_double lambda)
- epiworld_double **rlognormal** ()
- epiworld_double **rlognormal** (epiworld_double mean, epiworld_double shape)
- int **rbinom** ()
- int **rbinom** (int n, epiworld_double p)
- int **rnbinom** ()
- int **rnbinom** (int n, epiworld_double p)
- int **rgeom** ()
- int **rgeom** (epiworld_double p)
- int **rpois** ()
- int **rpois** (epiworld_double lambda)

Add Virus/Tool to the model

This is done before the model has been initialized.

Parameters

v	<i>Virus to be added</i>
t	<i>Tool to be added</i>
preval	<i>Initial prevalence (initial state.) It can be specified as a proportion (between zero and one,) or an integer indicating number of individuals.</i>

- void **add_virus** ([Virus](#)< TSeq > &v)
- void **add_tool** ([Tool](#)< TSeq > &t)
- void **add_entity** ([Entity](#)< TSeq > e)
- void **rm_virus** (size_t virus_pos)
- void **rm_tool** (size_t tool_pos)
- void **rm_entity** (size_t entity_id)

Accessing population of the model

Parameters

fn	<i>std::string Filename of the edgelist file.</i>
skip	<i>int Number of lines to skip in fn.</i>
directed	<i>bool Whether the graph is directed or not.</i>
size	<i>Size of the network.</i>
al	<i>AdjList to read into the model.</i>

- void **agents_from_adjlist** (std::string fn, int size, int skip=0, bool directed=false)
- void **agents_from_edgelist** (const std::vector< int > &source, const std::vector< int > &target, int size, bool directed)
- void **agents_from_adjlist** ([AdjList](#) al)
- bool **is_directed** () const
- std::vector< [Agent](#)< TSeq > > &**get_agents** ()
Returns a reference to the vector of agents.
- [Agent](#)< TSeq > &**get_agent** (size_t i)
- std::vector< epiworld_fast_uint > **get_agents_states** () const
Returns a vector with the states of the agents.
- std::vector< [Viruses](#)< TSeq > > **get_agents_viruses** () const
Returns a const vector with the viruses of the agents.
- std::vector< [Viruses](#)< TSeq > > **get_agents_viruses** ()
Returns a vector with the viruses of the agents.
- std::vector< [Entity](#)< TSeq > > &**get_entities** ()
- [Entity](#)< TSeq > &**get_entity** (size_t entity_id, int *entity_pos=nullptr)
- [Model](#)< TSeq > &**agents_smallworld** (epiworld_fast_uint n=1000, epiworld_fast_uint k=5, bool d=false, epiworld_double p=.01)
- void **agents_empty_graph** (epiworld_fast_uint n=1000)

Functions to run the model*Parameters*

seed	<i>Seed to be used for Pseudo-RNG.</i>
ndays	<i>Number of days (steps) of the simulation.</i>
fun	<i>In the case of <code>run_multiple</code>, a function that is called after each experiment.</i>

- void **update_state** ()
- void **mutate_virus** ()
- void **next** ()
- virtual [Model](#)< TSeq > &**run** (epiworld_fast_uint ndays, int seed=-1)
Runs the simulation (after initialization)
- void **run_multiple** (epiworld_fast_uint ndays, epiworld_fast_uint nexperiments, int seed_=-1, std::function< void(size_t, [Model](#)< TSeq > *)> fun=make_save_run< TSeq >(), bool **reset**=true, bool verbose=true, int nthreads=1)

Rewire the network preserving the degree sequence.

This implementation assumes an undirected network, thus if $\{(i,j), (k,l)\} \rightarrow \{(i,l), (k,j)\}$, the reciprocal is also true, i.e., $\{(j,i), (l,k)\} \rightarrow \{(j,k), (l,i)\}$.

Parameters

proportion	<i>Proportion of ties to be rewired.</i>
------------	------------------------------------------

Returns

A rewired version of the network.

- void **set_rewire_fun** (std::function< void(std::vector< [Agent](#)< TSeq >> *, [Model](#)< TSeq > *, epiworld_double)> fun)
- void **set_rewire_prop** (epiworld_double prop)
- epiworld_double **get_rewire_prop** () const
- void **rewire** ()

Export the network data in edgelist form**Parameters**

fn	<i>std::string. File name.</i>
source	<i>Integer vector</i>
target	<i>Integer vector</i>

When passing the source and target, the function will write the edgelist on those.

- void **write_edgelist** (std::string fn) const
- void **write_edgelist** (std::vector< int > &source, std::vector< int > &target) const

Manage state (states) in the model

The functions `get_state` return the current values for the states included in the model.

Parameters

lab	<i>std::string Name of the state.</i>
-----	---------------------------------------

Returns

add_state returns nothing.*

get_state_ returns a vector of pairs with the states and their labels.*

- void **add_state** (std::string lab, UpdateFun< TSeq > fun=nullptr)
- const std::vector< std::string > & **get_states** () const
- const std::vector< UpdateFun< TSeq > > & **get_state_fun** () const
- void **print_state_codes** () const

Initial states

These functions are called before the simulation starts.

Parameters

proportions↔	<i>Vector of proportions for each state.</i>
—	
queue_	<i>Vector of queue for each state.</i>

- virtual [Model](#)< TSeq > & **initial_states** (std::vector< double >, std::vector< int >)

Setting and accessing parameters from the model

[Tools](#) can incorporate parameters included in the model. Internally, parameters in the tool are stored as pointers to an std::map<> of parameters in the model. Using the `epiworld_fast_uint` method directly fetches the

parameters in the order these were added to the tool. Accessing parameters via the `std::string` method involves searching the parameter directly in the `std::map<>` member of the model (so it is not recommended.)

The `par()` function members are aliases for `get_param()`.

In the case of the function `read_params`, users can pass a file listing parameters to be included in the model. Each line in the file should have the following structure:

```
[name of parameter 1]: [value in double]
[name of parameter 2]: [value in double]
...
```

The only condition for parameter names is that these do not include a colon.

Parameters

initial_val	
pname	Name of the parameter to add or to fetch
fn	Path to the file containing parameters

Returns

The current value of the parameter in the model.

- `epiworld_double` **add_param** (`epiworld_double` initial_val, `std::string` pname, `bool` overwrite=false)
- `Model< TSeq > &` **read_params** (`std::string` fn, `bool` overwrite=false)
- `epiworld_double` **get_param** (`epiworld_fast_uint` k)
- `epiworld_double` **get_param** (`std::string` pname)
- `void` **set_param** (`std::string` pname, `epiworld_double` val)
- `epiworld_double` **par** (`std::string` pname) `const`

Set the user data object

Parameters

names	string vector with the names of the variables.
-------	------------------------------------------------

- `void` **set_user_data** (`std::vector< std::string >` names)
- `[@`
- `void` **add_user_data** (`epiworld_fast_uint` j, `epiworld_double` x)
- `void` **add_user_data** (`std::vector< epiworld_double >` x)
- `UserData< TSeq > &` **get_user_data** ()

Queuing system

When queueing is on, the model will keep track of which agents are either in risk of exposure or exposed. This then is used at each step to act only on the aforementioned agents.

- `void` **queuing_on** ()
Activates the queuing system (default.)
- `Model< TSeq > &` **queuing_off** ()
Deactivates the queuing system.
- `bool` **is_queuing_on** () `const`
Query if the queuing system is on.
- `Queue< TSeq > &` **get_queue** ()
Retrieve the `Queue` object.

Get the susceptibility reduction object

Parameters

v	
---	--

Returns

epiworld_double

- void **set_susceptibility_reduction_mixer** (MixerFun< TSeq > fun)
- void **set_transmission_reduction_mixer** (MixerFun< TSeq > fun)
- void **set_recovery_enhancer_mixer** (MixerFun< TSeq > fun)
- void **set_death_reduction_mixer** (MixerFun< TSeq > fun)

Protected Member Functions

- void **dist_tools** ()
- void **dist_virus** ()
- void **dist_entities** ()
- void **chrono_start** ()
- void **chrono_end** ()
- void **events_add** (Agent< TSeq > *agent_, VirusPtr< TSeq > virus_, ToolPtr< TSeq > tool_, Entity< TSeq > *entity_, epiworld_fast_int new_state_, epiworld_fast_int queue_, EventFun< TSeq > call_, int idx_↵ agent_, int idx_object_)

Construct a new [Event](#) object.

Protected Attributes

- std::string **name** = ""
Name of the model.
- DataBase< TSeq > **db** = DataBase<TSeq>(*this)
- std::vector< Agent< TSeq > > **population** = {}
- bool **using_backup** = true
- std::vector< Agent< TSeq > > **population_backup** = {}
- bool **directed** = false
- std::vector< VirusPtr< TSeq > > **viruses** = {}
- std::vector< ToolPtr< TSeq > > **tools** = {}
- std::vector< Entity< TSeq > > **entities** = {}
- std::vector< Entity< TSeq > > **entities_backup** = {}
- std::shared_ptr< std::mt19937 > **engine** = std::make_shared< std::mt19937 >()
- std::uniform_real_distribution **runifd**
- std::normal_distribution **rnormd**
- std::gamma_distribution **rgammad**
- std::lognormal_distribution **rlognormald**
- std::exponential_distribution **rexp**
- std::binomial_distribution **rbinomd**
- std::negative_binomial_distribution **rnbinomd**
- std::geometric_distribution **rgeomd**
- std::poisson_distribution **rpoissd**
- std::function< void(std::vector< Agent< TSeq > > *, Model< TSeq > *, epiworld_double)> **rewire_fun**
- epiworld_double **rewire_prop** = 0.0
- std::map< std::string, epiworld_double > **parameters**
- epiworld_fast_uint **ndays** = 0
- [Progress](#) **pb**

- `std::vector< UpdateFun< TSeq > > state_fun = {}`
Functions to update states.
- `std::vector< std::string > states_labels = {}`
Labels of the states.
- `std::function< void(Model< TSeq > *)> initial_states_fun`
- `epiworld_fast_uint nstates = 0u`
- `bool verbose = true`
- `int current_date = 0`
- `std::chrono::time_point< std::chrono::steady_clock > time_start`
- `std::chrono::time_point< std::chrono::steady_clock > time_end`
- `std::chrono::duration< epiworld_double, std::micro > time_elapsed`
- `epiworld_fast_uint n_replicates = 0u`
- `std::vector< GlobalEvent< TSeq > > globalevents`
- `Queue< TSeq > queue`
- `bool use_queueing = true`
- `std::vector< Event< TSeq > > events = {}`
Variables used to keep track of the events to be made regarding viruses.
- `epiworld_fast_uint nactions = 0u`

Auxiliary variables for AgentsSample<TSeq> iterators

These variables+objects are used by the AgentsSample<TSeq> class for building efficient iterators over agents. The idea is to reduce the memory allocation, so only during the first call of AgentsSample<TSeq>::AgentsSample(Model<TSeq>) these vectors are allocated.

- `std::vector< Agent< TSeq > * > sampled_population`
- `size_t sampled_population_n = 0u`
- `std::vector< size_t > population_left`
- `size_t population_left_n = 0u`

Agents features

Optionally, a model can include an external data source pointing to agents information. The data can then be access through the `Agent::operator()` method.

- `double * agents_data = nullptr`
- `size_t agents_data_ncols = 0u`

Friends

- `class Agent< TSeq >`
- `class AgentsSample< TSeq >`
- `class DataBase< TSeq >`
- `class Queue< TSeq >`

Tool Mixers

These functions combine the effects tools have to deliver a single effect. For example, wearing a mask, been vaccinated, and the immune system combine together to jointly reduce the susceptibility for a given virus.

- `MixerFun< TSeq > susceptibility_reduction_mixer = susceptibility_reduction_mixer_default<TSeq>`
- `MixerFun< TSeq > transmission_reduction_mixer = transmission_reduction_mixer_default<TSeq>`
- `MixerFun< TSeq > recovery_enhancer_mixer = recovery_enhancer_mixer_default<TSeq>`

- MixerFun< TSeq > **death_reduction_mixer** = death_reduction_mixer_default<TSeq>
- std::vector< epiworld_double > **array_double_tmp**
- std::vector< [Virus](#)< TSeq > * > **array_virus_tmp**
- virtual [Model](#)< TSeq > * **clone_ptr** ()

Advanced usage: Makes a copy of data and returns it as undeleted pointer.

- **Model** ()
- **Model** (const [Model](#)< TSeq > &m)
- **Model** ([Model](#)< TSeq > &m)
- **Model** ([Model](#)< TSeq > &&m)
- [Model](#)< TSeq > & **operator=** (const [Model](#)< TSeq > &m)
- virtual ~**Model** ()

15.21.1 Detailed Description

```
template<typename TSeq>
class epiworld::Model< TSeq >
```

Core class of epiworld.

The model class provides the wrapper that puts together [Agent](#), [Virus](#), and [Tools](#).

Template Parameters

<i>TSeq</i>	Type of sequence. In principle, users can build models in which virus and human sequence is represented as numeric vectors (if needed.)
-------------	-----------------------------------------------------------------------------------------------------------------------------------------

15.21.2 Member Function Documentation

15.21.2.1 add_globalevent()

```
template<typename TSeq >
void Model< TSeq >::add_globalevent (
    std::function< void(Model< TSeq > *)> fun,
    std::string name = "A global action",
    int date = -99 ) [inline]
```

Set a global action.

Parameters

<i>fun</i>	A function to be called on the prescribed date
<i>name</i>	Name of the action.
<i>date</i>	Integer indicating when the function is called (see details)

When date is less than zero, then the function is called at the end of every day. Otherwise, the function will be called only at the end of the indicated date.

15.21.2.2 clone_ptr()

```
template<typename TSeq >
Model< TSeq > * Model< TSeq >::clone_ptr [inline], [protected], [virtual]
```

Advanced usage: Makes a copy of data and returns it as undeleted pointer.

Parameters

<i>copy</i>	
-------------	--

Reimplemented in [ModelSIRMixing< TSeq >](#), [ModelSIRLogit< TSeq >](#), [ModelSIRDCONN< TSeq >](#), [ModelSIRCONN< TSeq >](#), [ModelSEIRMixing< TSeq >](#), [ModelSEIRDCONN< TSeq >](#), [ModelSEIRCONN< TSeq >](#), [epiworld::epimodels::ModelMeaslesQuar](#), [epiworld::epimodels::ModelSIRMixing< TSeq >](#), [epiworld::epimodels::ModelSEIRMixing< TSeq >](#), [epiworld::epimodels::ModelSIRL](#), [epiworld::epimodels::ModelSEIRDCONN< TSeq >](#), [epiworld::epimodels::ModelSIRDCONN< TSeq >](#), [epiworld::epimodels::ModelS](#) and [epiworld::epimodels::ModelSIRCONN< TSeq >](#).

15.21.2.3 draw()

```
template<typename TSeq >
void Model< TSeq >::draw (
    const std::string & fn_output = "",
    bool self = false ) [inline]
```

Draws a mermaid diagram of the model.

Parameters

<i>model</i>	The model to draw.
<i>fn_output</i>	The name of the file to write the diagram. If empty, the diagram will be printed to the standard output.
<i>self</i>	Whether to allow self-transitions.

15.21.2.4 events_add()

```
template<typename TSeq >
void Model< TSeq >::events_add (
    Agent< TSeq > * agent_,
    VirusPtr< TSeq > virus_,
    ToolPtr< TSeq > tool_,
    Entity< TSeq > * entity_,
    epiworld_fast_int new_state_,
    epiworld_fast_int queue_,
    EventFun< TSeq > call_,
    int idx_agent_,
    int idx_object_ ) [inline], [protected]
```

Construct a new [Event](#) object.

Parameters

<i>agent_</i>	Agent over which the action will be called
<i>virus_</i>	Virus pointer included in the action
<i>tool_</i>	Tool pointer included in the action
<i>entity_</i>	Entity pointer included in the action
<i>new_↔ state_</i>	New state of the agent
<i>call_</i>	Function the action will call
<i>queue_</i>	Change in the queue
<i>idx_↔ agent_</i>	Location of agent in object.
<i>idx_↔ object_</i>	Location of object in agent.

15.21.2.5 events_run()

```
template<typename TSeq >
void Model< TSeq >::events_run [inline]
```

Executes the stored action.

Parameters

<i>model↔ _</i>	Model over which it will be executed.
---------------------	-------------------------------------------------------

15.21.2.6 load_agents_entities_ties()

```
template<typename TSeq >
void Model< TSeq >::load_agents_entities_ties (
    std::string fn,
    int skip ) [inline]
```

Associate agents-entities from a file.

The structure of the file should be two columns separated by space. The first column indexing between 0 and nagents-1, and the second column between 0 and nentities - 1.

Parameters

<i>fn</i>	Path to the file.
<i>skip</i>	How many rows to skip.

15.21.2.7 reset()

```
template<typename TSeq >
void Model< TSeq >::reset [inline], [virtual]
```

Reset the model.

Resetting the model will:

- clear the database
- restore the population (if `set_backup()` was called before)
- re-distribute tools
- re-distribute viruses
- set the date to 0

Reimplemented in [ModelSURV< TSeq >](#), [ModelSIRMixing< TSeq >](#), [ModelSIRLogit< TSeq >](#), [ModelSIRDCONN< TSeq >](#), [ModelSIRCONN< TSeq >](#), [ModelSEIRMixing< TSeq >](#), [ModelSEIRDCONN< TSeq >](#), [ModelSEIRCONN< TSeq >](#), [epiworld::epimodels::ModelMeaslesQuarantine< TSeq >](#), [epiworld::epimodels::ModelSIRMixing< TSeq >](#), [epiworld::epimodels::ModelSEIRMixing< TSeq >](#), [epiworld::epimodels::ModelSIRLogit< TSeq >](#), [epiworld::epimodels::ModelSEIRDCONN< TSeq >](#), [epiworld::epimodels::ModelSEIRCONN< TSeq >](#), [epiworld::epimodels::ModelSIRCONN< TSeq >](#) and [epiworld::epimodels::ModelSURV< TSeq >](#).

15.21.2.8 run_multiple()

```
template<typename TSeq >
void Model< TSeq >::run_multiple (
    epiworld_fast_uint ndays,
    epiworld_fast_uint nexperiments,
    int seed_ = -1,
    std::function< void(size_t, Model< TSeq > *)> fun = make_save_run<TSeq>(),
    bool reset = true,
    bool verbose = true,
    int nthreads = 1 ) [inline]
```

Parameters

<i>ndays</i>	Multiple runs of the simulation
--------------	---------------------------------

15.21.2.9 set_agents_data()

```
template<typename TSeq >
void Model< TSeq >::set_agents_data (
    double * data_,
    size_t ncols_ ) [inline]
```

Set the agents data object.

The data should be an array with the data stored in a column major order, i.e., by column.

Parameters

<i>data</i> ↔ —	Pointer to the first element of an array of size <code>size() * ncols_</code> .
<i>ncols</i> ↔ —	Number of features included in the data.

15.21.2.10 set_name()

```
template<typename TSeq >
void Model< TSeq >::set_name (
    std::string name ) [inline]
```

Set the name object.

Parameters

<i>name</i>	
-------------	--

15.21.2.11 write_data()

```
template<typename TSeq >
void Model< TSeq >::write_data (
    std::string fn_virus_info,
    std::string fn_virus_hist,
    std::string fn_tool_info,
    std::string fn_tool_hist,
    std::string fn_total_hist,
    std::string fn_transmission,
    std::string fn_transition,
    std::string fn_reproductive_number,
    std::string fn_generation_time ) const [inline]
```

Wrapper of `DataBase::write_data`

Parameters

<i>fn_virus_info</i>	Filename. Information about the virus.
<i>fn_virus_hist</i>	Filename. History of the virus.
<i>fn_tool_info</i>	Filename. Information about the tool.
<i>fn_tool_hist</i>	Filename. History of the tool.
<i>fn_total_hist</i>	Filename. Aggregated history (state)
<i>fn_transmission</i>	Filename. Transmission history.
<i>fn_transition</i>	Filename. Markov transition history.
<i>fn_reproductive_number</i>	Filename. Case by case reproductive number

15.21.3 Member Data Documentation

15.21.3.1 initial_states_fun

```
template<typename TSeq >
std::function<void (Model<TSeq>*)> epiworld::Model< TSeq >::initial_states_fun [protected]
```

Initial value:

```
= [] (Model<TSeq> * )
    -> void {}
```

Function to distribute states. Goes along with the function

15.21.3.2 rbinomd

```
template<typename TSeq >
std::binomial_distribution epiworld::Model< TSeq >::rbinomd [protected]
```

Initial value:

```
=
    std::binomial_distribution<>()
```

15.21.3.3 rexp

```
template<typename TSeq >
std::exponential_distribution epiworld::Model< TSeq >::rexp [protected]
```

Initial value:

```
=
    std::exponential_distribution<>()
```

15.21.3.4 rgammad

```
template<typename TSeq >
std::gamma_distribution epiworld::Model< TSeq >::rgammad [protected]
```

Initial value:

```
=
    std::gamma_distribution<>()
```

15.21.3.5 rgeomd

```
template<typename TSeq >  
std::geometric_distribution<epiworld::Model< TSeq >::rgeomd [protected]
```

Initial value:

```
=  
    std::geometric_distribution<>()
```

15.21.3.6 rlognormald

```
template<typename TSeq >  
std::lognormal_distribution<epiworld::Model< TSeq >::rlognormald [protected]
```

Initial value:

```
=  
    std::lognormal_distribution<>()
```

15.21.3.7 rnbinomd

```
template<typename TSeq >  
std::negative_binomial_distribution<epiworld::Model< TSeq >::rnbinomd [protected]
```

Initial value:

```
=  
    std::negative_binomial_distribution<>()
```

15.21.3.8 rnormd

```
template<typename TSeq >  
std::normal_distribution<epiworld::Model< TSeq >::rnormd [protected]
```

Initial value:

```
=  
    std::normal_distribution<>(0.0)
```

15.21.3.9 rpoissd

```
template<typename TSeq >  
std::poisson_distribution<epiworld::Model< TSeq >::rpoissd [protected]
```

Initial value:

```
=  
    std::poisson_distribution<>()
```

15.21.3.10 runifd

```
template<typename TSeq >
std::uniform_real_distribution<epiworld::Model< TSeq >::runifd [protected]
```

Initial value:

```
=
    std::uniform_real_distribution<> (0.0, 1.0)
```

15.21.3.11 time_elapsed

```
template<typename TSeq >
std::chrono::duration<epiworld_double, std::micro> epiworld::Model< TSeq >::time_elapsed [protected]
```

Initial value:

```
=
    std::chrono::duration<epiworld_double, std::micro>::zero()
```

The documentation for this class was generated from the following file:

- epiworld.hpp

15.22 Model< TSeq > Class Template Reference

Core class of epiworld.

```
#include <model-bones.hpp>
```

Inheritance diagram for Model< TSeq >:



Collaboration diagram for Model< TSeq >:



Public Member Functions

- [DataBase](#)< TSeq > & **get_db** ()
- const [DataBase](#)< TSeq > & **get_db** () const
- epiworld_double & **operator()** (std::string pname)
- size_t **size** () const
- void [load_agents_entities_ties](#) (std::string fn, int skip)
 - Associate agents-entities from a file.*
- void [load_agents_entities_ties](#) (const std::vector< int > &agents_ids, const std::vector< int > &entities_ids)
 - Associate agents-entities from data.*
- void **load_agents_entities_ties** (const int *agents_id, const int *entities_id, size_t n)
- size_t [get_n_viruses](#) () const
 - Number of viruses in the model.*
- size_t [get_n_tools](#) () const
 - Number of tools in the model.*
- epiworld_fast_uint **get_ndays** () const
- epiworld_fast_uint **get_n_replicates** () const
- void **set_ndays** (epiworld_fast_uint ndays)
- bool **get_verbose** () const
- [Model](#)< TSeq > & **verbose_off** ()
- [Model](#)< TSeq > & **verbose_on** ()
- int [today](#) () const
 - The current time of the model.*
- void [write_data](#) (std::string fn_virus_info, std::string fn_virus_hist, std::string fn_tool_info, std::string fn_tool_hist, std::string fn_total_hist, std::string fn_transmission, std::string fn_transition, std::string fn_reproductive_number, std::string fn_generation_time) const
 - Wrapper of DataBase::write_data*
- std::map< std::string, epiworld_double > & **params** ()
- virtual void [reset](#) ()
 - Reset the model.*
- const [Model](#)< TSeq > & **print** (bool lite=false) const
- void **get_elapsed** (std::string unit="auto", epiworld_double *last_elapsed=nullptr, epiworld_double *total_elapsed=nullptr, std::string *unit_abbr=nullptr, bool print=true) const
- void [add_globlevent](#) (std::function< void([Model](#)< TSeq > *)> fun, std::string name="A global action", int date=-99)
 - Set a global action.*

- void **add_globlevent** (GlobalEvent< TSeq > action)
- GlobalEvent< TSeq > & **get_globlevent** (std::string name)
Retrieve a global action by name.
- GlobalEvent< TSeq > & **get_globlevent** (size_t i)
Retrieve a global action by index.
- void **rm_globlevent** (std::string name)
Remove a global action by name.
- void **rm_globlevent** (size_t i)
Remove a global action by index.
- void **run_globlevents** ()
- void **clear_state_set** ()
- const std::vector< VirusPtr< TSeq > > & **get_viruses** () const
- const std::vector< ToolPtr< TSeq > > & **get_tools** () const
- Virus< TSeq > & **get_virus** (size_t id)
- Tool< TSeq > & **get_tool** (size_t id)
- void **set_agents_data** (double *data_, size_t ncols_)
Set the agents data object.
- double * **get_agents_data** ()
- size_t **get_agents_data_ncols** () const
- void **set_name** (std::string name)
Set the name object.
- std::string **get_name** () const
- bool **operator==** (const Model< TSeq > &other) const
- bool **operator!=** (const Model< TSeq > &other) const
- void **events_run** ()
Executes the stored action.
- void **draw** (const std::string &fn_output="", bool self=false)
Draws a mermaid diagram of the model.

Set the backup object

backup can be used to restore the entire object after a run. This can be useful if the user wishes to have individuals start with the same network from the beginning.

- void **set_backup** ()

Random number generation

Parameters

eng	Random number generator
s	Seed

- void **set_rand_engine** (std::shared_ptr< std::mt19937 > &eng)
- std::shared_ptr< std::mt19937 > & **get_rand_engine** ()
- void **seed** (size_t s)
- void **set_rand_norm** (epiworld_double mean, epiworld_double sd)
- void **set_rand_unif** (epiworld_double a, epiworld_double b)
- void **set_rand_exp** (epiworld_double lambda)
- void **set_rand_gamma** (epiworld_double alpha, epiworld_double beta)
- void **set_rand_lognormal** (epiworld_double mean, epiworld_double shape)
- void **set_rand_binom** (int n, epiworld_double p)
- void **set_rand_nbinom** (int n, epiworld_double p)
- void **set_rand_geom** (epiworld_double p)

- void **set_rand_pois** (epiworld_double lambda)
- epiworld_double **runif** ()
- epiworld_double **runif** (epiworld_double a, epiworld_double b)
- epiworld_double **rnorm** ()
- epiworld_double **rnorm** (epiworld_double mean, epiworld_double sd)
- epiworld_double **rgamma** ()
- epiworld_double **rgamma** (epiworld_double alpha, epiworld_double beta)
- epiworld_double **rexp** ()
- epiworld_double **rexp** (epiworld_double lambda)
- epiworld_double **rlognormal** ()
- epiworld_double **rlognormal** (epiworld_double mean, epiworld_double shape)
- int **rbinom** ()
- int **rbinom** (int n, epiworld_double p)
- int **rnbinom** ()
- int **rnbinom** (int n, epiworld_double p)
- int **rgeom** ()
- int **rgeom** (epiworld_double p)
- int **rpoiss** ()
- int **rpoiss** (epiworld_double lambda)

Add Virus/Tool to the model

This is done before the model has been initialized.

Parameters

v	Virus to be added
t	Tool to be added
preval	Initial prevalence (initial state.) It can be specified as a proportion (between zero and one,) or an integer indicating number of individuals.

- void **add_virus** ([Virus](#)< TSeq > &v)
- void **add_tool** ([Tool](#)< TSeq > &t)
- void **add_entity** ([Entity](#)< TSeq > e)
- void **rm_virus** (size_t virus_pos)
- void **rm_tool** (size_t tool_pos)
- void **rm_entity** (size_t entity_id)

Accessing population of the model

Parameters

fn	<i>std::string</i> Filename of the edgelist file.
skip	<i>int</i> Number of lines to skip in <i>fn</i> .
directed	<i>bool</i> Whether the graph is directed or not.
size	<i>Size of the network.</i>
al	AdjList to read into the model.

- void **agents_from_adjlist** (std::string fn, int size, int skip=0, bool directed=false)
- void **agents_from_edgelist** (const std::vector< int > &source, const std::vector< int > &target, int size, bool directed)
- void **agents_from_adjlist** ([AdjList](#) al)
- bool **is_directed** () const
- std::vector< [Agent](#)< TSeq > > &**get_agents** ()
Returns a reference to the vector of agents.
- [Agent](#)< TSeq > &**get_agent** (size_t i)
- std::vector< epiworld_fast_uint > **get_agents_states** () const

- Returns a vector with the states of the agents.*
- std::vector< [Viruses_const](#)< TSeq > > [get_agents_viruses](#) () const
Returns a const vector with the viruses of the agents.
- std::vector< [Viruses](#)< TSeq > > [get_agents_viruses](#) ()
Returns a vector with the viruses of the agents.
- std::vector< [Entity](#)< TSeq > > & [get_entities](#) ()
- [Entity](#)< TSeq > & [get_entity](#) (size_t entity_id, int *entity_pos=nullptr)
- [Model](#)< TSeq > & [agents_smallworld](#) (epiworld_fast_uint n=1000, epiworld_fast_uint k=5, bool d=false, epiworld_double p=.01)
- void [agents_empty_graph](#) (epiworld_fast_uint n=1000)

Functions to run the model

Parameters

seed	<i>Seed to be used for Pseudo-RNG.</i>
ndays	<i>Number of days (steps) of the simulation.</i>
fun	<i>In the case of <code>run_multiple</code>, a function that is called after each experiment.</i>

- void [update_state](#) ()
- void [mutate_virus](#) ()
- void [next](#) ()
- virtual [Model](#)< TSeq > & [run](#) (epiworld_fast_uint ndays, int seed=-1)
Runs the simulation (after initialization)
- void [run_multiple](#) (epiworld_fast_uint ndays, epiworld_fast_uint nexperiments, int seed_=-1, std::function< void(size_t, [Model](#)< TSeq > *)> fun=make_save_run< TSeq >(), bool [reset](#)=true, bool verbose=true, int nthreads=1)

Rewire the network preserving the degree sequence.

This implementation assumes an undirected network, thus if $\{(i,j), (k,l)\} \rightarrow \{(i,l), (k,j)\}$, the reciprocal is also true, i.e., $\{(j,i), (l,k)\} \rightarrow \{(j,k), (l,i)\}$.

Parameters

proportion	<i>Proportion of ties to be rewired.</i>
------------	------------------------------------------

Returns

A rewired version of the network.

- void [set_rewire_fun](#) (std::function< void(std::vector< [Agent](#)< TSeq > > *, [Model](#)< TSeq > *, epiworld_double)> fun)
- void [set_rewire_prop](#) (epiworld_double prop)
- epiworld_double [get_rewire_prop](#) () const
- void [rewire](#) ()

Export the network data in edgelist form

Parameters

fn	<i>std::string. File name.</i>
source	<i>Integer vector</i>
target	<i>Integer vector</i>

When passing the source and target, the function will write the edgelist on those.

- void **write_edgelist** (std::string fn) const
- void **write_edgelist** (std::vector< int > &source, std::vector< int > &target) const

Manage state (states) in the model

The functions `get_state` return the current values for the states included in the model.

Parameters

lab	<code>std::string</code> Name of the state.
-----	---------------------------------------------

Returns

`add_state*` returns nothing.

`get_state_*` returns a vector of pairs with the states and their labels.

- void **add_state** (std::string lab, UpdateFun< TSeq > fun=nullptr)
- const std::vector< std::string > & **get_states** () const
- const std::vector< UpdateFun< TSeq > > & **get_state_fun** () const
- void **print_state_codes** () const

Initial states

These functions are called before the simulation starts.

Parameters

proportions↔	Vector of proportions for each state.
—	
queue_	Vector of queue for each state.

- virtual [Model](#)< TSeq > & **initial_states** (std::vector< double >, std::vector< int >)

Setting and accessing parameters from the model

[Tools](#) can incorporate parameters included in the model. Internally, parameters in the tool are stored as pointers to an `std::map<>` of parameters in the model. Using the `epiworld_fast_uint` method directly fetches the parameters in the order these were added to the tool. Accessing parameters via the `std::string` method involves searching the parameter directly in the `std::map<>` member of the model (so it is not recommended.)

The `par()` function members are aliases for `get_param()`.

In the case of the function `read_params`, users can pass a file listing parameters to be included in the model.

Each line in the file should have the following structure:

```
[name of parameter 1]: [value in double]
[name of parameter 2]: [value in double]
...
```

The only condition for parameter names is that these do not include a colon.

Parameters

initial_val	
pname	Name of the parameter to add or to fetch
fn	Path to the file containing parameters

Returns

The current value of the parameter in the model.

- `epiworld_double` **add_param** (`epiworld_double` initial_val, `std::string` pname, `bool` overwrite=false)
- `Model< TSeq >` & **read_params** (`std::string` fn, `bool` overwrite=false)
- `epiworld_double` **get_param** (`epiworld_fast_uint` k)
- `epiworld_double` **get_param** (`std::string` pname)
- `void` **set_param** (`std::string` pname, `epiworld_double` val)
- `epiworld_double` **par** (`std::string` pname) `const`

Set the user data object**Parameters**

names	<i>string vector with the names of the variables.</i>
-------	-------------------------------------------------------

- `void` **set_user_data** (`std::vector< std::string >` names)
- `void` **add_user_data** (`epiworld_fast_uint` j, `epiworld_double` x)
- `void` **add_user_data** (`std::vector< epiworld_double >` x)
- `UserData< TSeq >` & **get_user_data** ()

Queuing system

When queueing is on, the model will keep track of which agents are either in risk of exposure or exposed. This then is used at each step to act only on the aforementioned agents.

- `void` **queueing_on** ()
Activates the queueing system (default.)
- `Model< TSeq >` & **queueing_off** ()
Deactivates the queueing system.
- `bool` **is_queueing_on** () `const`
Query if the queueing system is on.
- `Queue< TSeq >` & **get_queue** ()
Retrieve the `Queue` object.

Get the susceptibility reduction object**Parameters**

v	
---	--

Returns

epiworld_double

- `void` **set_susceptibility_reduction_mixer** (`MixerFun< TSeq >` fun)
- `void` **set_transmission_reduction_mixer** (`MixerFun< TSeq >` fun)
- `void` **set_recovery_enhancer_mixer** (`MixerFun< TSeq >` fun)
- `void` **set_death_reduction_mixer** (`MixerFun< TSeq >` fun)

Protected Member Functions

- `void` **dist_tools** ()
- `void` **dist_virus** ()

- void **dist_entities** ()
- void **chrono_start** ()
- void **chrono_end** ()
- void **events_add** ([Agent](#)< TSeq > *agent_, [VirusPtr](#)< TSeq > virus_, [ToolPtr](#)< TSeq > tool_, [Entity](#)< TSeq > *entity_, [epiworld_fast_int](#) new_state_, [epiworld_fast_int](#) queue_, [EventFun](#)< TSeq > call_, [int](#) idx_↵ agent_, [int](#) idx_object_)

Construct a new [Event](#) object.

Protected Attributes

- [std::string](#) **name** = ""
Name of the model.
- [DataBase](#)< TSeq > **db** = [DataBase](#)<TSeq>(*this)
- [std::vector](#)< [Agent](#)< TSeq > > **population** = {}
- bool **using_backup** = true
- [std::vector](#)< [Agent](#)< TSeq > > **population_backup** = {}
- bool **directed** = false
- [std::vector](#)< [VirusPtr](#)< TSeq > > **viruses** = {}
- [std::vector](#)< [ToolPtr](#)< TSeq > > **tools** = {}
- [std::vector](#)< [Entity](#)< TSeq > > **entities** = {}
- [std::vector](#)< [Entity](#)< TSeq > > **entities_backup** = {}
- [std::shared_ptr](#)< [std::mt19937](#) > **engine** = [std::make_shared](#)< [std::mt19937](#) >()
- [std::uniform_real_distribution](#) **runifd**
- [std::normal_distribution](#) **rnormd**
- [std::gamma_distribution](#) **rgammad**
- [std::lognormal_distribution](#) **rlognormald**
- [std::exponential_distribution](#) **rexp**
- [std::binomial_distribution](#) **rbinomd**
- [std::negative_binomial_distribution](#) **rnbinomd**
- [std::geometric_distribution](#) **rgeomd**
- [std::poisson_distribution](#) **rpoissd**
- [std::function](#)< void([std::vector](#)< [Agent](#)< TSeq > > *, [Model](#)< TSeq > *, [epiworld_double](#))> **rewire_fun**
- [epiworld_double](#) **rewire_prop** = 0.0
- [std::map](#)< [std::string](#), [epiworld_double](#) > **parameters**
- [epiworld_fast_uint](#) **ndays** = 0
- [Progress](#) **pb**
- [std::vector](#)< [UpdateFun](#)< TSeq > > **state_fun** = {}
Functions to update states.
- [std::vector](#)< [std::string](#) > **states_labels** = {}
Labels of the states.
- [std::function](#)< void([Model](#)< TSeq > *)> **initial_states_fun**
- [epiworld_fast_uint](#) **nstates** = 0u
- bool **verbose** = true
- [int](#) **current_date** = 0
- [std::chrono::time_point](#)< [std::chrono::steady_clock](#) > **time_start**
- [std::chrono::time_point](#)< [std::chrono::steady_clock](#) > **time_end**
- [std::chrono::duration](#)< [epiworld_double](#), [std::micro](#) > **time_elapsed**
- [epiworld_fast_uint](#) **n_replicates** = 0u
- [std::vector](#)< [GlobalEvent](#)< TSeq > > **globalevents**
- [Queue](#)< TSeq > **queue**
- bool **use_queuing** = true
- [std::vector](#)< [Event](#)< TSeq > > **events** = {}
Variables used to keep track of the events to be made regarding viruses.

- `epiworld_fast_uint nactions = 0u`

Auxiliary variables for AgentsSample<TSeq> iterators

These variables+objects are used by the `AgentsSample<TSeq>` class for building efficient iterators over agents. The idea is to reduce the memory allocation, so only during the first call of `AgentsSample<TSeq>::AgentsSample(Model<TSeq>)` these vectors are allocated.

- `std::vector< Agent< TSeq > * > sampled_population`
- `size_t sampled_population_n = 0u`
- `std::vector< size_t > population_left`
- `size_t population_left_n = 0u`

Agents features

Optionally, a model can include an external data source pointing to agents information. The data can then be access through the `Agent::operator()` method.

- `double * agents_data = nullptr`
- `size_t agents_data_ncols = 0u`

Friends

- `class Agent< TSeq >`
- `class AgentsSample< TSeq >`
- `class DataBase< TSeq >`
- `class Queue< TSeq >`

Tool Mixers

These functions combine the effects tools have to deliver a single effect. For example, wearing a mask, been vaccinated, and the immune system combine together to jointly reduce the susceptibility for a given virus.

- `MixerFun< TSeq > susceptibility_reduction_mixer = susceptibility_reduction_mixer_default<TSeq>`
- `MixerFun< TSeq > transmission_reduction_mixer = transmission_reduction_mixer_default<TSeq>`
- `MixerFun< TSeq > recovery_enhancer_mixer = recovery_enhancer_mixer_default<TSeq>`
- `MixerFun< TSeq > death_reduction_mixer = death_reduction_mixer_default<TSeq>`
- `std::vector< epiworld_double > array_double_tmp`
- `std::vector< Virus< TSeq > * > array_virus_tmp`
- `virtual Model< TSeq > * clone_ptr ()`

Advanced usage: Makes a copy of data and returns it as undeleted pointer.

- `Model ()`
- `Model (const Model< TSeq > &m)`
- `Model (Model< TSeq > &m)`
- `Model (Model< TSeq > &&m)`
- `Model< TSeq > & operator= (const Model< TSeq > &m)`
- `virtual ~Model ()`

15.22.1 Detailed Description

```
template<typename TSeq>
class Model< TSeq >
```

Core class of epiworld.

The model class provides the wrapper that puts together `Agent`, `Virus`, and `Tools`.

Template Parameters

<i>TSeq</i>	Type of sequence. In principle, users can build models in which virus and human sequence is represented as numeric vectors (if needed.)
-------------	-----------------------------------------------------------------------------------------------------------------------------------------

15.22.2 Member Function Documentation

15.22.2.1 add_globalevent()

```
template<typename TSeq >
void Model< TSeq >::add_globalevent (
    std::function< void(Model< TSeq > *)> fun,
    std::string name = "A global action",
    int date = -99 ) [inline]
```

Set a global action.

Parameters

<i>fun</i>	A function to be called on the prescribed date
<i>name</i>	Name of the action.
<i>date</i>	Integer indicating when the function is called (see details)

When date is less than zero, then the function is called at the end of every day. Otherwise, the function will be called only at the end of the indicated date.

15.22.2.2 clone_ptr()

```
template<typename TSeq >
Model< TSeq > * Model< TSeq >::clone_ptr [inline], [protected], [virtual]
```

Advanced usage: Makes a copy of data and returns it as undeleted pointer.

Parameters

<i>copy</i>	
-------------	--

Reimplemented in [ModelMeaslesQuarantine< TSeq >](#).

15.22.2.3 draw()

```
template<typename TSeq >
void Model< TSeq >::draw (
```



```
const std::string & fn_output = "",
bool self = false ) [inline]
```

Draws a mermaid diagram of the model.

Parameters

<i>model</i>	The model to draw.
<i>fn_output</i>	The name of the file to write the diagram. If empty, the diagram will be printed to the standard output.
<i>self</i>	Whether to allow self-transitions.

15.22.2.4 events_add()

```
template<typename TSeq >
void Model< TSeq >::events_add (
    Agent< TSeq > * agent_,
    VirusPtr< TSeq > virus_,
    ToolPtr< TSeq > tool_,
    Entity< TSeq > * entity_,
    epiworld_fast_int new_state_,
    epiworld_fast_int queue_,
    EventFun< TSeq > call_,
    int idx_agent_,
    int idx_object_ ) [inline], [protected]
```

Construct a new [Event](#) object.

Parameters

<i>agent_</i>	Agent over which the action will be called
<i>virus_</i>	Virus pointer included in the action
<i>tool_</i>	Tool pointer included in the action
<i>entity_</i>	Entity pointer included in the action
<i>new_↔ state_</i>	New state of the agent
<i>call_</i>	Function the action will call
<i>queue_</i>	Change in the queue
<i>idx_↔ agent_</i>	Location of agent in object.
<i>idx_↔ object_</i>	Location of object in agent.

15.22.2.5 events_run()

```
template<typename TSeq >
void Model< TSeq >::events_run [inline]
```

Executes the stored action.

Parameters

<i>model</i> ↔	Model over which it will be executed.
—	

15.22.2.6 load_agents_entities_ties()

```
template<typename TSeq >
void Model< TSeq >::load_agents_entities_ties (
    std::string fn,
    int skip ) [inline]
```

Associate agents-entities from a file.

The structure of the file should be two columns separated by space. The first column indexing between 0 and nagents-1, and the second column between 0 and nentities - 1.

Parameters

<i>fn</i>	Path to the file.
<i>skip</i>	How many rows to skip.

15.22.2.7 reset()

```
template<typename TSeq >
void Model< TSeq >::reset [inline], [virtual]
```

Reset the model.

Resetting the model will:

- clear the database
- restore the population (if `set_backup()` was called before)
- re-distribute tools
- re-distribute viruses
- set the date to 0

Reimplemented in [ModelMeaslesQuarantine< TSeq >](#).

15.22.2.8 run_multiple()

```
template<typename TSeq >
void Model< TSeq >::run_multiple (
    epiworld_fast_uint ndays,
    epiworld_fast_uint nexperiments,
    int seed_ = -1,
    std::function< void(size_t, Model< TSeq > *)> fun = make_save_run<TSeq>(),
    bool reset = true,
    bool verbose = true,
    int nthreads = 1 ) [inline]
```

Parameters

<i>ndays</i>	Multiple runs of the simulation
--------------	---------------------------------

15.22.2.9 set_agents_data()

```
template<typename TSeq >
void Model< TSeq >::set_agents_data (
    double * data_,
    size_t ncols_ ) [inline]
```

Set the agents data object.

The data should be an array with the data stored in a column major order, i.e., by column.

Parameters

<i>data</i> ↔ —	Pointer to the first element of an array of size <code>size() * ncols_</code> .
<i>ncols</i> ↔ —	Number of features included in the data.

15.22.2.10 set_name()

```
template<typename TSeq >
void Model< TSeq >::set_name (
    std::string name ) [inline]
```

Set the name object.

Parameters

<i>name</i>	
-------------	--

15.22.2.11 write_data()

```
template<typename TSeq >
void Model< TSeq >::write_data (
    std::string fn_virus_info,
    std::string fn_virus_hist,
    std::string fn_tool_info,
    std::string fn_tool_hist,
    std::string fn_total_hist,
    std::string fn_transmission,
    std::string fn_transition,
    std::string fn_reproductive_number,
    std::string fn_generation_time ) const [inline]
```

Wrapper of DataBase::write_data

Parameters

<i>fn_virus_info</i>	Filename. Information about the virus.
<i>fn_virus_hist</i>	Filename. History of the virus.
<i>fn_tool_info</i>	Filename. Information about the tool.
<i>fn_tool_hist</i>	Filename. History of the tool.
<i>fn_total_hist</i>	Filename. Aggregated history (state)
<i>fn_transmission</i>	Filename. Transmission history.
<i>fn_transition</i>	Filename. Markov transition history.
<i>fn_reproductive_number</i>	Filename. Case by case reproductive number

15.22.3 Member Data Documentation

15.22.3.1 initial_states_fun

```
template<typename TSeq >
std::function<void (Model<TSeq>*)> Model< TSeq >::initial_states_fun [protected]
```

Initial value:

```
= [] (Model<TSeq> * )
    -> void {}
```

Function to distribute states. Goes along with the function

15.22.3.2 rbinomd

```
template<typename TSeq >
std::binomial_distribution Model< TSeq >::rbinomd [protected]
```

Initial value:

```
=
    std::binomial_distribution<>()
```

15.22.3.3 rexp

```
template<typename TSeq >
std::exponential_distribution Model< TSeq >::rexp [protected]
```

Initial value:

```
=
    std::exponential_distribution<>()
```

15.22.3.4 rgammad

```
template<typename TSeq >
std::gamma_distribution Model< TSeq >::rgammad [protected]
```

Initial value:

```
=
    std::gamma_distribution<>()
```

15.22.3.5 rgeomd

```
template<typename TSeq >
std::geometric_distribution Model< TSeq >::rgeomd [protected]
```

Initial value:

```
=
    std::geometric_distribution<>()
```

15.22.3.6 rlognormald

```
template<typename TSeq >
std::lognormal_distribution Model< TSeq >::rlognormald [protected]
```

Initial value:

```
=
    std::lognormal_distribution<>()
```

15.22.3.7 rnbinomd

```
template<typename TSeq >
std::negative_binomial_distribution Model< TSeq >::rnbinomd [protected]
```

Initial value:

```
=
    std::negative_binomial_distribution<>()
```

15.22.3.8 rnormd

```
template<typename TSeq >
std::normal_distribution Model< TSeq >::rnormd [protected]
```

Initial value:

```
=
    std::normal_distribution<>(0.0)
```

15.22.3.9 rpoissd

```
template<typename TSeq >
std::poisson_distribution Model< TSeq >::rpoissd [protected]
```

Initial value:

```
=
    std::poisson_distribution<>()
```

15.22.3.10 runifd

```
template<typename TSeq >
std::uniform_real_distribution Model< TSeq >::runifd [protected]
```

Initial value:

```
=
    std::uniform_real_distribution<>(0.0, 1.0)
```

15.22.3.11 time_elapsed

```
template<typename TSeq >
std::chrono::duration<epiworld_double, std::micro> Model< TSeq >::time_elapsed [protected]
```

Initial value:

```
=
    std::chrono::duration<epiworld_double, std::micro>::zero()
```

The documentation for this class was generated from the following files:

- include/epiworld/agent-bones.hpp
- include/epiworld/model-bones.hpp
- include/epiworld/model-meat-print.hpp
- include/epiworld/model-meat.hpp

15.23 epiworld::ModelDiagram Class Reference

Public Member Functions

- void **draw_from_data** (const std::vector< std::string > &states, const std::vector< epiworld_double > &tprob, const std::string &fn_output="", bool self=false)
- void **draw_from_file** (const std::string &fn_transition, const std::string &fn_output="", bool self=false)
- void **draw_from_files** (const std::vector< std::string > &fns_transition, const std::string &fn_output="", bool self=false)

The documentation for this class was generated from the following file:

- epiworld.hpp

15.24 ModelDiagram Class Reference

Public Member Functions

- void **draw_from_data** (const std::vector< std::string > &states, const std::vector< epiworld_double > &tprob, const std::string &fn_output="", bool self=false)
- void **draw_from_file** (const std::string &fn_transition, const std::string &fn_output="", bool self=false)
- void **draw_from_files** (const std::vector< std::string > &fns_transition, const std::string &fn_output="", bool self=false)

The documentation for this class was generated from the following files:

- include/epiworld/modeldiagram-bones.hpp
- include/epiworld/modeldiagram-meat.hpp

15.25 epiworld::epimodels::ModelDiffNet< TSeq > Class Template Reference

Template for a [Network](#) Diffusion [Model](#).

```
#include <epiworld.hpp>
```

Inheritance diagram for epiworld::epimodels::ModelDiffNet< TSeq >:



Collaboration diagram for `epiworld::epimodels::ModelDiffNet< TSeq >`:



Public Member Functions

- **ModelDiffNet** ([ModelDiffNet](#)< TSeq > &model, const std::string &innovation_name, epiworld_double prevalence, epiworld_double prob_adopt, bool normalize_exposure=true, double *agents_data=nullptr, size_t data_ncols=0u, std::vector< size_t > data_cols={}, std::vector< double > params={})
- **ModelDiffNet** (const std::string &innovation_name, epiworld_double prevalence, epiworld_double prob_adopt, bool normalize_exposure=true, double *agents_data=nullptr, size_t data_ncols=0u, std::vector< size_t > data_cols={}, std::vector< double > params={})

Public Attributes

- bool **normalize_exposure** = true
- std::vector< size_t > **data_cols**
- std::vector< double > **params**

Static Public Attributes

- static const int **NONADOPTER** = 0
- static const int **ADOPTER** = 1

Additional Inherited Members

15.25.1 Detailed Description

```
template<typename TSeq = EPI_DEFAULT_TSEQ>
class epiworld::epimodels::ModelDiffNet< TSeq >
```

Template for a [Network](#) Diffusion [Model](#).

Parameters

<i>model</i>	A Model<TSeq> object where to set up the SIR.
<i>vname</i>	std::string Name of the virus
<i>initial_prevalence</i>	epiworld_double Initial prevalence
<i>initial_efficacy</i>	epiworld_double Initial susceptibility_reduction of the immune system
<i>initial_recovery</i>	epiworld_double Initial recovery rate of the immune system

The documentation for this class was generated from the following file:

- epiworld.hpp

15.26 ModelDiffNet< TSeq > Class Template Reference

Template for a [Network](#) Diffusion [Model](#).

```
#include <diffnet.hpp>
```

Inheritance diagram for ModelDiffNet< TSeq >:



Collaboration diagram for ModelDiffNet< TSeq >:



Public Member Functions

- **ModelDiffNet** ([ModelDiffNet](#)< TSeq > &model, const std::string &innovation_name, epiworld_double prevalence, epiworld_double prob_adopt, bool normalize_exposure=true, double *agents_data=nullptr, size_t data_ncols=0u, std::vector< size_t > data_cols={}, std::vector< double > params={})
- **ModelDiffNet** (const std::string &innovation_name, epiworld_double prevalence, epiworld_double prob_adopt, bool normalize_exposure=true, double *agents_data=nullptr, size_t data_ncols=0u, std::vector< size_t > data_cols={}, std::vector< double > params={})

Public Attributes

- bool **normalize_exposure** = true
- std::vector< size_t > **data_cols**
- std::vector< double > **params**

Static Public Attributes

- static const int **NONADOPTER** = 0
- static const int **ADOPTER** = 1

Additional Inherited Members

15.26.1 Detailed Description

```
template<typename TSeq = EPI_DEFAULT_TSEQ>
class ModelDiffNet< TSeq >
```

Template for a [Network](#) Diffusion [Model](#).

Parameters

<i>model</i>	A Model<TSeq> object where to set up the SIR.
<i>vname</i>	std::string Name of the virus
<i>initial_prevalence</i>	epiworld_double Initial prevalence
<i>initial_efficiency</i>	epiworld_double Initial susceptibility_reduction of the immune system
<i>initial_recovery</i>	epiworld_double Initial recovery rate of the immune system

The documentation for this class was generated from the following file:

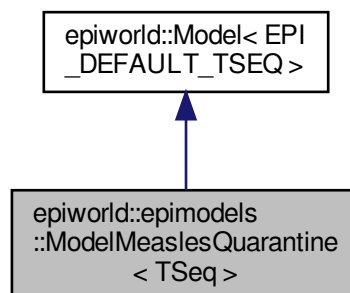
- include/epiworld/models/diffnet.hpp

15.27 epiworld::epimodels::ModelMeaslesQuarantine< TSeq > Class Template Reference

Template for a Measles model with quarantine.

```
#include <epiworld.hpp>
```

Inheritance diagram for epiworld::epimodels::ModelMeaslesQuarantine< TSeq >:



Collaboration diagram for epiworld::epimodels::ModelMeaslesQuarantine< TSeq >:



Public Member Functions

- void [quarantine_agents](#) ()
Quarantine agents that are in the system.
- void [reset](#) ()
Reset the model.
- void [update_infectious](#) ()
- [Model](#)< TSeq > * [clone_ptr](#) ()
Advanced usage: Makes a copy of data and returns it as undeleted pointer.

- [ModelMeaslesQuarantine](#) ([ModelMeaslesQuarantine](#)< TSeq > &model, `epiworld_fast_uint n`, `epiworld_fast_uint n_exposed`, `epiworld_double contact_rate`, `epiworld_double transmission_rate`, `epiworld_double vax_efficacy`, `epiworld_double vax_reduction_recovery_rate`, `epiworld_double incubation_period`, `epiworld_double prodromal_period`, `epiworld_double rash_period`, `epiworld_double days_undetected`, `epiworld_double hospitalization_rate`, `epiworld_double hospitalization_period`, `epiworld_double prop_vaccinated`, `epiworld_fast_int quarantine_period`, `epiworld_double quarantine_willingness`, `epiworld_fast_int isolation_period`)
- **ModelMeaslesQuarantine** (`epiworld_fast_uint n`, `epiworld_fast_uint n_exposed`, `epiworld_double contact_rate`, `epiworld_double transmission_rate`, `epiworld_double vax_efficacy`, `epiworld_double vax_reduction_recovery_rate`, `epiworld_double incubation_period`, `epiworld_double prodromal_period`, `epiworld_double rash_period`, `epiworld_double days_undetected`, `epiworld_double hospitalization_rate`, `epiworld_double hospitalization_period`, `epiworld_double prop_vaccinated`, `epiworld_fast_int quarantine_period`, `epiworld_double quarantine_willingness`, `epiworld_fast_int isolation_period`)

Public Attributes

- `std::vector< Agent< TSeq > * > infectious`
Agents infectious for contact.
- `bool system_quarantine_triggered = false`
- `std::vector< int > day_flagged`
Either detected or started quarantine.
- `std::vector< int > day_rash_onset`
Day of rash onset.

Static Public Attributes

- `static const epiworld_fast_uint SUSCEPTIBLE = 0u`
- `static const epiworld_fast_uint EXPOSED = 1u`
- `static const epiworld_fast_uint PRODROMAL = 2u`
- `static const epiworld_fast_uint RASH = 3u`
- `static const epiworld_fast_uint ISOLATED = 4u`
- `static const epiworld_fast_uint ISOLATED_RECOVERED = 5u`
- `static const epiworld_fast_uint DETECTED_HOSPITALIZED = 6u`
- `static const epiworld_fast_uint QUARANTINED_EXPOSED = 7u`
- `static const epiworld_fast_uint QUARANTINED_SUSCEPTIBLE = 8u`
- `static const epiworld_fast_uint QUARANTINED_PRODROMAL = 9u`
- `static const epiworld_fast_uint QUARANTINED_RECOVERED = 10u`
- `static const epiworld_fast_uint HOSPITALIZED = 11u`
- `static const epiworld_fast_uint RECOVERED = 12u`

Additional Inherited Members

15.27.1 Detailed Description

```
template<typename TSeq = EPI_DEFAULT_TSEQ>
class epiworld::epimodels::ModelMeaslesQuarantine< TSeq >
```

Template for a Measles model with quarantine.

Parameters

<i>TSeq</i>	The type of the sequence to be used.
-------------	--------------------------------------

This model can be described as a SEIHR model with isolation and quarantine. The infectious state is divided into prodromal and rash phases. Furthermore, the quarantine state includes exposed, susceptible, prodromal, and recovered states.

The quarantine process is triggered any time that an agent with rash is detected. The agent is then isolated and all agents who are unvaccinated are quarantined. Isolated agents then may be moved out of the isolation in `isolation_↔_period` days.

15.27.2 Constructor & Destructor Documentation

15.27.2.1 ModelMeaslesQuarantine()

```
template<typename TSeq >
ModelMeaslesQuarantine< TSeq >::ModelMeaslesQuarantine (
    ModelMeaslesQuarantine< TSeq > & model,
    epiworld_fast_uint n,
    epiworld_fast_uint n_exposed,
    epiworld_double contact_rate,
    epiworld_double transmission_rate,
    epiworld_double vax_efficacy,
    epiworld_double vax_reduction_recovery_rate,
    epiworld_double incubation_period,
    epiworld_double prodromal_period,
    epiworld_double rash_period,
    epiworld_double days_undetected,
    epiworld_double hospitalization_rate,
    epiworld_double hospitalization_period,
    epiworld_double prop_vaccinated,
    epiworld_fast_int quarantine_period,
    epiworld_double quarantine_willingness,
    epiworld_fast_int isolation_period ) [inline]
```

Parameters

<i>n</i>	The number of agents in the system.
<i>n_exposed</i>	The number of exposed agents in the system.
<i>contact_rate</i>	The rate of contact between agents.
<i>transmission_rate</i>	The rate of transmission of the virus.
<i>vax_efficacy</i>	The efficacy of the vaccine.
<i>vax_reduction_recovery_rate</i>	The reduction in recovery rate due to the vaccine.
<i>incubation_period</i>	The incubation period of the virus.
<i>prodromal_period</i>	The prodromal period of the virus.
<i>rash_period</i>	The rash period of the virus.
<i>days_undetected</i>	The number of days the virus goes undetected.
<i>hospitalization_rate</i>	The rate of hospitalization.

Parameters

<i>hospitalization_period</i>	The duration of hospitalization.
<i>prop_vaccinated</i>	The proportion of vaccinated agents.
<i>quarantine_period</i>	The number of days for quarantine.
<i>quarantine_willingness</i>	The willingness to be quarantined.
<i>isolation_period</i>	The number of days for isolation.

15.27.3 Member Function Documentation

15.27.3.1 clone_ptr()

```
template<typename TSeq >
Model< TSeq > * ModelMeaslesQuarantine< TSeq >::clone_ptr [inline], [virtual]
```

Advanced usage: Makes a copy of data and returns it as undeleted pointer.

Parameters

<i>copy</i>	
-------------	--

Reimplemented from [epiworld::Model< EPI_DEFAULT_TSEQ >](#).

15.27.3.2 quarantine_agents()

```
template<typename TSeq >
void ModelMeaslesQuarantine< TSeq >::quarantine_agents [inline]
```

Quarantine agents that are in the system.

The flow should be:

- The function only runs if the quarantine status is active.
- Agents who are in quarantine, isolation, removed, or hospitalized are ignored.
- Agents who are in the RASH state are isolated.
- Vaccinated agents are ignored.
- Susceptible, Exposed, and Prodromal agents are moved to the QUARANTINED_* state.
- At the end of the function, the quarantine status is set false.

15.27.3.3 reset()

```
template<typename TSeq >
void ModelMeaslesQuarantine< TSeq >::reset [inline], [virtual]
```

Reset the model.

Resetting the model will:

- clear the database
- restore the population (if `set_backup()` was called before)
- re-distribute tools
- re-distribute viruses
- set the date to 0

Reimplemented from [epiworld::Model< EPI_DEFAULT_TSEQ >](#).

The documentation for this class was generated from the following file:

- `epiworld.hpp`

15.28 ModelMeaslesQuarantine< TSeq > Class Template Reference

Template for a Measles model with quarantine.

```
#include <measlesquarantine.hpp>
```

Inheritance diagram for ModelMeaslesQuarantine< TSeq >:



Collaboration diagram for ModelMeaslesQuarantine< TSeq >:



Public Member Functions

- void [quarantine_agents](#) ()
Quarantine agents that are in the system.
 - void [reset](#) ()
Reset the model.
 - void [update_infectious](#) ()
 - [Model< TSeq > * clone_ptr](#) ()
Advanced usage: Makes a copy of data and returns it as undeleted pointer.
-
- [ModelMeaslesQuarantine](#) ([ModelMeaslesQuarantine](#)< TSeq > &model, epiworld_fast_uint n, epiworld_double contact_rate, epiworld_double transmission_rate, epiworld_double vax_efficacy, epiworld_double vax_reduction_recovery_rate, epiworld_double incubation_period, epiworld_double prodromal_period, epiworld_double rash_period, epiworld_double days_undetected, epiworld_double hospitalization_rate, epiworld_double hospitalization_period, epiworld_double prop_vaccinated, epiworld_fast_int quarantine_period, epiworld_double quarantine_willingness, epiworld_fast_int isolation_period)
 - **ModelMeaslesQuarantine** (epiworld_fast_uint n, epiworld_fast_uint n_exposed, epiworld_double contact_rate, epiworld_double transmission_rate, epiworld_double vax_efficacy, epiworld_double vax_reduction_recovery_rate, epiworld_double incubation_period, epiworld_double prodromal_period, epiworld_double rash_period, epiworld_double days_undetected, epiworld_double hospitalization_rate, epiworld_double hospitalization_period, epiworld_double prop_vaccinated, epiworld_fast_int quarantine_period, epiworld_double quarantine_willingness, epiworld_fast_int isolation_period)

Public Attributes

- `std::vector< Agent< TSeq > * > infectious`
Agents infectious for contact.
- `bool system_quarantine_triggered = false`
- `std::vector< int > day_flagged`
Either detected or started quarantine.
- `std::vector< int > day_rash_onset`
Day of rash onset.

Static Public Attributes

- `static const epiworld_fast_uint SUSCEPTIBLE = 0u`
- `static const epiworld_fast_uint EXPOSED = 1u`
- `static const epiworld_fast_uint PRODROMAL = 2u`
- `static const epiworld_fast_uint RASH = 3u`
- `static const epiworld_fast_uint ISOLATED = 4u`
- `static const epiworld_fast_uint ISOLATED_RECOVERED = 5u`
- `static const epiworld_fast_uint DETECTED_HOSPITALIZED = 6u`
- `static const epiworld_fast_uint QUARANTINED_EXPOSED = 7u`
- `static const epiworld_fast_uint QUARANTINED_SUSCEPTIBLE = 8u`
- `static const epiworld_fast_uint QUARANTINED_PRODROMAL = 9u`
- `static const epiworld_fast_uint QUARANTINED_RECOVERED = 10u`
- `static const epiworld_fast_uint HOSPITALIZED = 11u`
- `static const epiworld_fast_uint RECOVERED = 12u`

Additional Inherited Members

15.28.1 Detailed Description

```
template<typename TSeq = EPI_DEFAULT_TSEQ>
class ModelMeaslesQuarantine< TSeq >
```

Template for a Measles model with quarantine.

Parameters

<i>TSeq</i>	The type of the sequence to be used.
-------------	--------------------------------------

This model can be described as a SEIHR model with isolation and quarantine. The infectious state is divided into prodromal and rash phases. Furthermore, the quarantine state includes exposed, susceptible, prodromal, and recovered states.

The quarantine process is triggered any time that an agent with rash is detected. The agent is then isolated and all agents who are unvaccinated are quarantined. Isolated agents then may be moved out of the isolation in `isolation←_period` days.

15.28.2 Constructor & Destructor Documentation

15.28.2.1 ModelMeaslesQuarantine()

```
template<typename TSeq >
ModelMeaslesQuarantine< TSeq >::ModelMeaslesQuarantine (
    ModelMeaslesQuarantine< TSeq > & model,
    epiworld_fast_uint n,
    epiworld_fast_uint n_exposed,
    epiworld_double contact_rate,
    epiworld_double transmission_rate,
    epiworld_double vax_efficacy,
    epiworld_double vax_reduction_recovery_rate,
    epiworld_double incubation_period,
    epiworld_double prodromal_period,
    epiworld_double rash_period,
    epiworld_double days_undetected,
    epiworld_double hospitalization_rate,
    epiworld_double hospitalization_period,
    epiworld_double prop_vaccinated,
    epiworld_fast_int quarantine_period,
    epiworld_double quarantine_willingness,
    epiworld_fast_int isolation_period ) [inline]
```

Parameters

<i>n</i>	The number of agents in the system.
<i>n_exposed</i>	The number of exposed agents in the system.
<i>contact_rate</i>	The rate of contact between agents.
<i>transmission_rate</i>	The rate of transmission of the virus.
<i>vax_efficacy</i>	The efficacy of the vaccine.
<i>vax_reduction_recovery_rate</i>	The reduction in recovery rate due to the vaccine.
<i>incubation_period</i>	The incubation period of the virus.
<i>prodromal_period</i>	The prodromal period of the virus.
<i>rash_period</i>	The rash period of the virus.
<i>days_undetected</i>	The number of days the virus goes undetected.
<i>hospitalization_rate</i>	The rate of hospitalization.
<i>hospitalization_period</i>	The duration of hospitalization.
<i>prop_vaccinated</i>	The proportion of vaccinated agents.
<i>quarantine_period</i>	The number of days for quarantine.
<i>quarantine_willingness</i>	The willingness to be quarantined.
<i>isolation_period</i>	The number of days for isolation.

15.28.3 Member Function Documentation

15.28.3.1 clone_ptr()

```
template<typename TSeq >
Model< TSeq > * ModelMeaslesQuarantine< TSeq >::clone_ptr [inline], [virtual]
```

Advanced usage: Makes a copy of data and returns it as undeleted pointer.

Parameters

copy	
----------------------	--

Reimplemented from [Model< TSeq >](#).

15.28.3.2 quarantine_agents()

```
template<typename TSeq >
void ModelMeaslesQuarantine< TSeq >::quarantine_agents [inline]
```

Quarantine agents that are in the system.

The flow should be:

- The function only runs if the quarantine status is active.
- Agents who are in quarantine, isolation, removed, or hospitalized are ignored.
- Agents who are in the RASH state are isolated.
- Vaccinated agents are ignored.
- Susceptible, Exposed, and Prodromal agents are moved to the QUARANTINED_* state.
- At the end of the function, the quarantine status is set false.

15.28.3.3 reset()

```
template<typename TSeq >
void ModelMeaslesQuarantine< TSeq >::reset [inline], [virtual]
```

Reset the model.

Resetting the model will:

- clear the database
- restore the population (if `set_backup()` was called before)
- re-distribute tools
- re-distribute viruses
- set the date to 0

Reimplemented from [Model< TSeq >](#).

The documentation for this class was generated from the following file:

- `include/epiworld/models/measlesquarantine.hpp`

15.29 epiworld::epimodels::ModelSEIR< TSeq > Class Template Reference

Template for a Susceptible-Exposed-Infected-Removed (SEIR) model.

```
#include <epiworld.hpp>
```

Inheritance diagram for epiworld::epimodels::ModelSEIR< TSeq >:



Collaboration diagram for epiworld::epimodels::ModelSEIR< TSeq >:



Public Member Functions

- **ModelSEIR** ([ModelSEIR](#)< TSeq > &model, const std::string &vname, epiworld_double prevalence, epiworld_double transmission_rate, epiworld_double avg_incubation_days, epiworld_double recovery_rate↵rate)
- **ModelSEIR** (const std::string &vname, epiworld_double prevalence, epiworld_double transmission_rate, epiworld_double avg_incubation_days, epiworld_double recovery_rate)
- [ModelSEIR](#)< TSeq > & [initial_states](#) (std::vector< double > proportions_, std::vector< int > queue_={})

Set up the initial states of the model.

Public Attributes

- epiworld::UpdateFun< TSeq > **update_exposed_seir**
- epiworld::UpdateFun< TSeq > **update_infected_seir**

Static Public Attributes

- static const int **SUSCEPTIBLE** = 0
- static const int **EXPOSED** = 1
- static const int **INFECTED** = 2
- static const int **REMOVED** = 3

Additional Inherited Members

15.29.1 Detailed Description

```
template<typename TSeq = EPI_DEFAULT_TSEQ>
class epiworld::epimodels::ModelSEIR< TSeq >
```

Template for a Susceptible-Exposed-Infected-Removed (SEIR) model.

Parameters

<i>model</i>	A Model<TSeq> object where to set up the SIR.
<i>vname</i>	std::string Name of the virus
<i>prevalence</i>	epiworld_double Initial prevalence the immune system
<i>transmission_rate</i>	epiworld_double Transmission rate of the virus
<i>avg_incubation_days</i>	epiworld_double Average incubation days of the virus.
<i>recovery_rate</i>	epiworld_double Recovery rate of the virus.

15.29.2 Member Function Documentation

15.29.2.1 initial_states()

```
template<typename TSeq >
ModelSEIR< TSeq > & ModelSEIR< TSeq >::initial_states (
    std::vector< double > proportions_,
    std::vector< int > queue_ = {} ) [inline], [virtual]
```

Set up the initial states of the model.

Parameters

<i>proportions</i> ↔	Double vector with the following values:
—	<ul style="list-style-type: none"> • 0: Proportion of non-infected agents who are removed. • 1: Proportion of exposed agents to be set as infected.

Reimplemented from [epiworld::Model< EPI_DEFAULT_TSEQ >](#).

15.29.3 Member Data Documentation

15.29.3.1 update_exposed_seir

```
template<typename TSeq = EPI_DEFAULT_TSEQ>
epiworld::UpdateFun<TSeq> epiworld::epimodels::ModelSEIR< TSeq >::update\_exposed\_seir
```

Initial value:

```
= [] (
    epiworld::Agent<TSeq> * p,
    epiworld::Model<TSeq> * m
) -> void {
    auto v = p->get_virus();
    if (m->runif() < 1.0/(v->get_incubation(m)))
        p->change_state(m, ModelSEIR<TSeq>::INFECTED);
    return;
}
```

15.29.3.2 update_infected_seir

```
template<typename TSeq = EPI_DEFAULT_TSEQ>
epiworld::UpdateFun<TSeq> epiworld::epimodels::ModelSEIR< TSeq >::update\_infected\_seir
```

Initial value:

```
= [] (
    epiworld::Agent<TSeq> * p,
    epiworld::Model<TSeq> * m
) -> void {
    if (m->runif() < (m->par("Recovery rate")))
        p->rm_virus(m);
    return;
}
```

The documentation for this class was generated from the following file:

- [epiworld.hpp](#)

15.30 ModelSEIR< TSeq > Class Template Reference

Template for a Susceptible-Exposed-Infected-Removed (SEIR) model.

```
#include <seir.hpp>
```

Inheritance diagram for ModelSEIR< TSeq >:



Collaboration diagram for ModelSEIR< TSeq >:



Public Member Functions

- **ModelSEIR** ([ModelSEIR](#)< TSeq > &model, const std::string &vname, epiworld_double prevalence, epiworld_double transmission_rate, epiworld_double avg_incubation_days, epiworld_double recovery_rate↵rate)
- **ModelSEIR** (const std::string &vname, epiworld_double prevalence, epiworld_double transmission_rate, epiworld_double avg_incubation_days, epiworld_double recovery_rate)
- [ModelSEIR](#)< TSeq > & [initial_states](#) (std::vector< double > proportions_, std::vector< int > queue_={})
Set up the initial states of the model.

Public Attributes

- epiworld::UpdateFun< TSeq > **update_exposed_seir**
- epiworld::UpdateFun< TSeq > **update_infected_seir**

Static Public Attributes

- static const int **SUSCEPTIBLE** = 0
- static const int **EXPOSED** = 1
- static const int **INFECTED** = 2
- static const int **REMOVED** = 3

Additional Inherited Members

15.30.1 Detailed Description

```
template<typename TSeq = EPI_DEFAULT_TSEQ>
class ModelSEIR< TSeq >
```

Template for a Susceptible-Exposed-Infected-Removed (SEIR) model.

Parameters

<i>model</i>	A Model<TSeq> object where to set up the SIR.
<i>vname</i>	std::string Name of the virus
<i>prevalence</i>	epiworld_double Initial prevalence the immune system
<i>transmission_rate</i>	epiworld_double Transmission rate of the virus
<i>avg_incubation_days</i>	epiworld_double Average incubation days of the virus.
<i>recovery_rate</i>	epiworld_double Recovery rate of the virus.

15.30.2 Member Function Documentation

15.30.2.1 initial_states()

```
template<typename TSeq >
ModelSEIR< TSeq > & ModelSEIR< TSeq >::initial_states (
    std::vector< double > proportions_,
    std::vector< int > queue_ = {} ) [inline], [virtual]
```

Set up the initial states of the model.

Parameters

<i>proportions_</i>	Double vector with the following values:
—	<ul style="list-style-type: none"> • 0: Proportion of non-infected agents who are removed. • 1: Proportion of exposed agents to be set as infected.

Reimplemented from [epiworld::Model< EPI_DEFAULT_TSEQ >](#).

15.30.3 Member Data Documentation

15.30.3.1 update_exposed_seir

```
template<typename TSeq = EPI_DEFAULT_TSEQ>
epiworld::UpdateFun<TSeq> ModelSEIR< TSeq >::update_exposed_seir
```

Initial value:

```
= [] (
    epiworld::Agent<TSeq> * p,
    epiworld::Model<TSeq> * m
) -> void {
    auto v = p->get_virus();
    if (m->runif() < 1.0/(v->get_incubation(m)))
        p->change_state(m, ModelSEIR<TSeq>::INFECTED);
    return;
}
```

15.30.3.2 update_infected_seir

```
template<typename TSeq = EPI_DEFAULT_TSEQ>
epiworld::UpdateFun<TSeq> ModelSEIR< TSeq >::update_infected_seir
```

Initial value:

```
= [] (
    epiworld::Agent<TSeq> * p,
    epiworld::Model<TSeq> * m
) -> void {
    if (m->runif() < (m->par("Recovery rate")))
        p->rm_virus(m);
    return;
}
```

The documentation for this class was generated from the following file:

- include/epiworld/models/seir.hpp

15.31 epiworld::epimodels::ModelSEIRCONN< TSeq > Class Template Reference

Inheritance diagram for epiworld::epimodels::ModelSEIRCONN< TSeq >:



Collaboration diagram for `epiworld::epimodels::ModelSEIRCONN< TSeq >`:



Public Member Functions

- [ModelSEIRCONN](#) ([ModelSEIRCONN](#)< TSeq > &model, const std::string &vname, epiworld_fast_uint n, epiworld_double prevalence, epiworld_double contact_rate, epiworld_double transmission_rate, epiworld_double avg_incubation_days, epiworld_double recovery_rate)
Template for a Susceptible-Exposed-Infected-Removed (SEIR) model.
- **ModelSEIRCONN** (const std::string &vname, epiworld_fast_uint n, epiworld_double prevalence, epiworld_double contact_rate, epiworld_double transmission_rate, epiworld_double avg_incubation_days, epiworld_double recovery_rate)
- [ModelSEIRCONN](#)< TSeq > & [run](#) (epiworld_fast_uint ndays, int seed=-1)
Runs the simulation (after initialization)
- void [reset](#) ()
Reset the model.
- [Model](#)< TSeq > * [clone_ptr](#) ()
Advanced usage: Makes a copy of data and returns it as undeleted pointer.
- [ModelSEIRCONN](#)< TSeq > & [initial_states](#) (std::vector< double > proportions_, std::vector< int > queue_={})
Set the initial states of the model.
- size_t **get_n_infected** () const
- std::vector< double > **generation_time_expected** (int max_days=200, int max_contacts=200) const

Static Public Attributes

- static const int **SUSCEPTIBLE** = 0
- static const int **EXPOSED** = 1
- static const int **INFECTED** = 2
- static const int **RECOVERED** = 3

Additional Inherited Members

15.31.1 Constructor & Destructor Documentation

15.31.1.1 `ModelSEIRCONN()`

```
template<typename TSeq >
ModelSEIRCONN< TSeq >::ModelSEIRCONN (
    ModelSEIRCONN< TSeq > & model,
    const std::string & vname,
    epiworld_fast_uint n,
    epiworld_double prevalence,
    epiworld_double contact_rate,
    epiworld_double transmission_rate,
    epiworld_double avg_incubation_days,
    epiworld_double recovery_rate ) [inline]
```

Template for a Susceptible-Exposed-Infected-Removed (SEIR) model.

Parameters

<i>model</i>	A <code>Model<TSeq></code> object where to set up the SIR.
<i>vname</i>	<code>std::string</code> Name of the virus
<i>prevalence</i>	Initial prevalence (proportion)
<i>contact_rate</i>	Average number of contacts (interactions) per step.
<i>transmission_rate</i>	Probability of transmission
<i>recovery_rate</i>	Probability of recovery

15.31.2 Member Function Documentation

15.31.2.1 `clone_ptr()`

```
template<typename TSeq >
Model< TSeq > * ModelSEIRCONN< TSeq >::clone_ptr [inline], [virtual]
```

Advanced usage: Makes a copy of data and returns it as undeleted pointer.

Parameters

<i>copy</i>	
-------------	--

Reimplemented from `epiworld::Model< EPI_DEFAULT_TSEQ >`.

15.31.2.2 `initial_states()`

```
template<typename TSeq >
ModelSEIRCONN< TSeq > & ModelSEIRCONN< TSeq >::initial_states (
    std::vector< double > proportions_,
    std::vector< int > queue_ = {} ) [inline], [virtual]
```

Set the initial states of the model.

Parameters

<i>proportions</i> ↔	Double vector with a single element:
—	<ul style="list-style-type: none"> The proportion of non-infected individuals who have recovered.

Reimplemented from [epiworld::Model< EPI_DEFAULT_TSEQ >](#).

15.31.2.3 reset()

```
template<typename TSeq >
void ModelSEIRCONN< TSeq >::reset [inline], [virtual]
```

Reset the model.

Resetting the model will:

- clear the database
- restore the population (if `set_backup()` was called before)
- re-distribute tools
- re-distribute viruses
- set the date to 0

Reimplemented from [epiworld::Model< EPI_DEFAULT_TSEQ >](#).

The documentation for this class was generated from the following file:

- `epiworld.hpp`

15.32 ModelSEIRCONN< TSeq > Class Template Reference

Inheritance diagram for ModelSEIRCONN< TSeq >:



Collaboration diagram for ModelSEIRCONN< TSeq >:



Public Member Functions

- [ModelSEIRCONN](#) ([ModelSEIRCONN](#)< TSeq > &model, const std::string &vname, epiworld_fast_uint n, epiworld_double prevalence, epiworld_double contact_rate, epiworld_double transmission_rate, epiworld_double avg_incubation_days, epiworld_double recovery_rate)
Template for a Susceptible-Exposed-Infected-Removed (SEIR) model.
- **ModelSEIRCONN** (const std::string &vname, epiworld_fast_uint n, epiworld_double prevalence, epiworld_double contact_rate, epiworld_double transmission_rate, epiworld_double avg_incubation_days, epiworld_double recovery_rate)
- [ModelSEIRCONN](#)< TSeq > & [run](#) (epiworld_fast_uint ndays, int seed=-1)
Runs the simulation (after initialization)
- void [reset](#) ()
Reset the model.
- [Model](#)< TSeq > * [clone_ptr](#) ()
Advanced usage: Makes a copy of data and returns it as undeleted pointer.
- [ModelSEIRCONN](#)< TSeq > & [initial_states](#) (std::vector< double > proportions_, std::vector< int > queue_=
_={})
Set the initial states of the model.
- size_t [get_n_infected](#) () const
- std::vector< double > [generation_time_expected](#) (int max_days=200, int max_contacts=200) const

Static Public Attributes

- static const int **SUSCEPTIBLE** = 0
- static const int **EXPOSED** = 1
- static const int **INFECTED** = 2
- static const int **RECOVERED** = 3

Additional Inherited Members

15.32.1 Constructor & Destructor Documentation

15.32.1.1 ModelSEIRCONN()

```
template<typename TSeq >
ModelSEIRCONN< TSeq >::ModelSEIRCONN (
    ModelSEIRCONN< TSeq > & model,
    const std::string & vname,
    epiworld_fast_uint n,
    epiworld_double prevalence,
    epiworld_double contact_rate,
    epiworld_double transmission_rate,
    epiworld_double avg_incubation_days,
    epiworld_double recovery_rate ) [inline]
```

Template for a Susceptible-Exposed-Infected-Removed (SEIR) model.

Parameters

<i>model</i>	A Model<TSeq> object where to set up the SIR.
<i>vname</i>	std::string Name of the virus
<i>prevalence</i>	Initial prevalence (proportion)
<i>contact_rate</i>	Average number of contacts (interactions) per step.
<i>transmission_rate</i>	Probability of transmission
<i>recovery_rate</i>	Probability of recovery

15.32.2 Member Function Documentation

15.32.2.1 clone_ptr()

```
template<typename TSeq >
Model< TSeq > * ModelSEIRCONN< TSeq >::clone_ptr [inline], [virtual]
```

Advanced usage: Makes a copy of data and returns it as undeleted pointer.

Parameters

<i>copy</i>	
-------------	--

Reimplemented from [epiworld::Model< EPI_DEFAULT_TSEQ >](#).

15.32.2.2 initial_states()

```
template<typename TSeq >
ModelSEIRCONN< TSeq > & ModelSEIRCONN< TSeq >::initial_states (
    std::vector< double > proportions_,
    std::vector< int > queue_ = {} ) [inline], [virtual]
```

Set the initial states of the model.

Parameters

<code>proportions</code> ↔	Double vector with a single element:
—	<ul style="list-style-type: none"> The proportion of non-infected individuals who have recovered.

Reimplemented from [epiworld::Model< EPI_DEFAULT_TSEQ >](#).

15.32.2.3 reset()

```
template<typename TSeq >
void ModelSEIRCONN< TSeq >::reset [inline], [virtual]
```

Reset the model.

Resetting the model will:

- clear the database
- restore the population (if `set_backup()` was called before)
- re-distribute tools
- re-distribute viruses
- set the date to 0

Reimplemented from [epiworld::Model< EPI_DEFAULT_TSEQ >](#).

The documentation for this class was generated from the following file:

- `include/epiworld/models/seirconnected.hpp`

15.33 epiworld::epimodels::ModelSEIRD< TSeq > Class Template Reference

Template for a Susceptible-Exposed-Infected-Removed-Deceased (SEIRD) model.

```
#include <epiworld.hpp>
```

Inheritance diagram for `epiworld::epimodels::ModelSEIRD< TSeq >`:



Collaboration diagram for `epiworld::epimodels::ModelSEIRD< TSeq >`:



Public Member Functions

- [ModelSEIRD](#) ([ModelSEIRD](#)< TSeq > &model, const std::string &vname, epiworld_double prevalence, epiworld_double transmission_rate, epiworld_double avg_incubation_days, epiworld_double recovery_rate, epiworld_double death_rate)
Constructor for the SEIRD model.
- [ModelSEIRD](#) (const std::string &vname, epiworld_double prevalence, epiworld_double transmission_rate, epiworld_double avg_incubation_days, epiworld_double recovery_rate, epiworld_double death_rate)
Constructor for the SEIRD model.
- [ModelSEIRD](#)< TSeq > & **initial_states** (std::vector< double > proportions_, std::vector< int > queue_={})

Public Attributes

- epiworld::UpdateFun< TSeq > **update_exposed_seir**
- epiworld::UpdateFun< TSeq > **update_infected**

Static Public Attributes

- static const int **SUSCEPTIBLE** = 0
- static const int **EXPOSED** = 1
- static const int **INFECTED** = 2
- static const int **REMOVED** = 3
- static const int **DECEASED** = 4

Additional Inherited Members

15.33.1 Detailed Description

```
template<typename TSeq = EPI_DEFAULT_TSEQ>
class epiworld::epimodels::ModelSEIRD< TSeq >
```

Template for a Susceptible-Exposed-Infected-Removed-Deceased (SEIRD) model.

15.33.2 Constructor & Destructor Documentation

15.33.2.1 ModelSEIRD() [1/2]

```
template<typename TSeq >
ModelSEIRD< TSeq >::ModelSEIRD (
    ModelSEIRD< TSeq > & model,
    const std::string & vname,
    epiworld_double prevalence,
    epiworld_double transmission_rate,
    epiworld_double avg_incubation_days,
    epiworld_double recovery_rate,
    epiworld_double death_rate ) [inline]
```

Constructor for the SEIRD model.

Template Parameters

<i>TSeq</i>	Type of the sequence used in the model.
-------------	-----------------------------------------

Parameters

<i>model</i>	Reference to the SEIRD model.
<i>vname</i>	Name of the model.
<i>prevalence</i>	Prevalence of the disease.
<i>transmission_rate</i>	Transmission rate of the disease.
<i>avg_incubation_days</i>	Average incubation period of the disease.
<i>recovery_rate</i>	Recovery rate of the disease.
<i>death_rate</i>	Death rate of the disease.

15.33.2.2 ModelSEIRD() [2/2]

```
template<typename TSeq >
ModelSEIRD< TSeq >::ModelSEIRD (
    const std::string & vname,
    epiworld_double prevalence,
    epiworld_double transmission_rate,
    epiworld_double avg_incubation_days,
    epiworld_double recovery_rate,
    epiworld_double death_rate ) [inline]
```

Constructor for the SEIRD model.

Parameters

<i>vname</i>	Name of the model.
<i>prevalence</i>	Initial prevalence of the disease.
<i>transmission_rate</i>	Transmission rate of the disease.
<i>avg_incubation_days</i>	Average incubation period of the disease.
<i>recovery_rate</i>	Recovery rate of the disease.
<i>death_rate</i>	Death rate of the disease.

15.33.3 Member Data Documentation

15.33.3.1 update_exposed_seir

```
template<typename TSeq = EPI_DEFAULT_TSEQ>
epiworld::UpdateFun<TSeq> epiworld::epimodels::ModelSEIRD< TSeq >::update_exposed_seir
```

Initial value:

```
= [] (
    epiworld::Agent<TSeq> * p,
    epiworld::Model<TSeq> * m
) -> void {

    auto v = p->get_virus();

    if (m->runif() < 1.0/(v->get_incubation(m)))
        p->change_state(m, ModelSEIRD<TSeq>::INFECTED);
    return;
}
```

The documentation for this class was generated from the following file:

- epiworld.hpp

15.34 ModelSEIRD< TSeq > Class Template Reference

Template for a Susceptible-Exposed-Infected-Removed-Deceased (SEIRD) model.

```
#include <seird.hpp>
```

Inheritance diagram for ModelSEIRD< TSeq >:



Collaboration diagram for ModelSEIRD< TSeq >:



Public Member Functions

- [ModelSEIRD](#) ([ModelSEIRD](#)< TSeq > &model, const std::string &vname, epiworld_double prevalence, epiworld_double transmission_rate, epiworld_double avg_incubation_days, epiworld_double recovery_rate, epiworld_double death_rate)
Constructor for the SEIRD model.
- [ModelSEIRD](#) (const std::string &vname, epiworld_double prevalence, epiworld_double transmission_rate, epiworld_double avg_incubation_days, epiworld_double recovery_rate, epiworld_double death_rate)
Constructor for the SEIRD model.
- [ModelSEIRD](#)< TSeq > & **initial_states** (std::vector< double > proportions_, std::vector< int > queue_={})

Public Attributes

- `epiworld::UpdateFun< TSeq >` **update_exposed_seir**
- `epiworld::UpdateFun< TSeq >` **update_infected**

Static Public Attributes

- static const int **SUSCEPTIBLE** = 0
- static const int **EXPOSED** = 1
- static const int **INFECTED** = 2
- static const int **REMOVED** = 3
- static const int **DECEASED** = 4

Additional Inherited Members

15.34.1 Detailed Description

```
template<typename TSeq = EPI_DEFAULT_TSEQ>
class ModelSEIRD< TSeq >
```

Template for a Susceptible-Exposed-Infected-Removed-Deceased (SEIRD) model.

15.34.2 Constructor & Destructor Documentation

15.34.2.1 ModelSEIRD() [1/2]

```
template<typename TSeq >
ModelSEIRD< TSeq >::ModelSEIRD (
    ModelSEIRD< TSeq > & model,
    const std::string & vname,
    epiworld_double prevalence,
    epiworld_double transmission_rate,
    epiworld_double avg_incubation_days,
    epiworld_double recovery_rate,
    epiworld_double death_rate ) [inline]
```

Constructor for the SEIRD model.

Template Parameters

<i>TSeq</i>	Type of the sequence used in the model.
-------------	-----------------------------------------

Parameters

<i>model</i>	Reference to the SEIRD model.
<i>vname</i>	Name of the model.

Parameters

<i>prevalence</i>	Prevalence of the disease.
<i>transmission_rate</i>	Transmission rate of the disease.
<i>avg_incubation_days</i>	Average incubation period of the disease.
<i>recovery_rate</i>	Recovery rate of the disease.
<i>death_rate</i>	Death rate of the disease.

15.34.2.2 ModelSEIRD() [2/2]

```
template<typename TSeq >
ModelSEIRD< TSeq >::ModelSEIRD (
    const std::string & vname,
    epiworld_double prevalence,
    epiworld_double transmission_rate,
    epiworld_double avg_incubation_days,
    epiworld_double recovery_rate,
    epiworld_double death_rate ) [inline]
```

Constructor for the SEIRD model.

Parameters

<i>vname</i>	Name of the model.
<i>prevalence</i>	Initial prevalence of the disease.
<i>transmission_rate</i>	Transmission rate of the disease.
<i>avg_incubation_days</i>	Average incubation period of the disease.
<i>recovery_rate</i>	Recovery rate of the disease.
<i>death_rate</i>	Death rate of the disease.

15.34.3 Member Data Documentation

15.34.3.1 update_exposed_seir

```
template<typename TSeq = EPI_DEFAULT_TSEQ>
epiworld::UpdateFun<TSeq> ModelSEIRD< TSeq >::update_exposed_seir
```

Initial value:

```
= [] (
    epiworld::Agent<TSeq> * p,
    epiworld::Model<TSeq> * m
) -> void {
    auto v = p->get_virus();
    if (m->runif() < 1.0/(v->get_incubation(m)))
        p->change_state(m, ModelSEIRD<TSeq>::INFECTED);
    return;
}
```

The documentation for this class was generated from the following file:

- `include/epiworld/models/seird.hpp`

15.35 `epiworld::epimodels::ModelSEIRDCONN< TSeq >` Class Template Reference

Inheritance diagram for `epiworld::epimodels::ModelSEIRDCONN< TSeq >`:



Collaboration diagram for `epiworld::epimodels::ModelSEIRDCONN< TSeq >`:



Public Member Functions

- [ModelSEIRDCONN](#) ([ModelSEIRDCONN](#)< TSeq > &model, const std::string &vname, epiworld_fast_uint n, epiworld_double prevalence, epiworld_double contact_rate, epiworld_double transmission_rate, epiworld_double avg_incubation_days, epiworld_double recovery_rate, epiworld_double death_rate)
Template for a Susceptible-Exposed-Infected-Removed (SEIR) model.
- **ModelSEIRDCONN** (const std::string &vname, epiworld_fast_uint n, epiworld_double prevalence, epiworld_double contact_rate, epiworld_double transmission_rate, epiworld_double avg_incubation_days, epiworld_double recovery_rate, epiworld_double death_rate)
- [ModelSEIRDCONN](#)< TSeq > & [run](#) (epiworld_fast_uint ndays, int seed=-1)

- Runs the simulation (after initialization)*
- void `reset` ()
Reset the model.
- `Model< TSeq > * clone_ptr` ()
Advanced usage: Makes a copy of data and returns it as undeleted pointer.
- `ModelSEIRDCONN< TSeq > & initial_states` (std::vector< double > proportions_, std::vector< int > queue_={})
Set up the initial states of the model.
- size_t `get_n_infected` () const

Static Public Attributes

- static const int **SUSCEPTIBLE** = 0
- static const int **EXPOSED** = 1
- static const int **INFECTED** = 2
- static const int **REMOVED** = 3
- static const int **DECEASED** = 4

Additional Inherited Members

15.35.1 Constructor & Destructor Documentation

15.35.1.1 ModelSEIRDCONN()

```
template<typename TSeq >
ModelSEIRDCONN< TSeq >::ModelSEIRDCONN (
    ModelSEIRDCONN< TSeq > & model,
    const std::string & vname,
    epiworld_fast_uint n,
    epiworld_double prevalence,
    epiworld_double contact_rate,
    epiworld_double transmission_rate,
    epiworld_double avg_incubation_days,
    epiworld_double recovery_rate,
    epiworld_double death_rate ) [inline]
```

Template for a Susceptible-Exposed-Infected-Removed (SEIR) model.

Parameters

<i>model</i>	A Model<TSeq> object where to set up the SIR.
<i>vname</i>	std::string Name of the virus
<i>prevalence</i>	Initial prevalence (proportion)
<i>contact_rate</i>	Average number of contacts (interactions) per step.
<i>transmission_rate</i>	Probability of transmission
<i>recovery_rate</i>	Probability of recovery
<i>death_rate</i>	Probability of death

15.35.2 Member Function Documentation

15.35.2.1 clone_ptr()

```
template<typename TSeq >
Model< TSeq > * ModelSEIRDCONN< TSeq >::clone_ptr [inline], [virtual]
```

Advanced usage: Makes a copy of data and returns it as undeleted pointer.

Parameters

<i>copy</i>	
-------------	--

Reimplemented from [epiworld::Model< EPI_DEFAULT_TSEQ >](#).

15.35.2.2 initial_states()

```
template<typename TSeq >
ModelSEIRDCONN< TSeq > & ModelSEIRDCONN< TSeq >::initial_states (
    std::vector< double > proportions_,
    std::vector< int > queue_ = {} ) [inline], [virtual]
```

Set up the initial states of the model.

Parameters

<i>proportions_↵</i>	Double vector with the following values:
—	<ul style="list-style-type: none"> • 0: Proportion of non-infected agents who are removed. • 1: Proportion of exposed agents to be set as infected.

Reimplemented from [epiworld::Model< EPI_DEFAULT_TSEQ >](#).

15.35.2.3 reset()

```
template<typename TSeq >
void ModelSEIRDCONN< TSeq >::reset [inline], [virtual]
```

Reset the model.

Resetting the model will:

- clear the database
- restore the population (if `set_backup()` was called before)
- re-distribute tools
- re-distribute viruses
- set the date to 0

Reimplemented from [epiworld::Model< EPI_DEFAULT_TSEQ >](#).

The documentation for this class was generated from the following file:

- `epiworld.hpp`

15.36 ModelSEIRDCONN< TSeq > Class Template Reference

Inheritance diagram for ModelSEIRDCONN< TSeq >:



Collaboration diagram for ModelSEIRDCONN< TSeq >:



Public Member Functions

- [ModelSEIRDCONN](#) ([ModelSEIRDCONN](#)< TSeq > &model, const std::string &vname, epiworld_fast_uint n, epiworld_double prevalence, epiworld_double contact_rate, epiworld_double transmission_rate, epiworld_double avg_incubation_days, epiworld_double recovery_rate, epiworld_double death_rate)
Template for a Susceptible-Exposed-Infected-Removed (SEIR) model.
- **ModelSEIRDCONN** (const std::string &vname, epiworld_fast_uint n, epiworld_double prevalence, epiworld_double contact_rate, epiworld_double transmission_rate, epiworld_double avg_incubation_days, epiworld_double recovery_rate, epiworld_double death_rate)
- [ModelSEIRDCONN](#)< TSeq > & [run](#) (epiworld_fast_uint ndays, int seed=-1)
Runs the simulation (after initialization)
- void [reset](#) ()
Reset the model.
- [Model](#)< TSeq > * [clone_ptr](#) ()
Advanced usage: Makes a copy of data and returns it as undeleted pointer.
- [ModelSEIRDCONN](#)< TSeq > & [initial_states](#) (std::vector< double > proportions_, std::vector< int > queue_={})
Set up the initial states of the model.
- size_t [get_n_infected](#) () const

Static Public Attributes

- static const int **SUSCEPTIBLE** = 0
- static const int **EXPOSED** = 1
- static const int **INFECTED** = 2
- static const int **REMOVED** = 3
- static const int **DECEASED** = 4

Additional Inherited Members

15.36.1 Constructor & Destructor Documentation

15.36.1.1 ModelSEIRDCONN()

```
template<typename TSeq >
ModelSEIRDCONN< TSeq >::ModelSEIRDCONN (
    ModelSEIRDCONN< TSeq > & model,
    const std::string & vname,
    epiworld_fast_uint n,
    epiworld_double prevalence,
    epiworld_double contact_rate,
    epiworld_double transmission_rate,
    epiworld_double avg_incubation_days,
    epiworld_double recovery_rate,
    epiworld_double death_rate ) [inline]
```

Template for a Susceptible-Exposed-Infected-Removed (SEIR) model.

Parameters

<i>model</i>	A Model<TSeq> object where to set up the SIR.
<i>vname</i>	std::string Name of the virus
<i>prevalence</i>	Initial prevalence (proportion)
<i>contact_rate</i>	Average number of contacts (interactions) per step.
<i>transmission_rate</i>	Probability of transmission
<i>recovery_rate</i>	Probability of recovery
<i>death_rate</i>	Probability of death

15.36.2 Member Function Documentation

15.36.2.1 clone_ptr()

```
template<typename TSeq >
Model< TSeq > * ModelSEIRDCONN< TSeq >::clone_ptr [inline], [virtual]
```

Advanced usage: Makes a copy of data and returns it as undeleted pointer.

Parameters

<i>copy</i>	
-------------	--

Reimplemented from [epiworld::Model< EPI_DEFAULT_TSEQ >](#).

15.36.2.2 initial_states()

```
template<typename TSeq >
ModelSEIRDCONN< TSeq > & ModelSEIRDCONN< TSeq >::initial_states (
    std::vector< double > proportions_,
    std::vector< int > queue_ = {} ) [inline], [virtual]
```

Set up the initial states of the model.

Parameters

<i>proportions_↩</i>	Double vector with the following values:
—	<ul style="list-style-type: none"> • 0: Proportion of non-infected agents who are removed. • 1: Proportion of exposed agents to be set as infected.

Reimplemented from [epiworld::Model< EPI_DEFAULT_TSEQ >](#).

15.36.2.3 reset()

```
template<typename TSeq >
void ModelSEIRDCONN< TSeq >::reset [inline], [virtual]
```

Reset the model.

Resetting the model will:

- clear the database
- restore the population (if `set_backup()` was called before)
- re-distribute tools
- re-distribute viruses
- set the date to 0

Reimplemented from `epiworld::Model< EPI_DEFAULT_TSEQ >`.

The documentation for this class was generated from the following file:

- `include/epiworld/models/seirdconnected.hpp`

15.37 epiworld::epimodels::ModelSEIRMixing< TSeq > Class Template Reference

Inheritance diagram for `epiworld::epimodels::ModelSEIRMixing< TSeq >`:



Collaboration diagram for epiworld::epimodels::ModelSEIRMixing< TSeq >:



Public Member Functions

- [ModelSEIRMixing](#) ([ModelSEIRMixing](#)< TSeq > &model, const std::string &vname, epiworld_fast_uint n, epiworld_double prevalence, epiworld_double contact_rate, epiworld_double transmission_rate, epiworld_double avg_incubation_days, epiworld_double recovery_rate, std::vector< double > contact_matrix)
Constructs a [ModelSEIRMixing](#) object.
- [ModelSEIRMixing](#) (const std::string &vname, epiworld_fast_uint n, epiworld_double prevalence, epiworld_double contact_rate, epiworld_double transmission_rate, epiworld_double avg_incubation_days, epiworld_double recovery_rate, std::vector< double > contact_matrix)
Constructs a [ModelSEIRMixing](#) object.
- [ModelSEIRMixing](#)< TSeq > & [run](#) (epiworld_fast_uint ndays, int seed=-1)
Runs the simulation (after initialization)
- void [reset](#) ()
Reset the model.
- [Model](#)< TSeq > * [clone_ptr](#) ()
Advanced usage: Makes a copy of data and returns it as undeleted pointer.
- [ModelSEIRMixing](#)< TSeq > & [initial_states](#) (std::vector< double > proportions_, std::vector< int > queue_={})
Set the initial states of the model.
- void [set_contact_matrix](#) (std::vector< double > cmat)

Static Public Attributes

- static const int **SUSCEPTIBLE** = 0
- static const int **EXPOSED** = 1
- static const int **INFECTED** = 2
- static const int **RECOVERED** = 3

Additional Inherited Members

15.37.1 Constructor & Destructor Documentation

15.37.1.1 ModelSEIRMixing() [1/2]

```
template<typename TSeq >
ModelSEIRMixing< TSeq >::ModelSEIRMixing (
    ModelSEIRMixing< TSeq > & model,
    const std::string & vname,
    epiworld_fast_uint n,
    epiworld_double prevalence,
    epiworld_double contact_rate,
    epiworld_double transmission_rate,
    epiworld_double avg_incubation_days,
    epiworld_double recovery_rate,
    std::vector< double > contact_matrix ) [inline]
```

Constructs a [ModelSEIRMixing](#) object.

Template for a Susceptible-Exposed-Infected-Removed (SEIR) model.

Parameters

<i>model</i>	A reference to an existing ModelSEIRMixing object.
<i>vname</i>	The name of the ModelSEIRMixing object.
<i>n</i>	The number of entities in the model.
<i>prevalence</i>	The initial prevalence of the disease in the model.
<i>contact_rate</i>	The contact rate between entities in the model.
<i>transmission_rate</i>	The transmission rate of the disease in the model.
<i>avg_incubation_days</i>	The average incubation period of the disease in the model.
<i>recovery_rate</i>	The recovery rate of the disease in the model.
<i>contact_matrix</i>	The contact matrix between entities in the model. Specified in column-major order.
<i>model</i>	A Model<TSeq> object where to set up the SIR.
<i>vname</i>	std::string Name of the virus
<i>prevalence</i>	Initial prevalence (proportion)
<i>contact_rate</i>	Average number of contacts (interactions) per step.
<i>transmission_rate</i>	Probability of transmission
<i>recovery_rate</i>	Probability of recovery

15.37.1.2 ModelSEIRMixing() [2/2]

```
template<typename TSeq >
ModelSEIRMixing< TSeq >::ModelSEIRMixing (
    const std::string & vname,
    epiworld_fast_uint n,
    epiworld_double prevalence,
    epiworld_double contact_rate,
    epiworld_double transmission_rate,
    epiworld_double avg_incubation_days,
    epiworld_double recovery_rate,
    std::vector< double > contact_matrix ) [inline]
```

Constructs a [ModelSEIRMixing](#) object.

Parameters

<i>vname</i>	The name of the ModelSEIRMixing object.
<i>n</i>	The number of entities in the model.
<i>prevalence</i>	The initial prevalence of the disease in the model.
<i>contact_rate</i>	The contact rate between entities in the model.
<i>transmission_rate</i>	The transmission rate of the disease in the model.
<i>avg_incubation_days</i>	The average incubation period of the disease in the model.
<i>recovery_rate</i>	The recovery rate of the disease in the model.
<i>contact_matrix</i>	The contact matrix between entities in the model.

15.37.2 Member Function Documentation

15.37.2.1 `clone_ptr()`

```
template<typename TSeq >
Model< TSeq > * ModelSEIRMixing< TSeq >::clone_ptr [inline], [virtual]
```

Advanced usage: Makes a copy of data and returns it as undeleted pointer.

Parameters

<i>copy</i>	
-------------	--

Reimplemented from [epiworld::Model< EPI_DEFAULT_TSEQ >](#).

15.37.2.2 `initial_states()`

```
template<typename TSeq >
ModelSEIRMixing< TSeq > & ModelSEIRMixing< TSeq >::initial_states (
    std::vector< double > proportions_,
    std::vector< int > queue_ = {} ) [inline], [virtual]
```

Set the initial states of the model.

Parameters

<i>proportions_</i>	Double vector with a single element:
—	<ul style="list-style-type: none"> The proportion of non-infected individuals who have recovered.

Reimplemented from [epiworld::Model< EPI_DEFAULT_TSEQ >](#).

15.37.2.3 reset()

```
template<typename TSeq >
void ModelSEIRMixing< TSeq >::reset [inline], [virtual]
```

Reset the model.

Resetting the model will:

- clear the database
- restore the population (if `set_backup()` was called before)
- re-distribute tools
- re-distribute viruses
- set the date to 0

Reimplemented from `epiworld::Model< EPI_DEFAULT_TSEQ >`.

The documentation for this class was generated from the following file:

- `epiworld.hpp`

15.38 ModelSEIRMixing< TSeq > Class Template Reference

Inheritance diagram for ModelSEIRMixing< TSeq >:



Collaboration diagram for ModelSEIRMixing< TSeq >:



Public Member Functions

- [ModelSEIRMixing](#) ([ModelSEIRMixing](#)< TSeq > &model, const std::string &vname, epiworld_fast_uint n, epiworld_double prevalence, epiworld_double contact_rate, epiworld_double transmission_rate, epiworld_double avg_incubation_days, epiworld_double recovery_rate, std::vector< double > contact_matrix)
Constructs a [ModelSEIRMixing](#) object.
- [ModelSEIRMixing](#) (const std::string &vname, epiworld_fast_uint n, epiworld_double prevalence, epiworld_double contact_rate, epiworld_double transmission_rate, epiworld_double avg_incubation_days, epiworld_double recovery_rate, std::vector< double > contact_matrix)
Constructs a [ModelSEIRMixing](#) object.
- [ModelSEIRMixing](#)< TSeq > & [run](#) (epiworld_fast_uint ndays, int seed=-1)
Runs the simulation (after initialization)
- void [reset](#) ()
Reset the model.
- [Model](#)< TSeq > * [clone_ptr](#) ()
Advanced usage: Makes a copy of data and returns it as undeleted pointer.
- [ModelSEIRMixing](#)< TSeq > & [initial_states](#) (std::vector< double > proportions_, std::vector< int > queue_ = {})
Set the initial states of the model.
- void [set_contact_matrix](#) (std::vector< double > cmat)

Static Public Attributes

- static const int **SUSCEPTIBLE** = 0
- static const int **EXPOSED** = 1
- static const int **INFECTED** = 2
- static const int **RECOVERED** = 3

Additional Inherited Members

15.38.1 Constructor & Destructor Documentation

15.38.1.1 ModelSEIRMixing() [1/2]

```
template<typename TSeq >
ModelSEIRMixing< TSeq >::ModelSEIRMixing (
    ModelSEIRMixing< TSeq > & model,
    const std::string & vname,
    epiworld_fast_uint n,
    epiworld_double prevalence,
    epiworld_double contact_rate,
    epiworld_double transmission_rate,
    epiworld_double avg_incubation_days,
    epiworld_double recovery_rate,
    std::vector< double > contact_matrix ) [inline]
```

Constructs a [ModelSEIRMixing](#) object.

Template for a Susceptible-Exposed-Infected-Removed (SEIR) model.

Parameters

<i>model</i>	A reference to an existing ModelSEIRMixing object.
<i>vname</i>	The name of the ModelSEIRMixing object.
<i>n</i>	The number of entities in the model.
<i>prevalence</i>	The initial prevalence of the disease in the model.
<i>contact_rate</i>	The contact rate between entities in the model.
<i>transmission_rate</i>	The transmission rate of the disease in the model.
<i>avg_incubation_days</i>	The average incubation period of the disease in the model.
<i>recovery_rate</i>	The recovery rate of the disease in the model.
<i>contact_matrix</i>	The contact matrix between entities in the model. Specified in column-major order.
<i>model</i>	A <code>Model<TSeq></code> object where to set up the SIR.
<i>vname</i>	<code>std::string</code> Name of the virus
<i>prevalence</i>	Initial prevalence (proportion)
<i>contact_rate</i>	Average number of contacts (interactions) per step.
<i>transmission_rate</i>	Probability of transmission
<i>recovery_rate</i>	Probability of recovery

15.38.1.2 [ModelSEIRMixing\(\)](#) [2/2]

```
template<typename TSeq >
ModelSEIRMixing< TSeq >::ModelSEIRMixing (
    const std::string & vname,
    epiworld_fast_uint n,
    epiworld_double prevalence,
    epiworld_double contact_rate,
    epiworld_double transmission_rate,
    epiworld_double avg_incubation_days,
    epiworld_double recovery_rate,
    std::vector< double > contact_matrix ) [inline]
```

Constructs a [ModelSEIRMixing](#) object.

Parameters

<i>vname</i>	The name of the ModelSEIRMixing object.
<i>n</i>	The number of entities in the model.
<i>prevalence</i>	The initial prevalence of the disease in the model.
<i>contact_rate</i>	The contact rate between entities in the model.
<i>transmission_rate</i>	The transmission rate of the disease in the model.
<i>avg_incubation_days</i>	The average incubation period of the disease in the model.
<i>recovery_rate</i>	The recovery rate of the disease in the model.
<i>contact_matrix</i>	The contact matrix between entities in the model.

15.38.2 Member Function Documentation

15.38.2.1 clone_ptr()

```
template<typename TSeq >
Model< TSeq > * ModelSEIRMixing< TSeq >::clone_ptr [inline], [virtual]
```

Advanced usage: Makes a copy of data and returns it as undeleted pointer.

Parameters

<i>copy</i>	
-------------	--

Reimplemented from [epiworld::Model< EPI_DEFAULT_TSEQ >](#).

15.38.2.2 initial_states()

```
template<typename TSeq >
ModelSEIRMixing< TSeq > & ModelSEIRMixing< TSeq >::initial_states (
    std::vector< double > proportions_,
    std::vector< int > queue_ = {} ) [inline], [virtual]
```

Set the initial states of the model.

Parameters

<i>proportions_↵</i>	Double vector with a single element:
—	<ul style="list-style-type: none"> The proportion of non-infected individuals who have recovered.

Reimplemented from [epiworld::Model< EPI_DEFAULT_TSEQ >](#).

15.38.2.3 reset()

```
template<typename TSeq >
void ModelSEIRMixing< TSeq >::reset [inline], [virtual]
```

Reset the model.

Resetting the model will:

- clear the database
- restore the population (if `set_backup()` was called before)
- re-distribute tools
- re-distribute viruses
- set the date to 0

Reimplemented from [epiworld::Model< EPI_DEFAULT_TSEQ >](#).

The documentation for this class was generated from the following file:

- `include/epiworld/models/seirmixing.hpp`

15.39 epiworld::epimodels::ModelSIR< TSeq > Class Template Reference

Template for a Susceptible-Infected-Removed (SIR) model.

```
#include <epiworld.hpp>
```

Inheritance diagram for epiworld::epimodels::ModelSIR< TSeq >:



Collaboration diagram for epiworld::epimodels::ModelSIR< TSeq >:



Public Member Functions

- **ModelSIR** ([ModelSIR](#)< TSeq > &model, const std::string &vname, epiworld_double prevalence, epiworld_double transmission_rate, epiworld_double recovery_rate)
- **ModelSIR** (const std::string &vname, epiworld_double prevalence, epiworld_double transmission_rate, epiworld_double recovery_rate)
- [ModelSIR](#)< TSeq > & **initial_states** (std::vector< double > proportions_, std::vector< int > queue_={})

Set the initial states of the model.

Additional Inherited Members

15.39.1 Detailed Description

```
template<typename TSeq = EPI_DEFAULT_TSEQ>
class epiworld::epimodels::ModelSIR< TSeq >
```

Template for a Susceptible-Infected-Removed (SIR) model.

Parameters

<i>model</i>	A Model<TSeq> object where to set up the SIR.
<i>vname</i>	std::string Name of the virus
<i>initial_prevalence</i>	epiworld_double Initial prevalence
<i>initial_efficiency</i>	epiworld_double Initial susceptibility_reduction of the immune system
<i>initial_recovery</i>	epiworld_double Initial recovery_rate rate of the immune system

15.39.2 Member Function Documentation

15.39.2.1 initial_states()

```
template<typename TSeq >
ModelSIR< TSeq > & ModelSIR< TSeq >::initial_states (
    std::vector< double > proportions_,
    std::vector< int > queue_ = {} ) [inline], [virtual]
```

Set the initial states of the model.

Parameters

<i>proportions_</i>	Double vector with a single element:
—	<ul style="list-style-type: none"> The proportion of non-infected individuals who have recovered.

Reimplemented from [epiworld::Model< EPI_DEFAULT_TSEQ >](#).

The documentation for this class was generated from the following file:

- epiworld.hpp

15.40 ModelSIR< TSeq > Class Template Reference

Template for a Susceptible-Infected-Removed (SIR) model.

```
#include <sir.hpp>
```

Inheritance diagram for ModelSIR< TSeq >:



Collaboration diagram for ModelSIR< TSeq >:



Public Member Functions

- **ModelSIR** ([ModelSIR](#)< TSeq > &model, const std::string &vname, epiworld_double prevalence, epiworld_double transmission_rate, epiworld_double recovery_rate)
- **ModelSIR** (const std::string &vname, epiworld_double prevalence, epiworld_double transmission_rate, epiworld_double recovery_rate)
- [ModelSIR](#)< TSeq > & [initial_states](#) (std::vector< double > proportions_, std::vector< int > queue_={})

Set the initial states of the model.

Additional Inherited Members

15.40.1 Detailed Description

```
template<typename TSeq = EPI_DEFAULT_TSEQ>
class ModelSIR< TSeq >
```

Template for a Susceptible-Infected-Removed (SIR) model.

Parameters

<i>model</i>	A Model<TSeq> object where to set up the SIR.
<i>vname</i>	std::string Name of the virus
<i>initial_prevalence</i>	epiworld_double Initial prevalence
<i>initial_efficiency</i>	epiworld_double Initial susceptibility_reduction of the immune system
<i>initial_recovery</i>	epiworld_double Initial recovery_rate rate of the immune system

15.40.2 Member Function Documentation

15.40.2.1 initial_states()

```
template<typename TSeq >
ModelSIR< TSeq > & ModelSIR< TSeq >::initial_states (
    std::vector< double > proportions_,
    std::vector< int > queue_ = {} ) [inline], [virtual]
```

Set the initial states of the model.

Parameters

<i>proportions_</i> ↔	Double vector with a single element:
—	<ul style="list-style-type: none"> The proportion of non-infected individuals who have recovered.

Reimplemented from [epiworld::Model< EPI_DEFAULT_TSEQ >](#).

The documentation for this class was generated from the following file:

- include/epiworld/models/sir.hpp

15.41 epiworld::epimodels::ModelSIRCONN< TSeq > Class Template Reference

Inheritance diagram for epiworld::epimodels::ModelSIRCONN< TSeq >:



Collaboration diagram for epiworld::epimodels::ModelSIRCONN< TSeq >:



Public Member Functions

- [ModelSIRCONN](#) ([ModelSIRCONN](#)< TSeq > &model, const std::string &vname, epiworld_fast_uint n, epiworld_double prevalence, epiworld_double contact_rate, epiworld_double transmission_rate, epiworld_double recovery_rate)
Template for a Susceptible-Infected-Removed (SIR) model.
- **ModelSIRCONN** (const std::string &vname, epiworld_fast_uint n, epiworld_double prevalence, epiworld_double contact_rate, epiworld_double transmission_rate, epiworld_double recovery_rate)
- [ModelSIRCONN](#)< TSeq > & [run](#) (epiworld_fast_uint ndays, int seed=-1)
Runs the simulation (after initialization)
- void [reset](#) ()
Reset the model.
- [Model](#)< TSeq > * [clone_ptr](#) ()

Advanced usage: Makes a copy of data and returns it as undeleted pointer.

- `ModelSIRCONN< TSeq > & initial_states` (`std::vector< double > proportions_`, `std::vector< int > queue_` → `_={}`)
Set the initial states of the model.
- `size_t get_n_infected` () const
Get the infected individuals.
- `std::vector< double > generation_time_expected` (`int max_days=200`, `int max_contacts=200`) const

Static Public Attributes

- static const int **SUSCEPTIBLE** = 0
- static const int **INFECTED** = 1
- static const int **RECOVERED** = 2

Additional Inherited Members

15.41.1 Constructor & Destructor Documentation

15.41.1.1 ModelSIRCONN()

```
template<typename TSeq >
ModelSIRCONN< TSeq >::ModelSIRCONN (
    ModelSIRCONN< TSeq > & model,
    const std::string & vname,
    epiworld_fast_uint n,
    epiworld_double prevalence,
    epiworld_double contact_rate,
    epiworld_double transmission_rate,
    epiworld_double recovery_rate ) [inline]
```

Template for a Susceptible-Infected-Removed (SIR) model.

Parameters

<i>model</i>	A Model<TSeq> object where to set up the SIR.
<i>vname</i>	std::string Name of the virus
<i>prevalence</i>	Initial prevalence (proportion)
<i>contact_rate</i>	Average number of contacts (interactions) per step.
<i>transmission_rate</i>	Probability of transmission
<i>recovery_rate</i>	Probability of recovery

15.41.2 Member Function Documentation

15.41.2.1 clone_ptr()

```
template<typename TSeq >
Model< TSeq > * ModelSIRCONN< TSeq >::clone_ptr [inline], [virtual]
```

Advanced usage: Makes a copy of data and returns it as undeleted pointer.

Parameters

<i>copy</i>	
-------------	--

Reimplemented from [epiworld::Model< EPI_DEFAULT_TSEQ >](#).

15.41.2.2 get_n_infected()

```
template<typename TSeq = EPI_DEFAULT_TSEQ>
size_t epiworld::epimodels::ModelSIRCONN< TSeq >::get_n_infected ( ) const [inline]
```

Get the infected individuals.

Returns

std::vector< epiworld::Agent<TSeq> * >

15.41.2.3 initial_states()

```
template<typename TSeq >
ModelSIRCONN< TSeq > & ModelSIRCONN< TSeq >::initial_states (
    std::vector< double > proportions_,
    std::vector< int > queue_ = {} ) [inline], [virtual]
```

Set the initial states of the model.

Parameters

<i>proportions_↔</i>	Double vector with a single element:
—	<ul style="list-style-type: none"> The proportion of non-infected individuals who have recovered.

Reimplemented from [epiworld::Model< EPI_DEFAULT_TSEQ >](#).

15.41.2.4 reset()

```
template<typename TSeq >
void ModelSIRCONN< TSeq >::reset [inline], [virtual]
```

Reset the model.

Resetting the model will:

- clear the database
- restore the population (if `set_backup()` was called before)
- re-distribute tools
- re-distribute viruses
- set the date to 0

Reimplemented from [epiworld::Model< EPI_DEFAULT_TSEQ >](#).

The documentation for this class was generated from the following file:

- `epiworld.hpp`

15.42 ModelSIRCONN< TSeq > Class Template Reference

Inheritance diagram for ModelSIRCONN< TSeq >:



Collaboration diagram for ModelSIRCONN< TSeq >:



Public Member Functions

- [ModelSIRCONN](#) ([ModelSIRCONN](#)< TSeq > &model, const std::string &vname, epiworld_fast_uint n, epiworld_double prevalence, epiworld_double contact_rate, epiworld_double transmission_rate, epiworld_double recovery_rate)
Template for a Susceptible-Infected-Removed (SIR) model.
- **ModelSIRCONN** (const std::string &vname, epiworld_fast_uint n, epiworld_double prevalence, epiworld_double contact_rate, epiworld_double transmission_rate, epiworld_double recovery_rate)
- [ModelSIRCONN](#)< TSeq > & [run](#) (epiworld_fast_uint ndays, int seed=-1)
Runs the simulation (after initialization)
- void [reset](#) ()
Reset the model.
- [Model](#)< TSeq > * [clone_ptr](#) ()
Advanced usage: Makes a copy of data and returns it as undeleted pointer.
- [ModelSIRCONN](#)< TSeq > & [initial_states](#) (std::vector< double > proportions_, std::vector< int > queue_ = {})
Set the initial states of the model.
- size_t [get_n_infected](#) () const
Get the infected individuals.
- std::vector< double > **generation_time_expected** (int max_days=200, int max_contacts=200) const

Static Public Attributes

- static const int **SUSCEPTIBLE** = 0
- static const int **INFECTED** = 1
- static const int **RECOVERED** = 2

Additional Inherited Members

15.42.1 Constructor & Destructor Documentation

15.42.1.1 ModelSIRCONN()

```
template<typename TSeq >
ModelSIRCONN< TSeq >::ModelSIRCONN (
    ModelSIRCONN< TSeq > & model,
    const std::string & vname,
    epiworld_fast_uint n,
    epiworld_double prevalence,
    epiworld_double contact_rate,
    epiworld_double transmission_rate,
    epiworld_double recovery_rate ) [inline]
```

Template for a Susceptible-Infected-Removed (SIR) model.

Parameters

<i>model</i>	A Model<TSeq> object where to set up the SIR.
<i>vname</i>	std::string Name of the virus
<i>prevalence</i>	Initial prevalence (proportion)
<i>contact_rate</i>	Average number of contacts (interactions) per step.
<i>transmission_rate</i>	Probability of transmission
<i>recovery_rate</i>	Probability of recovery

15.42.2 Member Function Documentation

15.42.2.1 clone_ptr()

```
template<typename TSeq >
Model< TSeq > * ModelSIRCONN< TSeq >::clone_ptr [inline], [virtual]
```

Advanced usage: Makes a copy of data and returns it as undeleted pointer.

Parameters

<i>copy</i>	
-------------	--

Reimplemented from [epiworld::Model< EPI_DEFAULT_TSEQ >](#).

15.42.2.2 get_n_infected()

```
template<typename TSeq = EPI_DEFAULT_TSEQ>
size_t ModelSIRCONN< TSeq >::get_n_infected ( ) const [inline]
```

Get the infected individuals.

Returns

`std::vector< epiworld::Agent<TSeq> * >`

15.42.2.3 initial_states()

```
template<typename TSeq >
ModelSIRCONN< TSeq > & ModelSIRCONN< TSeq >::initial_states (
    std::vector< double > proportions_,
    std::vector< int > queue_ = {} ) [inline], [virtual]
```

Set the initial states of the model.

Parameters

<i>proportions_↵</i>	Double vector with a single element:
—	<ul style="list-style-type: none"> The proportion of non-infected individuals who have recovered.

Reimplemented from [epiworld::Model< EPI_DEFAULT_TSEQ >](#).

15.42.2.4 reset()

```
template<typename TSeq >
void ModelSIRCONN< TSeq >::reset [inline], [virtual]
```

Reset the model.

Resetting the model will:

- clear the database
- restore the population (if `set_backup()` was called before)
- re-distribute tools
- re-distribute viruses
- set the date to 0

Reimplemented from `epiworld::Model< EPI_DEFAULT_TSEQ >`.

The documentation for this class was generated from the following file:

- `include/epiworld/models/sirconnected.hpp`

15.43 epiworld::epimodels::ModelSIRD< TSeq > Class Template Reference

Template for a Susceptible-Infected-Removed-Deceased (SIRD) model.

```
#include <epiworld.hpp>
```

Inheritance diagram for `epiworld::epimodels::ModelSIRD< TSeq >`:



Collaboration diagram for epiworld::epimodels::ModelSIRD< TSeq >:



Public Member Functions

- [ModelSIRD< TSeq >](#) & [initial_states](#) (std::vector< double > proportions_, std::vector< int > queue_={})
Set the initial states of the model.
- [ModelSIRD](#) ([ModelSIRD< TSeq >](#) &model, const std::string &vname, epiworld_double prevalence, epiworld_double transmission_rate, epiworld_double recovery_rate, epiworld_double death_rate)
Constructs a new SIRD model with the given parameters.
- **ModelSIRD** (const std::string &vname, epiworld_double prevalence, epiworld_double transmission_rate, epiworld_double recovery_rate, epiworld_double death_rate)

Additional Inherited Members

15.43.1 Detailed Description

```
template<typename TSeq = EPI_DEFAULT_TSEQ>
class epiworld::epimodels::ModelSIRD< TSeq >
```

Template for a Susceptible-Infected-Removed-Deceased (SIRD) model.

15.43.2 Constructor & Destructor Documentation

15.43.2.1 ModelSIRD()

```
template<typename TSeq >
ModelSIRD< TSeq >::ModelSIRD (
    ModelSIRD< TSeq > & model,
    const std::string & vname,
    epiworld_double prevalence,
    epiworld_double transmission_rate,
    epiworld_double recovery_rate,
    epiworld_double death_rate ) [inline]
```

Constructs a new SIRD model with the given parameters.

Parameters

<i>model</i>	The SIRD model to copy from.
<i>vname</i>	The name of the vertex associated with this model.
<i>prevalence</i>	The initial prevalence of the disease in the population.
<i>transmission_rate</i>	The rate at which the disease spreads from infected to susceptible individuals.
<i>recovery_rate</i>	The rate at which infected individuals recover and become immune.
<i>death_rate</i>	The rate at which infected individuals die.

15.43.3 Member Function Documentation

15.43.3.1 initial_states()

```
template<typename TSeq >
ModelSIRD< TSeq > & ModelSIRD< TSeq >::initial_states (
    std::vector< double > proportions_,
    std::vector< int > queue_ = {} ) [inline], [virtual]
```

Set the initial states of the model.

Parameters

<i>proportions_</i> ↔	Double vector with two elements:
—	<ul style="list-style-type: none"> • The proportion of non-infected individuals who have recovered. • The proportion of non-infected individuals who have died.

Reimplemented from [epiworld::Model< EPI_DEFAULT_TSEQ >](#).

The documentation for this class was generated from the following file:

- [epiworld.hpp](#)

15.44 ModelSIRD< TSeq > Class Template Reference

Template for a Susceptible-Infected-Removed-Deceased (SIRD) model.

```
#include <sird.hpp>
```

Inheritance diagram for ModelSIRD< TSeq >:



Collaboration diagram for ModelSIRD< TSeq >:



Public Member Functions

- [ModelSIRD](#) < TSeq > & [initial_states](#) (std::vector< double > proportions_, std::vector< int > queue_={})
Set the initial states of the model.
- [ModelSIRD](#) ([ModelSIRD](#) < TSeq > &model, const std::string &vname, epiworld_double prevalence, epiworld_double transmission_rate, epiworld_double recovery_rate, epiworld_double death_rate)
Constructs a new SIRD model with the given parameters.
- **ModelSIRD** (const std::string &vname, epiworld_double prevalence, epiworld_double transmission_rate, epiworld_double recovery_rate, epiworld_double death_rate)

Additional Inherited Members

15.44.1 Detailed Description

```
template<typename TSeq = EPI_DEFAULT_TSEQ>
class ModelSIRD< TSeq >
```

Template for a Susceptible-Infected-Removed-Deceased (SIRD) model.

15.44.2 Constructor & Destructor Documentation

15.44.2.1 ModelSIRD()

```
template<typename TSeq >
ModelSIRD< TSeq >::ModelSIRD (
    ModelSIRD< TSeq > & model,
    const std::string & vname,
    epiworld_double prevalence,
    epiworld_double transmission_rate,
    epiworld_double recovery_rate,
    epiworld_double death_rate ) [inline]
```

Constructs a new SIRD model with the given parameters.

Parameters

<i>model</i>	The SIRD model to copy from.
<i>vname</i>	The name of the vertex associated with this model.
<i>prevalence</i>	The initial prevalence of the disease in the population.
<i>transmission_rate</i>	The rate at which the disease spreads from infected to susceptible individuals.
<i>recovery_rate</i>	The rate at which infected individuals recover and become immune.
<i>death_rate</i>	The rate at which infected individuals die.

15.44.3 Member Function Documentation

15.44.3.1 initial_states()

```
template<typename TSeq >
ModelSIRD< TSeq > & ModelSIRD< TSeq >::initial_states (
    std::vector< double > proportions_,
    std::vector< int > queue_ = {} ) [inline], [virtual]
```

Set the initial states of the model.

Parameters

<i>proportions_</i>	Double vector with two elements:
—	<ul style="list-style-type: none"> • The proportion of non-infected individuals who have recovered. • The proportion of non-infected individuals who have died.

Reimplemented from [epiworld::Model< EPI_DEFAULT_TSEQ >](#).

The documentation for this class was generated from the following file:

- include/epiworld/models/sird.hpp

15.45 epiworld::epimodels::ModelSIRDCONN< TSeq > Class Template Reference

Inheritance diagram for epiworld::epimodels::ModelSIRDCONN< TSeq >:



Collaboration diagram for epiworld::epimodels::ModelSIRDCONN< TSeq >:



Public Member Functions

- [ModelSIRDCONN](#) ([ModelSIRDCONN](#)< TSeq > &model, const std::string &vname, epiworld_fast_uint n, epiworld_double prevalence, epiworld_double contact_rate, epiworld_double transmission_rate, epiworld_double recovery_rate, epiworld_double death_rate)

Template for a Susceptible-Infected-Removed (SIR) model.

- **ModelSIRDCONN** (const std::string &vname, ewiworld_fast_uint n, ewiworld_double prevalence, ewiworld_double contact_rate, ewiworld_double transmission_rate, ewiworld_double recovery_rate, ewiworld_double death_rate)
- **ModelSIRDCONN**< TSeq > & **run** (ewiworld_fast_uint ndays, int seed=-1)
Runs the simulation (after initialization)
- void **reset** ()
Reset the model.
- **Model**< TSeq > * **clone_ptr** ()
Advanced usage: Makes a copy of data and returns it as undeleted pointer.

Static Public Attributes

- static const int **SUSCEPTIBLE** = 0
- static const int **INFECTED** = 1
- static const int **RECOVERED** = 2
- static const int **DECEASED** = 3

Additional Inherited Members

15.45.1 Constructor & Destructor Documentation

15.45.1.1 ModelSIRDCONN()

```
template<typename TSeq >
ModelSIRDCONN< TSeq >::ModelSIRDCONN (
    ModelSIRDCONN< TSeq > & model,
    const std::string & vname,
    ewiworld_fast_uint n,
    ewiworld_double prevalence,
    ewiworld_double contact_rate,
    ewiworld_double transmission_rate,
    ewiworld_double recovery_rate,
    ewiworld_double death_rate ) [inline]
```

Template for a Susceptible-Infected-Removed (SIR) model.

Parameters

<i>model</i>	A Model<TSeq> object where to set up the SIR.
<i>vname</i>	std::string Name of the virus
<i>prevalence</i>	Initial prevalence (proportion)
<i>contact_rate</i>	Average number of contacts (interactions) per step.
<i>transmission_rate</i>	Probability of transmission
<i>recovery_rate</i>	Probability of recovery
<i>death_rate</i>	Probability of death

15.45.2 Member Function Documentation

15.45.2.1 clone_ptr()

```
template<typename TSeq >
Model< TSeq > * ModelSIRDCONN< TSeq >::clone_ptr [inline], [virtual]
```

Advanced usage: Makes a copy of data and returns it as undeleted pointer.

Parameters

<i>copy</i>	
-------------	--

Reimplemented from [epiworld::Model< EPI_DEFAULT_TSEQ >](#).

15.45.2.2 reset()

```
template<typename TSeq >
void ModelSIRDCONN< TSeq >::reset [inline], [virtual]
```

Reset the model.

Resetting the model will:

- clear the database
- restore the population (if `set_backup()` was called before)
- re-distribute tools
- re-distribute viruses
- set the date to 0

Reimplemented from [epiworld::Model< EPI_DEFAULT_TSEQ >](#).

The documentation for this class was generated from the following file:

- `epiworld.hpp`

15.46 ModelSIRDCONN< TSeq > Class Template Reference

Inheritance diagram for ModelSIRDCONN< TSeq >:



Collaboration diagram for ModelSIRDCONN< TSeq >:



Public Member Functions

- [ModelSIRDCONN](#) ([ModelSIRDCONN](#)< TSeq > &model, const std::string &vname, epiworld_fast_uint n, epiworld_double prevalence, epiworld_double contact_rate, epiworld_double transmission_rate, epiworld_double recovery_rate, epiworld_double death_rate)
Template for a Susceptible-Infected-Removed (SIR) model.
- **ModelSIRDCONN** (const std::string &vname, epiworld_fast_uint n, epiworld_double prevalence, epiworld_double contact_rate, epiworld_double transmission_rate, epiworld_double recovery_rate, epiworld_double death_rate)
- [ModelSIRDCONN](#)< TSeq > & [run](#) (epiworld_fast_uint ndays, int seed=-1)
Runs the simulation (after initialization)
- void [reset](#) ()
Reset the model.
- [Model](#)< TSeq > * [clone_ptr](#) ()
Advanced usage: Makes a copy of data and returns it as undeleted pointer.

Static Public Attributes

- static const int **SUSCEPTIBLE** = 0
- static const int **INFECTED** = 1
- static const int **RECOVERED** = 2
- static const int **DECEASED** = 3

Additional Inherited Members

15.46.1 Constructor & Destructor Documentation

15.46.1.1 ModelSIRDCONN()

```
template<typename TSeq >
ModelSIRDCONN< TSeq >::ModelSIRDCONN (
    ModelSIRDCONN< TSeq > & model,
    const std::string & vname,
    epiworld_uint n,
    epiworld_double prevalence,
    epiworld_double contact_rate,
    epiworld_double transmission_rate,
    epiworld_double recovery_rate,
    epiworld_double death_rate ) [inline]
```

Template for a Susceptible-Infected-Removed (SIR) model.

Parameters

<i>model</i>	A Model<TSeq> object where to set up the SIR.
<i>vname</i>	std::string Name of the virus
<i>prevalence</i>	Initial prevalence (proportion)
<i>contact_rate</i>	Average number of contacts (interactions) per step.
<i>transmission_rate</i>	Probability of transmission
<i>recovery_rate</i>	Probability of recovery
<i>death_rate</i>	Probability of death

15.46.2 Member Function Documentation

15.46.2.1 clone_ptr()

```
template<typename TSeq >
Model< TSeq > * ModelSIRDCONN< TSeq >::clone_ptr [inline], [virtual]
```

Advanced usage: Makes a copy of data and returns it as undeleted pointer.

Parameters

[copy](#)

Reimplemented from [epiworld::Model< EPI_DEFAULT_TSEQ >](#).

15.46.2.2 reset()

```
template<typename TSeq >
void ModelSIRDCONN< TSeq >::reset [inline], [virtual]
```

Reset the model.

Resetting the model will:

- clear the database
- restore the population (if `set_backup()` was called before)
- re-distribute tools
- re-distribute viruses
- set the date to 0

Reimplemented from [epiworld::Model< EPI_DEFAULT_TSEQ >](#).

The documentation for this class was generated from the following file:

- `include/epiworld/models/sirdconnected.hpp`

15.47 `epiworld::epimodels::ModelSIRLogit< TSeq >` Class Template Reference

Template for a Susceptible-Infected-Removed (SIR) model.

```
#include <epiworld.hpp>
```

Inheritance diagram for `epiworld::epimodels::ModelSIRLogit< TSeq >`:



Collaboration diagram for `epiworld::epimodels::ModelSIRLogit< TSeq >`:



Public Member Functions

- [ModelSIRLogit](#) ([ModelSIRLogit](#)< TSeq > &model, const std::string &vname, double *data, size_t ncols, std::vector< double > coefs_infect, std::vector< double > coefs_recover, std::vector< size_t > coef_infect_cols, std::vector< size_t > coef_recover_cols, epiworld_double transmission_rate, epiworld_double recovery_rate, epiworld_double prevalence)

Template for a Susceptible-Infected-Removed (SIR) model.

- **ModelSIRLogit** (const std::string &vname, double *data, size_t ncols, std::vector< double > coefs_infect, std::vector< double > coefs_recover, std::vector< size_t > coef_infect_cols, std::vector< size_t > coef_recover_cols, epiworld_double transmission_rate, epiworld_double recovery_rate, epiworld_double prevalence)
- [ModelSIRLogit](#)< TSeq > & [run](#) (epiworld_fast_uint ndays, int seed=-1)
Runs the simulation (after initialization)
- [Model](#)< TSeq > * [clone_ptr](#) ()
Advanced usage: Makes a copy of data and returns it as undeleted pointer.
- void [reset](#) ()
Reset the model.

Public Attributes

- std::vector< double > **coefs_infect**
- std::vector< double > **coefs_recover**
- std::vector< size_t > **coef_infect_cols**
- std::vector< size_t > **coef_recover_cols**

Additional Inherited Members

15.47.1 Detailed Description

```
template<typename TSeq = EPI_DEFAULT_TSEQ>
class epiworld::epimodels::ModelSIRLogit< TSeq >
```

Template for a Susceptible-Infected-Removed (SIR) model.

In this model, infection and recovery probabilities are computed using a logit model. Particularly, the probability of infection is computed as:

$$\frac{1}{1 + \exp(-(\beta_0 E_i + \sum_{i=1}^n \beta_i x_i))}$$

where β_0 is the exposure coefficient and E_i is the exposure number, β_i are the coefficients for the features x_i of the agents, and n is the number of features. The probability of recovery is computed as:

$$\frac{1}{1 + \exp(-(\sum_{i=1}^n \beta_i x_i))}$$

where β_i are the coefficients for the features x_i of the agents, and n is the number of features.

Parameters

<i>TSeq</i>	Type of the sequence (e.g. <code>std::vector</code> , <code>std::deque</code>)
-------------	---------------------------------------------------------------------------------

15.47.2 Constructor & Destructor Documentation

15.47.2.1 ModelSIRLogit()

```
template<typename TSeq >
ModelSIRLogit< TSeq >::ModelSIRLogit (
    ModelSIRLogit< TSeq > & model,
    const std::string & vname,
    double * data,
    size_t ncols,
    std::vector< double > coefs_infect,
    std::vector< double > coefs_recover,
    std::vector< size_t > coef_infect_cols,
    std::vector< size_t > coef_recover_cols,
    epiworld_double transmission_rate,
    epiworld_double recovery_rate,
    epiworld_double prevalence ) [inline]
```

Template for a Susceptible-Infected-Removed (SIR) model.

Parameters

<i>vname</i>	Name of the virus.
<i>coefs_infect</i>	Double ptr. Infection coefficients.
<i>coefs_recover</i>	Double ptr. Recovery coefficients.
<i>ncoenf_infect</i>	Unsigned int. Number of infection coefficients.
<i>ncoenf_recover</i>	Unsigned int. Number of recovery coefficients.
<i>coef_infect_cols</i>	Vector<unsigned int>. Ids of infection vars.
<i>coef_recover_cols</i>	Vector<unsigned int>. Ids of recover vars.

Parameters

<i>model</i>	A Model<TSeq> object where to set up the SIR.
<i>vname</i>	std::string Name of the virus
<i>prevalence</i>	Initial prevalence (proportion)
<i>contact_rate</i>	Average number of contacts (interactions) per step.
<i>prob_transmission</i>	Probability of transmission
<i>prob_recovery</i>	Probability of recovery

15.47.3 Member Function Documentation

15.47.3.1 clone_ptr()

```
template<typename TSeq >
Model< TSeq > * ModelSIRLogit< TSeq >::clone_ptr [inline], [virtual]
```

Advanced usage: Makes a copy of data and returns it as undeleted pointer.

Parameters

<i>copy</i>	
-------------	--

Reimplemented from [epiworld::Model< EPI_DEFAULT_TSEQ >](#).

15.47.3.2 reset()

```
template<typename TSeq >
void ModelSIRLogit< TSeq >::reset [inline], [virtual]
```

Reset the model.

Resetting the model will:

- clear the database
- restore the population (if `set_backup()` was called before)
- re-distribute tools
- re-distribute viruses
- set the date to 0

Reimplemented from [epiworld::Model< EPI_DEFAULT_TSEQ >](#).

The documentation for this class was generated from the following file:

- `epiworld.hpp`

15.48 ModelSIRLogit< TSeq > Class Template Reference

Template for a Susceptible-Infected-Removed (SIR) model.

```
#include <sirlogit.hpp>
```

Inheritance diagram for ModelSIRLogit< TSeq >:



Collaboration diagram for ModelSIRLogit< TSeq >:



Public Member Functions

- [ModelSIRLogit](#) ([ModelSIRLogit](#)< TSeq > &model, const std::string &vname, double *data, size_t ncols, std::vector< double > coefs_infect, std::vector< double > coefs_recover, std::vector< size_t > coef_infect_cols, std::vector< size_t > coef_recover_cols, epiworld_double transmission_rate, epiworld_double recovery_rate, epiworld_double prevalence)

Template for a Susceptible-Infected-Removed (SIR) model.

- **ModelSIRLogit** (const std::string &vname, double *data, size_t ncols, std::vector< double > coefs_infect, std::vector< double > coefs_recover, std::vector< size_t > coef_infect_cols, std::vector< size_t > coef_recover_cols, epiworld_double transmission_rate, epiworld_double recovery_rate, epiworld_double prevalence)
- [ModelSIRLogit](#)< TSeq > & [run](#) (epiworld_fast_uint ndays, int seed=-1)
Runs the simulation (after initialization)
- [Model](#)< TSeq > * [clone_ptr](#) ()
Advanced usage: Makes a copy of data and returns it as undeleted pointer.
- void [reset](#) ()
Reset the model.

Public Attributes

- `std::vector< double > coefs_infect`
- `std::vector< double > coefs_recover`
- `std::vector< size_t > coef_infect_cols`
- `std::vector< size_t > coef_recover_cols`

Additional Inherited Members

15.48.1 Detailed Description

```
template<typename TSeq = EPI_DEFAULT_TSEQ>
class ModelSIRLogit< TSeq >
```

Template for a Susceptible-Infected-Removed (SIR) model.

In this model, infection and recovery probabilities are computed using a logit model. Particularly, the probability of infection is computed as:

$$\frac{1}{1 + \exp(-(\beta_0 E_i + \sum_{i=1}^n \beta_i x_i))}$$

where β_0 is the exposure coefficient and E_i is the exposure number, β_i are the coefficients for the features x_i of the agents, and n is the number of features. The probability of recovery is computed as:

$$\frac{1}{1 + \exp(-(\sum_{i=1}^n \beta_i x_i))}$$

where β_i are the coefficients for the features x_i of the agents, and n is the number of features.

Parameters

<i>TSeq</i>	Type of the sequence (e.g. <code>std::vector</code> , <code>std::deque</code>)
-------------	---------------------------------------------------------------------------------

15.48.2 Constructor & Destructor Documentation

15.48.2.1 ModelSIRLogit()

```
template<typename TSeq >
ModelSIRLogit< TSeq >::ModelSIRLogit (
    ModelSIRLogit< TSeq > & model,
    const std::string & vname,
    double * data,
    size_t ncols,
```

```

std::vector< double > coefs_infect,
std::vector< double > coefs_recover,
std::vector< size_t > coef_infect_cols,
std::vector< size_t > coef_recover_cols,
epiworld_double transmission_rate,
epiworld_double recovery_rate,
epiworld_double prevalence ) [inline]

```

Template for a Susceptible-Infected-Removed (SIR) model.

Parameters

<i>vname</i>	Name of the virus.
<i>coefs_infect</i>	Double ptr. Infection coefficients.
<i>coefs_recover</i>	Double ptr. Recovery coefficients.
<i>ncoef_infect</i>	Unsigned int. Number of infection coefficients.
<i>ncoef_recover</i>	Unsigned int. Number of recovery coefficients.
<i>coef_infect_cols</i>	Vector<unsigned int>. Ids of infection vars.
<i>coef_recover_cols</i>	Vector<unsigned int>. Ids of recover vars.
<i>model</i>	A Model<TSeq> object where to set up the SIR.
<i>vname</i>	std::string Name of the virus
<i>prevalence</i>	Initial prevalence (proportion)
<i>contact_rate</i>	Average number of contacts (interactions) per step.
<i>prob_transmission</i>	Probability of transmission
<i>prob_recovery</i>	Probability of recovery

15.48.3 Member Function Documentation

15.48.3.1 clone_ptr()

```

template<typename TSeq >
Model< TSeq > * ModelSIRLogit< TSeq >::clone_ptr [inline], [virtual]

```

Advanced usage: Makes a copy of data and returns it as undeleted pointer.

Parameters

<i>copy</i>	
-------------	--

Reimplemented from [epiworld::Model< EPI_DEFAULT_TSEQ >](#).

15.48.3.2 reset()

```

template<typename TSeq >
void ModelSIRLogit< TSeq >::reset [inline], [virtual]

```

Reset the model.

Resetting the model will:

- clear the database
- restore the population (if `set_backup()` was called before)
- re-distribute tools
- re-distribute viruses
- set the date to 0

Reimplemented from [epiworld::Model< EPI_DEFAULT_TSEQ >](#).

The documentation for this class was generated from the following file:

- `include/epiworld/models/sirlogit.hpp`

15.49 epiworld::epimodels::ModelSIRMixing< TSeq > Class Template Reference

Inheritance diagram for `epiworld::epimodels::ModelSIRMixing< TSeq >`:



Collaboration diagram for `epiworld::epimodels::ModelSIRMixing< TSeq >`:



Public Member Functions

- `ModelSIRMixing` (`ModelSIRMixing< TSeq > &model`, `const std::string &vname`, `epiworld_fast_uint n`, `epiworld_double prevalence`, `epiworld_double contact_rate`, `epiworld_double transmission_rate`, `epiworld_double recovery_rate`, `std::vector< double > contact_matrix`)
Constructs a `ModelSIRMixing` object.
- `ModelSIRMixing` (`const std::string &vname`, `epiworld_fast_uint n`, `epiworld_double prevalence`, `epiworld_double contact_rate`, `epiworld_double transmission_rate`, `epiworld_double recovery_rate`, `std::vector< double > contact_matrix`)
Constructs a `ModelSIRMixing` object.
- `ModelSIRMixing< TSeq > &run` (`epiworld_fast_uint ndays`, `int seed=-1`)
Runs the simulation (after initialization)
- `void reset` ()
Reset the model.
- `Model< TSeq > * clone_ptr` ()
Advanced usage: Makes a copy of data and returns it as undeleted pointer.
- `ModelSIRMixing< TSeq > &initial_states` (`std::vector< double > proportions_`, `std::vector< int > queue_`, `_={}`)
Set the initial states of the model.
- `size_t get_n_infected` (`size_t group`) `const`
- `void set_contact_matrix` (`std::vector< double > cmat`)

Static Public Attributes

- `static const int SUSCEPTIBLE` = 0
- `static const int INFECTED` = 1
- `static const int RECOVERED` = 2

Additional Inherited Members

15.49.1 Constructor & Destructor Documentation

15.49.1.1 `ModelSIRMixing()` [1/2]

```
template<typename TSeq >
ModelSIRMixing< TSeq >::ModelSIRMixing (
    ModelSIRMixing< TSeq > & model,
    const std::string & vname,
    epiworld_fast_uint n,
    epiworld_double prevalence,
    epiworld_double contact_rate,
    epiworld_double transmission_rate,
    epiworld_double recovery_rate,
    std::vector< double > contact_matrix ) [inline]
```

Constructs a `ModelSIRMixing` object.

Template for a Susceptible-Exposed-Infected-Removed (SEIR) model.

Parameters

<i>model</i>	A reference to an existing ModelSIRMixing object.
<i>vname</i>	The name of the ModelSIRMixing object.
<i>n</i>	The number of entities in the model.
<i>prevalence</i>	The initial prevalence of the disease in the model.
<i>contact_rate</i>	The contact rate between entities in the model.
<i>transmission_rate</i>	The transmission rate of the disease in the model.
<i>recovery_rate</i>	The recovery rate of the disease in the model.
<i>contact_matrix</i>	The contact matrix between entities in the model.
<i>model</i>	A Model<TSeq> object where to set up the SIR.
<i>vname</i>	std::string Name of the virus
<i>prevalence</i>	Initial prevalence (proportion)
<i>contact_rate</i>	Average number of contacts (interactions) per step.
<i>transmission_rate</i>	Probability of transmission
<i>recovery_rate</i>	Probability of recovery

15.49.1.2 ModelSIRMixing() [2/2]

```
template<typename TSeq >
ModelSIRMixing< TSeq >::ModelSIRMixing (
    const std::string & vname,
    epiworld_fast_uint n,
    epiworld_double prevalence,
    epiworld_double contact_rate,
    epiworld_double transmission_rate,
    epiworld_double recovery_rate,
    std::vector< double > contact_matrix ) [inline]
```

Constructs a [ModelSIRMixing](#) object.

Parameters

<i>vname</i>	The name of the ModelSIRMixing object.
<i>n</i>	The number of entities in the model.
<i>prevalence</i>	The initial prevalence of the disease in the model.
<i>contact_rate</i>	The contact rate between entities in the model.
<i>transmission_rate</i>	The transmission rate of the disease in the model.
<i>recovery_rate</i>	The recovery rate of the disease in the model.
<i>contact_matrix</i>	The contact matrix between entities in the model.

15.49.2 Member Function Documentation

15.49.2.1 `clone_ptr()`

```
template<typename TSeq >
Model< TSeq > * ModelSIRMixing< TSeq >::clone_ptr [inline], [virtual]
```

Advanced usage: Makes a copy of data and returns it as undeleted pointer.

Parameters

<i>copy</i>	
-------------	--

Reimplemented from `epiworld::Model< EPI_DEFAULT_TSEQ >`.

15.49.2.2 `initial_states()`

```
template<typename TSeq >
ModelSIRMixing< TSeq > & ModelSIRMixing< TSeq >::initial_states (
    std::vector< double > proportions_,
    std::vector< int > queue_ = {} ) [inline], [virtual]
```

Set the initial states of the model.

Parameters

<i>proportions_</i> ↩	Double vector with a single element:
—	<ul style="list-style-type: none"> The proportion of non-infected individuals who have recovered.

Reimplemented from `epiworld::Model< EPI_DEFAULT_TSEQ >`.

15.49.2.3 `reset()`

```
template<typename TSeq >
void ModelSIRMixing< TSeq >::reset [inline], [virtual]
```

Reset the model.

Resetting the model will:

- clear the database
- restore the population (if `set_backup()` was called before)
- re-distribute tools
- re-distribute viruses
- set the date to 0

Reimplemented from `epiworld::Model< EPI_DEFAULT_TSEQ >`.

The documentation for this class was generated from the following file:

- `epiworld.hpp`

15.50 ModelSIRMixing< TSeq > Class Template Reference

Inheritance diagram for ModelSIRMixing< TSeq >:



Collaboration diagram for ModelSIRMixing< TSeq >:



Public Member Functions

- [ModelSIRMixing](#) ([ModelSIRMixing](#)< TSeq > &model, const std::string &vname, epiworld_fast_uint n, epiworld_double prevalence, epiworld_double contact_rate, epiworld_double transmission_rate, epiworld_double recovery_rate, std::vector< double > contact_matrix)
Constructs a [ModelSIRMixing](#) object.
- [ModelSIRMixing](#) (const std::string &vname, epiworld_fast_uint n, epiworld_double prevalence, epiworld_double contact_rate, epiworld_double transmission_rate, epiworld_double recovery_rate, std::vector< double > contact_matrix)
Constructs a [ModelSIRMixing](#) object.
- [ModelSIRMixing](#)< TSeq > & [run](#) (epiworld_fast_uint ndays, int seed=-1)
Runs the simulation (after initialization)
- void [reset](#) ()
Reset the model.
- [Model](#)< TSeq > * [clone_ptr](#) ()
Advanced usage: Makes a copy of data and returns it as undeleted pointer.

- [ModelSIRMixing](#)< TSeq > & [initial_states](#) (std::vector< double > proportions_, std::vector< int > queue_ ←
_={})
Set the initial states of the model.
- size_t **get_n_infected** (size_t group) const
- void **set_contact_matrix** (std::vector< double > cmat)

Static Public Attributes

- static const int **SUSCEPTIBLE** = 0
- static const int **INFECTED** = 1
- static const int **RECOVERED** = 2

Additional Inherited Members

15.50.1 Constructor & Destructor Documentation

15.50.1.1 ModelSIRMixing() [1/2]

```
template<typename TSeq >
ModelSIRMixing< TSeq >::ModelSIRMixing (
    ModelSIRMixing< TSeq > & model,
    const std::string & vname,
    epiworld_uint n,
    epiworld_double prevalence,
    epiworld_double contact_rate,
    epiworld_double transmission_rate,
    epiworld_double recovery_rate,
    std::vector< double > contact_matrix ) [inline]
```

Constructs a [ModelSIRMixing](#) object.

Template for a Susceptible-Exposed-Infected-Removed (SEIR) model.

Parameters

<i>model</i>	A reference to an existing ModelSIRMixing object.
<i>vname</i>	The name of the ModelSIRMixing object.
<i>n</i>	The number of entities in the model.
<i>prevalence</i>	The initial prevalence of the disease in the model.
<i>contact_rate</i>	The contact rate between entities in the model.
<i>transmission_rate</i>	The transmission rate of the disease in the model.
<i>recovery_rate</i>	The recovery rate of the disease in the model.
<i>contact_matrix</i>	The contact matrix between entities in the model.
<i>model</i>	A Model<TSeq> object where to set up the SIR.
<i>vname</i>	std::string Name of the virus
<i>prevalence</i>	Initial prevalence (proportion)
<i>contact_rate</i>	Average number of contacts (interactions) per step.
<i>transmission_rate</i>	Probability of transmission
<i>recovery_rate</i>	Probability of recovery

15.50.1.2 ModelSIRMixing() [2/2]

```
template<typename TSeq >
ModelSIRMixing< TSeq >::ModelSIRMixing (
    const std::string & vname,
    epiworld_fast_uint n,
    epiworld_double prevalence,
    epiworld_double contact_rate,
    epiworld_double transmission_rate,
    epiworld_double recovery_rate,
    std::vector< double > contact_matrix ) [inline]
```

Constructs a [ModelSIRMixing](#) object.

Parameters

<i>vname</i>	The name of the ModelSIRMixing object.
<i>n</i>	The number of entities in the model.
<i>prevalence</i>	The initial prevalence of the disease in the model.
<i>contact_rate</i>	The contact rate between entities in the model.
<i>transmission_rate</i>	The transmission rate of the disease in the model.
<i>recovery_rate</i>	The recovery rate of the disease in the model.
<i>contact_matrix</i>	The contact matrix between entities in the model.

15.50.2 Member Function Documentation

15.50.2.1 clone_ptr()

```
template<typename TSeq >
Model< TSeq > * ModelSIRMixing< TSeq >::clone_ptr [inline], [virtual]
```

Advanced usage: Makes a copy of data and returns it as undeleted pointer.

Parameters

<i>copy</i>	
-------------	--

Reimplemented from [epiworld::Model< EPI_DEFAULT_TSEQ >](#).

15.50.2.2 initial_states()

```
template<typename TSeq >
ModelSIRMixing< TSeq > & ModelSIRMixing< TSeq >::initial_states (
```

```
std::vector< double > proportions_,
std::vector< int > queue_ = {} ) [inline], [virtual]
```

Set the initial states of the model.

Parameters

<code>proportions_</code>	Double vector with a single element:
—	<ul style="list-style-type: none"> The proportion of non-infected individuals who have recovered.

Reimplemented from [epiworld::Model< EPI_DEFAULT_TSEQ >](#).

15.50.2.3 `reset()`

```
template<typename TSeq >
void ModelSIRMixing< TSeq >::reset [inline], [virtual]
```

Reset the model.

Resetting the model will:

- clear the database
- restore the population (if `set_backup()` was called before)
- re-distribute tools
- re-distribute viruses
- set the date to 0

Reimplemented from [epiworld::Model< EPI_DEFAULT_TSEQ >](#).

The documentation for this class was generated from the following file:

- `include/epiworld/models/sirmixing.hpp`

15.51 `epiworld::epimodels::ModelSIS< TSeq >` Class Template Reference

Template for a Susceptible-Infected-Susceptible (SIS) model.

```
#include <epiworld.hpp>
```

Inheritance diagram for `epiworld::epimodels::ModelSIS< TSeq >`:



Collaboration diagram for `epiworld::epimodels::ModelSIS< TSeq >`:



Public Member Functions

- **ModelSIS** ([ModelSIS](#)< TSeq > &model, const std::string &vname, epiworld_double prevalence, epiworld_double transmission_rate, epiworld_double recovery_rate)
- **ModelSIS** (const std::string &vname, epiworld_double prevalence, epiworld_double transmission_rate, epiworld_double recovery_rate)

Static Public Attributes

- static const int **SUSCEPTIBLE** = 0
- static const int **INFECTED** = 1

Additional Inherited Members

15.51.1 Detailed Description

```
template<typename TSeq = EPI_DEFAULT_TSEQ>  
class epiworld::epimodels::ModelSIS< TSeq >
```

Template for a Susceptible-Infected-Susceptible (SIS) model.

Parameters

<i>vname</i>	std::string Name of the virus
<i>initial_prevalence</i>	epiworld_double Initial prevalence
<i>initial_efficacy</i>	epiworld_double Initial susceptibility_reduction of the immune system
<i>initial_recovery</i>	epiworld_double Initial recovery_rate rate of the immune system

The documentation for this class was generated from the following file:

- epiworld.hpp

15.52 ModelSIS< TSeq > Class Template Reference

Template for a Susceptible-Infected-Susceptible (SIS) model.

```
#include <sis.hpp>
```

Inheritance diagram for ModelSIS< TSeq >:



Collaboration diagram for ModelSIS< TSeq >:



Public Member Functions

- **ModelSIS** ([ModelSIS](#)< TSeq > &model, const std::string &vname, epiworld_double prevalence, epiworld_double transmission_rate, epiworld_double recovery_rate)
- **ModelSIS** (const std::string &vname, epiworld_double prevalence, epiworld_double transmission_rate, epiworld_double recovery_rate)

Static Public Attributes

- static const int **SUSCEPTIBLE** = 0
- static const int **INFECTED** = 1

Additional Inherited Members

15.52.1 Detailed Description

```
template<typename TSeq = EPI_DEFAULT_TSEQ>
class ModelSIS< TSeq >
```

Template for a Susceptible-Infected-Susceptible (SIS) model.

Parameters

<i>vname</i>	std::string Name of the virus
<i>initial_prevalence</i>	epiworld_double Initial prevalence
<i>initial_efficiency</i>	epiworld_double Initial susceptibility_reduction of the immune system
<i>initial_recovery</i>	epiworld_double Initial recovery_rate rate of the immune system

The documentation for this class was generated from the following file:

- include/epiworld/models/sis.hpp

15.53 epiworld::epimodels::ModelSISD< TSeq > Class Template Reference

Template for a Susceptible-Infected-Susceptible-Deceased (SISD) model.

```
#include <epiworld.hpp>
```

Inheritance diagram for `epiworld::epimodels::ModelSISD< TSeq >`:



Collaboration diagram for `epiworld::epimodels::ModelSISD< TSeq >`:



Public Member Functions

- **ModelSISD** ([ModelSISD](#)< TSeq > &model, const std::string &vname, epiworld_double prevalence, epiworld_double transmission_rate, epiworld_double recovery_rate, epiworld_double death_rate)
- **ModelSISD** (const std::string &vname, epiworld_double prevalence, epiworld_double transmission_rate, epiworld_double recovery_rate, epiworld_double death_rate)

Additional Inherited Members

15.53.1 Detailed Description

```
template<typename TSeq = EPI_DEFAULT_TSEQ>
class epiworld::epimodels::ModelSISD< TSeq >
```

Template for a Susceptible-Infected-Susceptible-Deceased (SISD) model.

Parameters

<i>vname</i>	std::string Name of the virus
<i>initial_prevalence</i>	epiworld_double Initial prevalence
<i>initial_efficacy</i>	epiworld_double Initial susceptibility_reduction of the immune system
<i>initial_recovery</i>	epiworld_double Initial recovery_rate rate of the immune system
<i>inital_death</i>	epiworld_double Initial death_rate of the immune system

The documentation for this class was generated from the following file:

- epiworld.hpp

15.54 ModelSISD< TSeq > Class Template Reference

Template for a Susceptible-Infected-Susceptible-Deceased (SISD) model.

```
#include <sisd.hpp>
```

Inheritance diagram for ModelSISD< TSeq >:



Collaboration diagram for ModelSISD< TSeq >:



Public Member Functions

- **ModelSISD** ([ModelSISD](#)< TSeq > &model, const std::string &vname, epiworld_double prevalence, epiworld_double transmission_rate, epiworld_double recovery_rate, epiworld_double death_rate)
- **ModelSISD** (const std::string &vname, epiworld_double prevalence, epiworld_double transmission_rate, epiworld_double recovery_rate, epiworld_double death_rate)

Additional Inherited Members

15.54.1 Detailed Description

```
template<typename TSeq = EPI_DEFAULT_TSEQ>
class ModelSISD< TSeq >
```

Template for a Susceptible-Infected-Susceptible-Deceased (SISD) model.

Parameters

<i>vname</i>	std::string Name of the virus
<i>initial_prevalence</i>	epiworld_double Initial prevalence
<i>initial_efficiency</i>	epiworld_double Initial susceptibility_reduction of the immune system
<i>initial_recovery</i>	epiworld_double Initial recovery_rate rate of the immune system
<i>initial_death</i>	epiworld_double Initial death_rate of the immune system

The documentation for this class was generated from the following file:

- include/epiworld/models/sisd.hpp

15.55 epiworld::epimodels::ModelSURV< TSeq > Class Template Reference

Inheritance diagram for epiworld::epimodels::ModelSURV< TSeq >:



Collaboration diagram for epiworld::epimodels::ModelSURV< TSeq >:



Public Member Functions

- void [reset](#) ()
Reset the model.

Construct a new ModelSURV object

The [ModelSURV](#) class simulates a surveillance model where agents can be isolated, even if asymptomatic.

Parameters

vname	String. Name of the virus
prevalence	Integer. Number of initial cases of the virus.
efficacy_vax	Double. Efficacy of the vaccine ($1 - P(\text{acquire the disease})$).
latent_period	Double. Shape parameter of a <i>Gamma</i> (latent_period, 1) distribution. This coincides with the expected number of latent days.
infect_period	Double. Shape parameter of a <i>Gamma</i> (infected_period, 1) distribution. This coincides with the expected number of infectious days.
prob_symptoms	Double. Probability of generating symptoms.
prop_vaccinated	Double. Probability of vaccination. Coincides with the initial prevalence of vaccinated individuals.
prop_vax_redux_transm	Double. Factor by which the vaccine reduces transmissibility.
prop_vax_redux_infect	Double. Factor by which the vaccine reduces the chances of becoming infected.
surveillance_prob	Double. Probability of testing an agent.
prob_transmission	Double. Raw transmission probability.
prob_death	Double. Raw probability of death for symptomatic individuals.
prob_noreinfect	Double. Probability of no re-infection.

This model features the following states:

- Susceptible
- Latent
- Symptomatic
- Symptomatic isolated

- *Asymptomatic*
- *Asymptomatic isolated*
- *Recovered*
- *Removed*

Returns

An object of class `epiworld_surv`

- **ModelSURV** ()
- **ModelSURV** ([ModelSURV](#)< TSeq > &model, const std::string &vname, epiworld_fast_uint prevalence=50, epiworld_double efficacy_vax=0.9, epiworld_double latent_period=3u, epiworld_double infect_↵_period=6u, epiworld_double prob_symptoms=0.6, epiworld_double prop_vaccinated=0.25, epiworld_↵_double prop_vax_redux_transm=0.5, epiworld_double prop_vax_redux_infect=0.5, epiworld_double surveillance_prob=0.001, epiworld_double prob_transmission=1.0, epiworld_double prob_death=0.001, epiworld_double prob_noreinfect=0.9)
- **ModelSURV** (const std::string &vname, epiworld_fast_uint prevalence=50, epiworld_double efficacy_↵_vax=0.9, epiworld_double latent_period=3u, epiworld_double infect_period=6u, epiworld_double prob_↵_symptoms=0.6, epiworld_double prop_vaccinated=0.25, epiworld_double prop_vax_redux_transm=0.5, epiworld_double prop_vax_redux_infect=0.5, epiworld_double surveillance_prob=0.001, epiworld_double prob_transmission=1.0, epiworld_double prob_death=0.001, epiworld_double prob_noreinfect=0.9)

Public Attributes

- std::vector< epiworld_double > [days_latent_and_infectious](#)
Vector of days spent in latent and infectious states A row-major matrix.

Additional Inherited Members

15.55.1 Member Function Documentation

15.55.1.1 reset()

```
template<typename TSeq >
void ModelSURV< TSeq >::reset [inline], [virtual]
```

Reset the model.

Resetting the model will:

- clear the database
- restore the population (if `set_backup()` was called before)
- re-distribute tools
- re-distribute viruses
- set the date to 0

Reimplemented from [epiworld::Model< EPI_DEFAULT_TSEQ >](#).

The documentation for this class was generated from the following file:

- `epiworld.hpp`

15.56 ModelSURV< TSeq > Class Template Reference

Inheritance diagram for ModelSURV< TSeq >:



Collaboration diagram for ModelSURV< TSeq >:



Public Member Functions

- void [reset](#) ()
Reset the model.

Construct a new ModelSURV object

The [ModelSURV](#) class simulates a surveillance model where agents can be isolated, even if asymptomatic.

Parameters

vname	<i>String. Name of the virus</i>
prevalence	<i>Integer. Number of initial cases of the virus.</i>
efficacy_vax	<i>Double. Efficacy of the vaccine (1 - P(acquire the disease)).</i>
latent_period	<i>Double. Shape parameter of a Gamma (latent_period, 1) distribution. This coincides with the expected number of latent days.</i>

Parameters

infect_period	<i>Double. Shape parameter of a Gamma (infected_period, 1) distribution. This coincides with the expected number of infectious days.</i>
prob_symptoms	<i>Double. Probability of generating symptoms.</i>
prop_vaccinated	<i>Double. Probability of vaccination. Coincides with the initial prevalence of vaccinated individuals.</i>
prop_vax_redux_transm	<i>Double. Factor by which the vaccine reduces transmissibility.</i>
prop_vax_redux_infect	<i>Double. Factor by which the vaccine reduces the chances of becoming infected.</i>
surveillance_prob	<i>Double. Probability of testing an agent.</i>
prob_transmission	<i>Double. Raw transmission probability.</i>
prob_death	<i>Double. Raw probability of death for symptomatic individuals.</i>
prob_noreinfect	<i>Double. Probability of no re-infection.</i>

This model features the following states:

- *Susceptible*
- *Latent*
- *Symptomatic*
- *Symptomatic isolated*
- *Asymptomatic*
- *Asymptomatic isolated*
- *Recovered*
- *Removed*

Returns

An object of class `epiworld_surv`

- **ModelSURV** ()
- **ModelSURV** ([ModelSURV](#) < TSeq > &model, const std::string &vname, epiworld_fast_uint prevalence=50, epiworld_double efficacy_vax=0.9, epiworld_double latent_period=3u, epiworld_double infect_↵_period=6u, epiworld_double prob_symptoms=0.6, epiworld_double prop_vaccinated=0.25, epiworld_↵_double prop_vax_redux_transm=0.5, epiworld_double prop_vax_redux_infect=0.5, epiworld_double surveillance_prob=0.001, epiworld_double prob_transmission=1.0, epiworld_double prob_death=0.001, epiworld_double prob_noreinfect=0.9)
- **ModelSURV** (const std::string &vname, epiworld_fast_uint prevalence=50, epiworld_double efficacy_↵_vax=0.9, epiworld_double latent_period=3u, epiworld_double infect_period=6u, epiworld_double prob_↵_symptoms=0.6, epiworld_double prop_vaccinated=0.25, epiworld_double prop_vax_redux_transm=0.5, epiworld_double prop_vax_redux_infect=0.5, epiworld_double surveillance_prob=0.001, epiworld_double prob_transmission=1.0, epiworld_double prob_death=0.001, epiworld_double prob_noreinfect=0.9)

Public Attributes

- std::vector< epiworld_double > [days_latent_and_infectious](#)
Vector of days spent in latent and infectious states A row-major matrix.

Additional Inherited Members**15.56.1 Member Function Documentation**

15.56.1.1 reset()

```
template<typename TSeq >
void ModelSURV< TSeq >::reset [inline], [virtual]
```

Reset the model.

Resetting the model will:

- clear the database
- restore the population (if `set_backup()` was called before)
- re-distribute tools
- re-distribute viruses
- set the date to 0

Reimplemented from [epiworld::Model< EPI_DEFAULT_TSEQ >](#).

The documentation for this class was generated from the following file:

- `include/epiworld/models/surveillance.hpp`

15.57 Network< Nettype, Nodetype, Edgetype > Class Template Reference

Public Member Functions

- **NType** ()
- Edgetype **operator()** (int i, int j)
- bool **is_directed** () const
- size_t **vcount** () const
- size_t **ecount** () const
- void **add_edge** (int i, int j)
- void **rm_edge** (int i, int j)

The documentation for this class was generated from the following file:

- `include/epiworld/network-bones.hpp`

15.58 epiworld::PersonTools< TSeq > Class Template Reference

The documentation for this class was generated from the following file:

- `epiworld.hpp`

15.59 PersonTools< TSeq > Class Template Reference

The documentation for this class was generated from the following file:

- include/epiworld/config.hpp

15.60 epiworld::Progress Class Reference

A simple progress bar.

```
#include <epiworld.hpp>
```

Public Member Functions

- **Progress** (int n_, int width_)
- void **start** ()
- void **next** ()
- void **end** ()

15.60.1 Detailed Description

A simple progress bar.

The documentation for this class was generated from the following file:

- epiworld.hpp

15.61 Progress Class Reference

A simple progress bar.

```
#include <progress.hpp>
```

Public Member Functions

- **Progress** (int n_, int width_)
- void **start** ()
- void **next** ()
- void **end** ()

15.61.1 Detailed Description

A simple progress bar.

The documentation for this class was generated from the following file:

- include/epiworld/progress.hpp

15.62 epiworld::Queue< TSeq > Class Template Reference

Controls which agents are verified at each step.

```
#include <epiworld.hpp>
```

Public Member Functions

- void **operator+=** ([Agent](#)< TSeq > *p)
- void **operator-=** ([Agent](#)< TSeq > *p)
- epiworld_fast_int & **operator[]** (epiworld_fast_uint i)
- void **reset** ()
- bool **operator==** (const [Queue](#)< TSeq > &other) const
- bool **operator!=** (const [Queue](#)< TSeq > &other) const

Static Public Attributes

- static const int **NoOne** = 0
- static const int **OnlySelf** = 1
- static const int **Everyone** = 2

Friends

- class **Model**< TSeq >

15.62.1 Detailed Description

```
template<typename TSeq>
class epiworld::Queue< TSeq >
```

Controls which agents are verified at each step.

The idea is that only agents who are either in an infected state or have an infected neighbor should be checked. Otherwise it makes no sense (no chance to recover or capture the disease).

Template Parameters

<i>TSeq</i>	
-------------	--

The documentation for this class was generated from the following file:

- epiworld.hpp

15.63 Queue< TSeq > Class Template Reference

Controls which agents are verified at each step.

```
#include <queue-bones.hpp>
```

Public Member Functions

- void **operator+=** ([Agent](#)< TSeq > *p)
- void **operator-=** ([Agent](#)< TSeq > *p)
- [epiworld_fast_int](#) & **operator[]** ([epiworld_fast_uint](#) i)
- void **reset** ()
- bool **operator==** (const [Queue](#)< TSeq > &other) const
- bool **operator!=** (const [Queue](#)< TSeq > &other) const

Static Public Attributes

- static const int **NoOne** = 0
- static const int **OnlySelf** = 1
- static const int **Everyone** = 2

Friends

- class **Model**< TSeq >

15.63.1 Detailed Description

```
template<typename TSeq>
class Queue< TSeq >
```

Controls which agents are verified at each step.

The idea is that only agents who are either in an infected state or have an infected neighbor should be checked. Otherwise it makes no sense (no chance to recover or capture the disease).

Template Parameters

<i>TSeq</i>	
-------------	--

The documentation for this class was generated from the following files:

- include/epiworld/agent-bones.hpp
- include/epiworld/queue-bones.hpp

15.64 RandGraph Class Reference

Public Member Functions

- **RandGraph** (int N_)
- void **init** (int s)
- void **set_rand_engine** (std::shared_ptr< std::mt19937 > &e)
- [epiworld_double](#) **runif** ()

The documentation for this class was generated from the following file:

- include/epiworld/random_graph.hpp

15.65 epiworld::SAMPLETYPE Class Reference

Static Public Attributes

- static const int **MODEL** = 0
- static const int **ENTITY** = 1
- static const int **AGENT** = 2

The documentation for this class was generated from the following file:

- epiworld.hpp

15.66 SAMPLETYPE Class Reference

Static Public Attributes

- static const int **MODEL** = 0
- static const int **ENTITY** = 1
- static const int **AGENT** = 2

The documentation for this class was generated from the following file:

- include/epiworld/agentssample-bones.hpp

15.67 epiworld::Tool< TSeq > Class Template Reference

[Tools](#) for defending the agent against the virus.

```
#include <epiworld.hpp>
```

Public Member Functions

- **Tool** (std::string name="unknown tool")
- **Tool** (std::string name, epiworld_double prevalence, bool as_proportion)
- void **set_sequence** (TSeq d)
- void **set_sequence** (std::shared_ptr< TSeq > d)
- **EPI_TYPENAME_TRAITS** (TSeq, int) get_sequence()
- void **set_name** (std::string name)
- std::string **get_name** () const
- [Agent](#)< TSeq > * **get_agent** ()
- int **get_id** () const
- void **set_id** (int id)
- void **set_date** (int d)
- int **get_date** () const
- void **set_state** (epiworld_fast_int init, epiworld_fast_int post)
- void **set_queue** (epiworld_fast_int init, epiworld_fast_int post)
- void **get_state** (epiworld_fast_int *init, epiworld_fast_int *post)
- void **get_queue** (epiworld_fast_int *init, epiworld_fast_int *post)
- bool **operator==** (const [Tool](#)< TSeq > &other) const
- bool **operator!=** (const [Tool](#)< TSeq > &other) const
- void **print** () const
- void **distribute** ([Model](#)< TSeq > *model)
- void **set_distribution** (ToolToAgentFun< TSeq > fun)

Get and set the tool functions

Parameters

v	<i>The virus over which to operate</i>
fun	<i>the function to be used</i>

*Returns**epiworld_double*

- epiworld_double **get_susceptibility_reduction** (VirusPtr< TSeq > v, [Model](#)< TSeq > *model)
- epiworld_double **get_transmission_reduction** (VirusPtr< TSeq > v, [Model](#)< TSeq > *model)
- epiworld_double **get_recovery_enhancer** (VirusPtr< TSeq > v, [Model](#)< TSeq > *model)
- epiworld_double **get_death_reduction** (VirusPtr< TSeq > v, [Model](#)< TSeq > *model)
- void **set_susceptibility_reduction_fun** (ToolFun< TSeq > fun)
- void **set_transmission_reduction_fun** (ToolFun< TSeq > fun)
- void **set_recovery_enhancer_fun** (ToolFun< TSeq > fun)
- void **set_death_reduction_fun** (ToolFun< TSeq > fun)
- void **set_susceptibility_reduction** (epiworld_double *prob)
- void **set_transmission_reduction** (epiworld_double *prob)
- void **set_recovery_enhancer** (epiworld_double *prob)
- void **set_death_reduction** (epiworld_double *prob)
- void **set_susceptibility_reduction** (epiworld_double prob)
- void **set_transmission_reduction** (epiworld_double prob)
- void **set_recovery_enhancer** (epiworld_double prob)
- void **set_death_reduction** (epiworld_double prob)

Friends

- class **Agent**< TSeq >
- class **Model**< TSeq >
- void **default_add_tool** ([Event](#)< TSeq > &a, [Model](#)< TSeq > *m)
- void **default_rm_tool** ([Event](#)< TSeq > &a, [Model](#)< TSeq > *m)

15.67.1 Detailed Description

```
template<typename TSeq>
class epiworld::Tool< TSeq >
```

[Tools](#) for defending the agent against the virus.

Template Parameters

<i>TSeq</i>	Type of sequence
-------------	------------------

The documentation for this class was generated from the following file:

- epiworld.hpp

15.68 Tool< TSeq > Class Template Reference

[Tools](#) for defending the agent against the virus.

```
#include <tool-bones.hpp>
```


Public Member Functions

- **Tool** (std::string name="unknown tool")
- **Tool** (std::string name, epiworld_double prevalence, bool as_proportion)
- void **set_sequence** (TSeq d)
- void **set_sequence** (std::shared_ptr< TSeq > d)
- **EPI_TYPENAME_TRAITS** (TSeq, int) get_sequence()
- void **set_name** (std::string name)
- std::string **get_name** () const
- [Agent](#)< TSeq > * **get_agent** ()
- int **get_id** () const
- void **set_id** (int id)
- void **set_date** (int d)
- int **get_date** () const
- void **set_state** (epiworld_fast_int init, epiworld_fast_int post)
- void **set_queue** (epiworld_fast_int init, epiworld_fast_int post)
- void **get_state** (epiworld_fast_int *init, epiworld_fast_int *post)
- void **get_queue** (epiworld_fast_int *init, epiworld_fast_int *post)
- bool **operator==** (const [Tool](#)< TSeq > &other) const
- bool **operator!=** (const [Tool](#)< TSeq > &other) const
- void **print** () const
- void **distribute** ([Model](#)< TSeq > *model)
- void **set_distribution** (ToolToAgentFun< TSeq > fun)
- void **set_sequence** (int d)
- bool **operator==** (const [Tool](#)< std::vector< int >> &other) const
- void **set_sequence** (int d)
- bool **operator==** (const [Tool](#)< std::vector< int >> &other) const

Get and set the tool functions

Parameters

v	<i>The virus over which to operate</i>
fun	<i>the function to be used</i>

Returns

epiworld_double

- epiworld_double **get_susceptibility_reduction** (VirusPtr< TSeq > v, [Model](#)< TSeq > *model)
- epiworld_double **get_transmission_reduction** (VirusPtr< TSeq > v, [Model](#)< TSeq > *model)
- epiworld_double **get_recovery_enhancer** (VirusPtr< TSeq > v, [Model](#)< TSeq > *model)
- epiworld_double **get_death_reduction** (VirusPtr< TSeq > v, [Model](#)< TSeq > *model)
- void **set_susceptibility_reduction_fun** (ToolFun< TSeq > fun)
- void **set_transmission_reduction_fun** (ToolFun< TSeq > fun)
- void **set_recovery_enhancer_fun** (ToolFun< TSeq > fun)
- void **set_death_reduction_fun** (ToolFun< TSeq > fun)
- void **set_susceptibility_reduction** (epiworld_double *prob)
- void **set_transmission_reduction** (epiworld_double *prob)
- void **set_recovery_enhancer** (epiworld_double *prob)
- void **set_death_reduction** (epiworld_double *prob)
- void **set_susceptibility_reduction** (epiworld_double prob)
- void **set_transmission_reduction** (epiworld_double prob)
- void **set_recovery_enhancer** (epiworld_double prob)
- void **set_death_reduction** (epiworld_double prob)

Friends

- class **Agent**< TSeq >
- class **Model**< TSeq >
- void **default_add_tool** ([Event](#)< TSeq > &a, [Model](#)< TSeq > *m)
- void **default_rm_tool** ([Event](#)< TSeq > &a, [Model](#)< TSeq > *m)

15.68.1 Detailed Description

```
template<typename TSeq>
class Tool< TSeq >
```

[Tools](#) for defending the agent against the virus.

Template Parameters

<i>TSeq</i>	Type of sequence
-------------	------------------

The documentation for this class was generated from the following files:

- include/epiworld/agent-bones.hpp
- include/epiworld/tool-bones.hpp
- include/epiworld/tool-meat.hpp

15.69 epiworld::ToolFunctions< TSeq > Class Template Reference

Helper class to store the functions avoiding multiple shared_pointers (we have only one for the four of these)

```
#include <epiworld.hpp>
```

Public Attributes

- ToolFun< TSeq > **susceptibility_reduction** = nullptr
- ToolFun< TSeq > **transmission_reduction** = nullptr
- ToolFun< TSeq > **recovery_enhancer** = nullptr
- ToolFun< TSeq > **death_reduction** = nullptr
- ToolToAgentFun< TSeq > **dist** = nullptr

15.69.1 Detailed Description

```
template<typename TSeq>
class epiworld::ToolFunctions< TSeq >
```

Helper class to store the functions avoiding multiple shared_pointers (we have only one for the four of these)

The documentation for this class was generated from the following file:

- epiworld.hpp

15.70 ToolFunctions< TSeq > Class Template Reference

Helper class to store the functions avoiding multiple shared_pointers (we have only one for the four of these)

```
#include <tool-bones.hpp>
```

Public Attributes

- ToolFun< TSeq > **susceptibility_reduction** = nullptr
- ToolFun< TSeq > **transmission_reduction** = nullptr
- ToolFun< TSeq > **recovery_enhancer** = nullptr
- ToolFun< TSeq > **death_reduction** = nullptr
- ToolToAgentFun< TSeq > **dist** = nullptr

15.70.1 Detailed Description

```
template<typename TSeq>
class ToolFunctions< TSeq >
```

Helper class to store the functions avoiding multiple shared_pointers (we have only one for the four of these)

The documentation for this class was generated from the following file:

- include/epiworld/tool-bones.hpp

15.71 epiworld::Tools< TSeq > Class Template Reference

Set of tools (useful for building iterators)

```
#include <epiworld.hpp>
```

Public Member Functions

- **Tools** ([Agent](#)< TSeq > &p)
- std::vector< ToolPtr< TSeq > >::iterator **begin** ()
- std::vector< ToolPtr< TSeq > >::iterator **end** ()
- ToolPtr< TSeq > & **operator()** (size_t i)
- ToolPtr< TSeq > & **operator[]** (size_t i)
- size_t **size** () const noexcept
- void **print** () const noexcept

Friends

- class **Tool**< TSeq >
- class **Agent**< TSeq >

15.71.1 Detailed Description

```
template<typename TSeq>
class epiworld::Tools< TSeq >
```

Set of tools (useful for building iterators)

Template Parameters

<i>TSeq</i>	
-------------	--

The documentation for this class was generated from the following file:

- epiworld.hpp

15.72 Tools< TSeq > Class Template Reference

Set of tools (useful for building iterators)

```
#include <tools-bones.hpp>
```

Public Member Functions

- **Tools** ([Agent](#)< TSeq > &p)
- std::vector< ToolPtr< TSeq > >::iterator **begin** ()
- std::vector< ToolPtr< TSeq > >::iterator **end** ()
- ToolPtr< TSeq > & **operator()** (size_t i)
- ToolPtr< TSeq > & **operator[]** (size_t i)
- size_t **size** () const noexcept
- void **print** () const noexcept

Friends

- class **Tool**< TSeq >
- class **Agent**< TSeq >

15.72.1 Detailed Description

```
template<typename TSeq>
class Tools< TSeq >
```

Set of tools (useful for building iterators)

Template Parameters

<i>TSeq</i>	
-------------	--

The documentation for this class was generated from the following files:

- include/epiworld/agent-bones.hpp
- include/epiworld/tools-bones.hpp

15.73 epiworld::Tools_const< TSeq > Class Template Reference

Set of [Tools](#) (const) (useful for iterators)

```
#include <epiworld.hpp>
```

Public Member Functions

- **Tools_const** (const [Agent](#)< TSeq > &p)
- std::vector< ToolPtr< TSeq > >::const_iterator **begin** () const
- std::vector< ToolPtr< TSeq > >::const_iterator **end** () const
- const ToolPtr< TSeq > & **operator()** (size_t i)
- const ToolPtr< TSeq > & **operator[]** (size_t i)
- size_t **size** () const noexcept
- void **print** () const noexcept

Friends

- class **Tool**< TSeq >
- class **Agent**< TSeq >

15.73.1 Detailed Description

```
template<typename TSeq>
class epiworld::Tools_const< TSeq >
```

Set of [Tools](#) (const) (useful for iterators)

Template Parameters

<i>TSeq</i>	
-------------	--

The documentation for this class was generated from the following file:

- epiworld.hpp

15.74 Tools_const< TSeq > Class Template Reference

Set of [Tools](#) (const) (useful for iterators)

```
#include <tools-bones.hpp>
```

Public Member Functions

- **Tools_const** (const [Agent](#)< TSeq > &p)
- std::vector< ToolPtr< TSeq > >::const_iterator **begin** () const
- std::vector< ToolPtr< TSeq > >::const_iterator **end** () const
- const ToolPtr< TSeq > & **operator**() (size_t i)
- const ToolPtr< TSeq > & **operator**[] (size_t i)
- size_t **size** () const noexcept
- void **print** () const noexcept

Friends

- class **Tool**< TSeq >
- class **Agent**< TSeq >

15.74.1 Detailed Description

```
template<typename TSeq>
class Tools_const< TSeq >
```

Set of [Tools](#) (const) (useful for iterators)

Template Parameters

<i>TSeq</i>	
-------------	--

The documentation for this class was generated from the following files:

- include/epiworld/agent-bones.hpp
- include/epiworld/tools-bones.hpp

15.75 epiworld::UserData< TSeq > Class Template Reference

Personalized data by the user.

```
#include <epiworld.hpp>
```

Public Member Functions

- **UserData** ([Model](#)< TSeq > &m)
- **UserData** ([Model](#)< TSeq > *m)
- **UserData** (std::vector< std::string > names)
Construct a new User Data object.
- std::vector< std::string > & **get_names** ()
- std::vector< int > & **get_dates** ()
- std::vector< epiworld_double > & **get_data** ()

- void **get_all** (std::vector< std::string > *names=nullptr, std::vector< int > *date=nullptr, std::vector< epiworld_double > *data=nullptr)
- epiworld_fast_uint **nrow** () const
- epiworld_fast_uint **ncol** () const
- void **write** (std::string fn)
- void **print** () const

Append data

Parameters

x	A vector of length <code>ncol()</code> (if vector), otherwise a <code>epiworld_double</code> .
j	Index of the data point, from 0 to <code>ncol()</code> - 1.

- void **add** (std::vector< epiworld_double > x)
- void **add** (epiworld_fast_uint j, epiworld_double x)

Access data

Parameters

i	Row (0 through <code>ndays</code> - 1.)
j	Column (0 through <code>ncols()</code>).

Returns

`epiworld_double&`

- epiworld_double & **operator()** (epiworld_fast_uint i, epiworld_fast_uint j)
- epiworld_double & **operator()** (epiworld_fast_uint i, std::string name)

Friends

- class **Model**< TSeq >
- class **DataBase**< TSeq >

15.75.1 Detailed Description

```
template<typename TSeq>
class epiworld::UserData< TSeq >
```

Personalized data by the user.

Template Parameters

<i>TSeq</i>	
-------------	--

15.75.2 Constructor & Destructor Documentation

15.75.2.1 UserData()

```
template<typename TSeq >
UserData< TSeq >::UserData (
    std::vector< std::string > names ) [inline]
```

Construct a new User Data object.

Parameters

<i>names</i>	A vector of names. The length of the vector sets the number of columns to record.
--------------	-----------------------------------------------------------------------------------

The documentation for this class was generated from the following file:

- epiworld.hpp

15.76 UserData< TSeq > Class Template Reference

Personalized data by the user.

```
#include <userdata-bones.hpp>
```

Public Member Functions

- **UserData** ([Model](#)< TSeq > &m)
- **UserData** ([Model](#)< TSeq > *m)
- [UserData](#) (std::vector< std::string > names)
Construct a new User Data object.
- std::vector< std::string > & **get_names** ()
- std::vector< int > & **get_dates** ()
- std::vector< epiworld_double > & **get_data** ()
- void **get_all** (std::vector< std::string > *names=nullptr, std::vector< int > *date=nullptr, std::vector< epiworld_double > *data=nullptr)
- epiworld_fast_uint **nrow** () const
- epiworld_fast_uint **ncol** () const
- void **write** (std::string fn)
- void **print** () const

Append data

Parameters

<i>x</i>	A vector of length <i>ncol</i> () (if vector), otherwise a <i>epiworld_double</i> .
<i>j</i>	Index of the data point, from 0 to <i>ncol</i> () - 1.

- void **add** (std::vector< epiworld_double > x)
- void **add** (epiworld_fast_uint j, epiworld_double x)

Access data

Parameters

i	Row (0 through <i>ndays</i> - 1.)
j	Column (0 through <i>ncols</i> ()).

Returns

epiworld_double&

- epiworld_double & **operator()** (epiworld_fast_uint i, epiworld_fast_uint j)
- epiworld_double & **operator()** (epiworld_fast_uint i, std::string name)

Friends

- class **Model**< TSeq >
- class **DataBase**< TSeq >

15.76.1 Detailed Description

```
template<typename TSeq>
class UserData< TSeq >
```

Personalized data by the user.

Template Parameters

<i>TSeq</i>	
-------------	--

15.76.2 Constructor & Destructor Documentation

15.76.2.1 UserData()

```
template<typename TSeq >
UserData< TSeq >::UserData (
    std::vector< std::string > names ) [inline]
```

Construct a new User Data object.

Parameters

<i>names</i>	A vector of names. The length of the vector sets the number of columns to record.
--------------	-----------------------------------------------------------------------------------

The documentation for this class was generated from the following files:

- include/epiworld/database-bones.hpp
- include/epiworld/userdata-bones.hpp
- include/epiworld/userdata-meat.hpp

15.77 epiworld::vecHasher< T > Struct Template Reference

Vector hasher.

```
#include <epiworld.hpp>
```

Public Member Functions

- `std::size_t operator() (std::vector< T > const &dat) const` noexcept

15.77.1 Detailed Description

```
template<typename T>
struct epiworld::vecHasher< T >
```

Vector hasher.

Template Parameters

<i>T</i>	
----------	--

The documentation for this struct was generated from the following file:

- epiworld.hpp

15.78 vecHasher< T > Struct Template Reference

Vector hasher.

```
#include <misc.hpp>
```

Public Member Functions

- `std::size_t operator() (std::vector< T > const &dat) const` noexcept

15.78.1 Detailed Description

```
template<typename T>
struct vecHasher< T >
```

Vector hasher.

Template Parameters

<i>T</i>	
----------	--

The documentation for this struct was generated from the following file:

- include/epiworld/misc.hpp

15.79 epiworld::Virus< TSeq > Class Template Reference

[Virus.](#)

```
#include <epiworld.hpp>
```

Public Member Functions

- **Virus** (std::string name="unknown virus")
- **Virus** (std::string name, epiworld_double prevalence, bool as_proportion)
- void **mutate** ([Model](#)< TSeq > *model)
- void **set_mutation** (MutFun< TSeq > fun)
- **EPI_TYPENAME_TRAITS** (TSeq, int) get_sequence()
- void **set_sequence** (TSeq sequence)
- [Agent](#)< TSeq > * **get_agent** ()
- void **set_agent** ([Agent](#)< TSeq > *p)
- void **set_date** (int d)
- int **get_date** () const
- void **set_id** (int idx)
- int **get_id** () const
- void **set_name** (std::string name)
- std::string **get_name** () const
- bool **operator==** (const [Virus](#)< TSeq > &other) const
- bool **operator!=** (const [Virus](#)< TSeq > &other) const
- void **print** () const

Get and set the tool functions

Parameters

v	<i>The virus over which to operate</i>
fun	<i>the function to be used</i>

Returns

epiworld_double

- epiworld_double **get_prob_infecting** ([Model](#)< TSeq > *model)
- epiworld_double **get_prob_recovery** ([Model](#)< TSeq > *model)
- epiworld_double **get_prob_death** ([Model](#)< TSeq > *model)
- epiworld_double **get_incubation** ([Model](#)< TSeq > *model)
- void **post_recovery** ([Model](#)< TSeq > *model)

- void **set_post_recovery** (PostRecoveryFun< TSeq > fun)
- void **set_post_immunity** (epiworld_double prob)
- void **set_post_immunity** (epiworld_double *prob)
- void **set_prob_infecting_fun** (VirusFun< TSeq > fun)
- void **set_prob_recovery_fun** (VirusFun< TSeq > fun)
- void **set_prob_death_fun** (VirusFun< TSeq > fun)
- void **set_incubation_fun** (VirusFun< TSeq > fun)
- void **set_prob_infecting** (const epiworld_double *prob)
- void **set_prob_recovery** (const epiworld_double *prob)
- void **set_prob_death** (const epiworld_double *prob)
- void **set_incubation** (const epiworld_double *prob)
- void **set_prob_infecting** (epiworld_double prob)
- void **set_prob_recovery** (epiworld_double prob)
- void **set_prob_death** (epiworld_double prob)
- void **set_incubation** (epiworld_double prob)

Get and set the state and queue

After applied, viruses can change the state and affect the queue of agents. These function sets the default values, which are retrieved when adding or removing a virus does not specify a change in state or in queue.

Parameters

init	After the virus/tool is added to the agent.
end	After the virus/tool is removed.
removed	After the agent (<i>Agent</i>) is removed.

- void **set_state** (epiworld_fast_int init, epiworld_fast_int end, epiworld_fast_int removed=-99)
 - void **set_queue** (epiworld_fast_int init, epiworld_fast_int end, epiworld_fast_int removed=-99)
 - void **get_state** (epiworld_fast_int *init, epiworld_fast_int *end, epiworld_fast_int *removed=nullptr)
 - void **get_queue** (epiworld_fast_int *init, epiworld_fast_int *end, epiworld_fast_int *removed=nullptr)
-
- void **distribute** (*Model*< TSeq > *model)
Get information about the prevalence of the virus.
 - void **set_distribution** (VirusToAgentFun< TSeq > fun)

Friends

- class **Agent**< TSeq >
- class **Model**< TSeq >
- class **DataBase**< TSeq >
- void **default_add_virus** (*Event*< TSeq > &a, *Model*< TSeq > *m)
- void **default_rm_virus** (*Event*< TSeq > &a, *Model*< TSeq > *m)

15.79.1 Detailed Description

```
template<typename TSeq>
class epiworld::Virus< TSeq >
```

Virus.

Template Parameters

<i>TSeq</i>	
-------------	--

Raw transmissibility of a virus should be a function of its genetic sequence. Nonetheless, transmissibility can be reduced as a result of having one or more tools to fight the virus. Because of this, transmissibility should be a function of the agent.

The documentation for this class was generated from the following file:

- epiworld.hpp

15.80 Virus< TSeq > Class Template Reference

[Virus.](#)

```
#include <virus-bones.hpp>
```

Public Member Functions

- **Virus** (std::string name="unknown virus")
- **Virus** (std::string name, epiworld_double prevalence, bool as_proportion)
- void **mutate** ([Model](#)< TSeq > *model)
- void **set_mutation** (MutFun< TSeq > fun)
- **EPI_TYPENAME_TRAITS** (TSeq, int) get_sequence()
- void **set_sequence** (TSeq sequence)
- [Agent](#)< TSeq > * **get_agent** ()
- void **set_agent** ([Agent](#)< TSeq > *p)
- void **set_date** (int d)
- int **get_date** () const
- void **set_id** (int idx)
- int **get_id** () const
- void **set_name** (std::string name)
- std::string **get_name** () const
- bool **operator==** (const [Virus](#)< TSeq > &other) const
- bool **operator!=** (const [Virus](#)< TSeq > &other) const
- void **print** () const
- void **set_sequence** (int sequence)
- bool **operator==** (const [Virus](#)< std::vector< int >> &other) const
- void **set_sequence** (int sequence)
- bool **operator==** (const [Virus](#)< std::vector< int >> &other) const

Get and set the tool functions

Parameters

v	<i>The virus over which to operate</i>
fun	<i>the function to be used</i>

Returns

epiworld_double

- epiworld_double **get_prob_infecting** ([Model](#)< TSeq > *model)
- epiworld_double **get_prob_recovery** ([Model](#)< TSeq > *model)
- epiworld_double **get_prob_death** ([Model](#)< TSeq > *model)
- epiworld_double **get_incubation** ([Model](#)< TSeq > *model)
- void **post_recovery** ([Model](#)< TSeq > *model)
- void **set_post_recovery** (PostRecoveryFun< TSeq > fun)
- void **set_post_immunity** (epiworld_double prob)
- void **set_prob_infecting** (epiworld_double *prob)
- void **set_prob_infecting_fun** (VirusFun< TSeq > fun)
- void **set_prob_recovery_fun** (VirusFun< TSeq > fun)
- void **set_prob_death_fun** (VirusFun< TSeq > fun)
- void **set_incubation_fun** (VirusFun< TSeq > fun)
- void **set_prob_infecting** (const epiworld_double *prob)
- void **set_prob_recovery** (const epiworld_double *prob)
- void **set_prob_death** (const epiworld_double *prob)
- void **set_incubation** (const epiworld_double *prob)
- void **set_prob_infecting** (epiworld_double prob)
- void **set_prob_recovery** (epiworld_double prob)
- void **set_prob_death** (epiworld_double prob)
- void **set_incubation** (epiworld_double prob)

Get and set the state and queue

After applied, viruses can change the state and affect the queue of agents. These function sets the default values, which are retrieved when adding or removing a virus does not specify a change in state or in queue.

Parameters

init	After the virus/tool is added to the agent.
end	After the virus/tool is removed.
removed	After the agent (Agent) is removed.

- void **set_state** (epiworld_fast_int init, epiworld_fast_int end, epiworld_fast_int removed=-99)
- void **set_queue** (epiworld_fast_int init, epiworld_fast_int end, epiworld_fast_int removed=-99)
- void **get_state** (epiworld_fast_int *init, epiworld_fast_int *end, epiworld_fast_int *removed=nullptr)
- void **get_queue** (epiworld_fast_int *init, epiworld_fast_int *end, epiworld_fast_int *removed=nullptr)

- void **distribute** ([Model](#)< TSeq > *model)
Get information about the prevalence of the virus.
- void **set_distribution** (VirusToAgentFun< TSeq > fun)

Friends

- class **Agent**< TSeq >
- class **Model**< TSeq >
- class **DataBase**< TSeq >
- void **default_add_virus** ([Event](#)< TSeq > &a, [Model](#)< TSeq > *m)
- void **default_rm_virus** ([Event](#)< TSeq > &a, [Model](#)< TSeq > *m)

15.80.1 Detailed Description

```
template<typename TSeq>
class Virus< TSeq >
```

[Virus.](#)

Template Parameters

<i>TSeq</i>	
-------------	--

Raw transmissibility of a virus should be a function of its genetic sequence. Nonetheless, transmissibility can be reduced as a result of having one or more tools to fight the virus. Because of this, transmissibility should be a function of the agent.

The documentation for this class was generated from the following files:

- include/epiworld/agent-bones.hpp
- include/epiworld/virus-bones.hpp
- include/epiworld/virus-meat.hpp

15.81 epiworld::Viruses< TSeq > Class Template Reference

Set of viruses (useful for building iterators)

```
#include <epiworld.hpp>
```

Public Member Functions

- **Viruses** ([Agent](#)< TSeq > &p)
- std::vector< VirusPtr< TSeq > >::iterator **begin** ()
- std::vector< VirusPtr< TSeq > >::iterator **end** ()
- VirusPtr< TSeq > & **operator**() (size_t i)
- VirusPtr< TSeq > & **operator[]** (size_t i)
- size_t **size** () const noexcept
- void **print** () const noexcept

Friends

- class **Virus**< TSeq >
- class **Agent**< TSeq >

15.81.1 Detailed Description

```
template<typename TSeq>
class epiworld::Viruses< TSeq >
```

Set of viruses (useful for building iterators)

Template Parameters

<i>TSeq</i>	
-------------	--

The documentation for this class was generated from the following file:

- epiworld.hpp

15.82 Viruses< TSeq > Class Template Reference

Set of viruses (useful for building iterators)

```
#include <viruses-bones.hpp>
```

Public Member Functions

- **Viruses** ([Agent](#)< TSeq > &p)
- std::vector< VirusPtr< TSeq > >::iterator **begin** ()
- std::vector< VirusPtr< TSeq > >::iterator **end** ()
- VirusPtr< TSeq > & **operator()** (size_t i)
- VirusPtr< TSeq > & **operator[]** (size_t i)
- size_t **size** () const noexcept
- void **print** () const noexcept

Friends

- class **Virus**< TSeq >
- class **Agent**< TSeq >

15.82.1 Detailed Description

```
template<typename TSeq>
class Viruses< TSeq >
```

Set of viruses (useful for building iterators)

Template Parameters

<i>TSeq</i>	
-------------	--

The documentation for this class was generated from the following files:

- include/epiworld/agent-bones.hpp
- include/epiworld/viruses-bones.hpp

15.83 epiworld::Viruses_const< TSeq > Class Template Reference

Set of [Viruses](#) (const) (useful for iterators)

```
#include <epiworld.hpp>
```

Public Member Functions

- **Viruses_const** (const [Agent](#)< TSeq > &p)
- std::vector< VirusPtr< TSeq > >::const_iterator **begin** () const
- std::vector< VirusPtr< TSeq > >::const_iterator **end** () const
- const VirusPtr< TSeq > & **operator()** (size_t i)
- const VirusPtr< TSeq > & **operator[]** (size_t i)
- size_t **size** () const noexcept
- void **print** () const noexcept

Friends

- class **Virus**< TSeq >
- class **Agent**< TSeq >

15.83.1 Detailed Description

```
template<typename TSeq>
class epiworld::Viruses_const< TSeq >
```

Set of [Viruses](#) (const) (useful for iterators)

Template Parameters

<i>TSeq</i>	
-------------	--

The documentation for this class was generated from the following file:

- epiworld.hpp

15.84 Viruses_const< TSeq > Class Template Reference

Set of [Viruses](#) (const) (useful for iterators)

```
#include <viruses-bones.hpp>
```

Public Member Functions

- **Viruses_const** (const [Agent](#)< TSeq > &p)
- std::vector< VirusPtr< TSeq > >::const_iterator **begin** () const
- std::vector< VirusPtr< TSeq > >::const_iterator **end** () const
- const VirusPtr< TSeq > & **operator()** (size_t i)
- const VirusPtr< TSeq > & **operator[]** (size_t i)
- size_t **size** () const noexcept
- void **print** () const noexcept

Friends

- class **Virus**< TSeq >
- class **Agent**< TSeq >

15.84.1 Detailed Description

```
template<typename TSeq>
class Viruses_const< TSeq >
```

Set of [Viruses](#) (const) (useful for iterators)

Template Parameters

<i>TSeq</i>	
-------------	--

The documentation for this class was generated from the following files:

- include/epiworld/agent-bones.hpp
- include/epiworld/viruses-bones.hpp

15.85 epiworld::VirusFunctions< TSeq > Class Template Reference

Public Attributes

- MutFun< TSeq > **mutation** = nullptr
- PostRecoveryFun< TSeq > **post_recovery** = nullptr
- VirusFun< TSeq > **probability_of_infecting** = nullptr
- VirusFun< TSeq > **probability_of_recovery** = nullptr
- VirusFun< TSeq > **probability_of_death** = nullptr
- VirusFun< TSeq > **incubation** = nullptr
- VirusToAgentFun< TSeq > **dist** = nullptr

The documentation for this class was generated from the following file:

- epiworld.hpp

15.86 VirusFunctions< TSeq > Class Template Reference

Public Attributes

- MutFun< TSeq > **mutation** = nullptr
- PostRecoveryFun< TSeq > **post_recovery** = nullptr
- VirusFun< TSeq > **probability_of_infecting** = nullptr
- VirusFun< TSeq > **probability_of_recovery** = nullptr
- VirusFun< TSeq > **probability_of_death** = nullptr
- VirusFun< TSeq > **incubation** = nullptr
- VirusToAgentFun< TSeq > **dist** = nullptr

The documentation for this class was generated from the following file:

- include/epiworld/virus-bones.hpp

Chapter 16

File Documentation

16.1 include/epiworld/agent-meat-state.hpp File Reference

Sampling functions are getting big, so we keep them in a separate file.

```
#include "agent-meat-virus-sampling.hpp"
```

Include dependency graph for agent-meat-state.hpp:



This graph shows which files directly or indirectly include this file:



Functions

- `template<typename TSeq = EPI_DEFAULT_TSEQ>`
`void default_update_susceptible (Agent< TSeq > *p, Model< TSeq > *m)`
- `template<typename TSeq = EPI_DEFAULT_TSEQ>`
`void default_update_exposed (Agent< TSeq > *p, Model< TSeq > *m)`

16.1.1 Detailed Description

Sampling functions are getting big, so we keep them in a separate file.

Author

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Version

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Date

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Copyright

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Index

add_globlevent
 epiworld::Model< TSeq >, 89
 Model< TSeq >, 106
AdjList, 41
 AdjList, 41
 epiworld::AdjList, 43
 read_edgelist, 42
Agent< TSeq >, 44
 default_rm_entity, 48
 operator(), 46
 swap_neighbors, 48
AgentsSample
 AgentsSample< TSeq >, 53
 epiworld::AgentsSample< TSeq >, 55
AgentsSample< TSeq >, 52
 AgentsSample, 53

clone_ptr
 epiworld::epimodels::ModelMeaslesQuarantine<
 TSeq >, 120
 epiworld::epimodels::ModelSEIRCONN< TSeq >,
 133
 epiworld::epimodels::ModelSEIRDCONN< TSeq
 >, 146
 epiworld::epimodels::ModelSEIRMixing< TSeq >,
 153
 epiworld::epimodels::ModelSIRCONN< TSeq >,
 163
 epiworld::epimodels::ModelSIRDCONN< TSeq >,
 176
 epiworld::epimodels::ModelSIRLogit< TSeq >,
 182
 epiworld::epimodels::ModelSIRMixing< TSeq >,
 188
 epiworld::Model< TSeq >, 89
 Model< TSeq >, 106
 ModelMeaslesQuarantine< TSeq >, 124
 ModelSEIRCONN< TSeq >, 136
 ModelSEIRDCONN< TSeq >, 149
 ModelSEIRMixing< TSeq >, 156
 ModelSIRCONN< TSeq >, 167
 ModelSIRDCONN< TSeq >, 178
 ModelSIRLogit< TSeq >, 185
 ModelSIRMixing< TSeq >, 192

DataBase< TSeq >, 55
 generation_time, 58
 get_transmissions, 58
 operator==, 58, 59
 record_virus, 59

 reproductive_number, 60
 transition_probability, 60
default_rm_entity
 Agent< TSeq >, 48
 Entity< TSeq >, 70
 epiworld::Agent< TSeq >, 52
 epiworld::Entity< TSeq >, 72
draw
 epiworld::Model< TSeq >, 90
 Model< TSeq >, 106

Entities< TSeq >, 66
Entities_const< TSeq >, 67
Entity
 Entity< TSeq >, 70
 epiworld::Entity< TSeq >, 71
Entity< TSeq >, 69
 default_rm_entity, 70
 Entity, 70
epiworld::AdjList, 42
 AdjList, 43
 read_edgelist, 43
epiworld::Agent< TSeq >, 49
 default_rm_entity, 52
 operator(), 51
 swap_neighbors, 51
epiworld::AgentsSample< TSeq >, 54
 AgentsSample, 55
epiworld::DataBase< TSeq >, 61
 generation_time, 63
 get_transmissions, 63
 operator==, 64
 record_virus, 64
 reproductive_number, 64
 transition_probability, 65
epiworld::Entities< TSeq >, 66
epiworld::Entities_const< TSeq >, 68
epiworld::Entity< TSeq >, 71
 default_rm_entity, 72
 Entity, 71
epiworld::epimodels::ModelDiffNet< TSeq >, 113
epiworld::epimodels::ModelMeaslesQuarantine< TSeq
 >, 116
 clone_ptr, 120
 ModelMeaslesQuarantine, 119
 quarantine_agents, 120
 reset, 120
epiworld::epimodels::ModelSEIR< TSeq >, 126
 initial_states, 127
 update_exposed_seir, 128

- update_infected_seir, 128
- epiworld::epimodels::ModelSEIRCONN< TSeq >, 131
 - clone_ptr, 133
 - initial_states, 133
 - ModelSEIRCONN, 132
 - reset, 134
- epiworld::epimodels::ModelSEIRD< TSeq >, 137
 - ModelSEIRD, 139, 140
 - update_exposed_seir, 140
- epiworld::epimodels::ModelSEIRDCONN< TSeq >, 144
 - clone_ptr, 146
 - initial_states, 146
 - ModelSEIRDCONN, 145
 - reset, 146
- epiworld::epimodels::ModelSEIRMixing< TSeq >, 150
 - clone_ptr, 153
 - initial_states, 153
 - ModelSEIRMixing, 151, 152
 - reset, 153
- epiworld::epimodels::ModelSIR< TSeq >, 158
 - initial_states, 159
- epiworld::epimodels::ModelSIRCONN< TSeq >, 162
 - clone_ptr, 163
 - get_n_infected, 164
 - initial_states, 164
 - ModelSIRCONN, 163
 - reset, 164
- epiworld::epimodels::ModelSIRD< TSeq >, 168
 - initial_states, 171
 - ModelSIRD, 169
- epiworld::epimodels::ModelSIRDCONN< TSeq >, 174
 - clone_ptr, 176
 - ModelSIRDCONN, 175
 - reset, 176
- epiworld::epimodels::ModelSIRLogit< TSeq >, 179
 - clone_ptr, 182
 - ModelSIRLogit, 181
 - reset, 182
- epiworld::epimodels::ModelSIRMixing< TSeq >, 186
 - clone_ptr, 188
 - initial_states, 189
 - ModelSIRMixing, 187, 188
 - reset, 189
- epiworld::epimodels::ModelSIS< TSeq >, 193
- epiworld::epimodels::ModelSISD< TSeq >, 197
- epiworld::epimodels::ModelSURV< TSeq >, 200
 - reset, 202
- epiworld::Event< TSeq >, 72
 - Event, 73
- epiworld::GlobalEvent< TSeq >, 75
 - GlobalEvent, 76
- epiworld::LFMCMC< TData >, 78
- epiworld::Model< TSeq >, 81
 - add_globlevent, 89
 - clone_ptr, 89
 - draw, 90
 - events_add, 90
 - events_run, 91
 - initial_states_fun, 95
 - load_agents_entities_ties, 91
 - rbinomd, 95
 - reset, 91
 - rexp, 95
 - rgammad, 95
 - rgeomd, 95
 - rlognormald, 96
 - rnbinomd, 96
 - rnormd, 96
 - rpoissd, 96
 - run_multiple, 92
 - runifd, 96
 - set_agents_data, 92
 - set_name, 94
 - time_elapsed, 97
 - write_data, 94
- epiworld::ModelDiagram, 113
- epiworld::PersonTools< TSeq >, 205
- epiworld::Progress, 206
- epiworld::Queue< TSeq >, 207
- epiworld::sampler, 33
 - make_sample_virus_neighbors, 33
 - make_update_susceptible, 34
 - sample_virus_single, 34
- epiworld::SAMPLETYPE, 209
- epiworld::Tool< TSeq >, 209
- epiworld::ToolFunctions< TSeq >, 212
- epiworld::Tools< TSeq >, 213
- epiworld::Tools_const< TSeq >, 215
- epiworld::UserData< TSeq >, 216
 - UserData, 218
- epiworld::vecHasher< T >, 220
- epiworld::Virus< TSeq >, 221
- epiworld::Viruses< TSeq >, 225
- epiworld::Viruses_const< TSeq >, 227
- epiworld::VirusFunctions< TSeq >, 228
- Event
 - epiworld::Event< TSeq >, 73
 - Event< TSeq >, 75
- Event< TSeq >, 73
 - Event, 75
- events_add
 - epiworld::Model< TSeq >, 90
 - Model< TSeq >, 107
- events_run
 - epiworld::Model< TSeq >, 91
 - Model< TSeq >, 107
- generation_time
 - DataBase< TSeq >, 58
 - epiworld::DataBase< TSeq >, 63
- get_n_infected
 - epiworld::epimodels::ModelSIRCONN< TSeq >, 164
 - ModelSIRCONN< TSeq >, 167
- get_transmissions
 - DataBase< TSeq >, 58

- epiworld::DataBase< TSeq >, 63
- GlobalEvent
 - epiworld::GlobalEvent< TSeq >, 76
 - GlobalEvent< TSeq >, 77
- GlobalEvent< TSeq >, 77
 - GlobalEvent, 77
- include/epiworld/agent-meat-state.hpp, 231
- initial_states
 - epiworld::epimodels::ModelSEIR< TSeq >, 127
 - epiworld::epimodels::ModelSEIRCONN< TSeq >, 133
 - epiworld::epimodels::ModelSEIRDCONN< TSeq >, 146
 - epiworld::epimodels::ModelSEIRMixing< TSeq >, 153
 - epiworld::epimodels::ModelSIR< TSeq >, 159
 - epiworld::epimodels::ModelSIRCONN< TSeq >, 164
 - epiworld::epimodels::ModelSIRD< TSeq >, 171
 - epiworld::epimodels::ModelSIRMixing< TSeq >, 189
 - ModelSEIR< TSeq >, 130
 - ModelSEIRCONN< TSeq >, 136
 - ModelSEIRDCONN< TSeq >, 149
 - ModelSEIRMixing< TSeq >, 157
 - ModelSIR< TSeq >, 161
 - ModelSIRCONN< TSeq >, 167
 - ModelSIRD< TSeq >, 173
 - ModelSIRMixing< TSeq >, 192
- initial_states_fun
 - epiworld::Model< TSeq >, 95
 - Model< TSeq >, 110
- LFMCMC< TData >, 79
- load_agents_entities_ties
 - epiworld::Model< TSeq >, 91
 - Model< TSeq >, 108
- make_sample_virus_neighbors
 - epiworld::sampler, 33
 - sampler, 36
- make_update_susceptible
 - epiworld::sampler, 34
 - sampler, 37
- Model< TSeq >, 97
 - add_globlevent, 106
 - clone_ptr, 106
 - draw, 106
 - events_add, 107
 - events_run, 107
 - initial_states_fun, 110
 - load_agents_entities_ties, 108
 - rbinomd, 110
 - reset, 108
 - rexp, 110
 - rgammad, 111
 - rgeomd, 111
 - rlognormald, 111
 - rnbinomd, 111
 - rnormd, 111
 - rpoissd, 112
 - run_multiple, 108
 - runifd, 112
 - set_agents_data, 109
 - set_name, 109
 - time_elapsed, 112
 - write_data, 110
- ModelDiagram, 113
- ModelDiffNet< TSeq >, 115
- ModelMeaslesQuarantine
 - epiworld::epimodels::ModelMeaslesQuarantine< TSeq >, 119
 - ModelMeaslesQuarantine< TSeq >, 123
- ModelMeaslesQuarantine< TSeq >, 121
 - clone_ptr, 124
 - ModelMeaslesQuarantine, 123
 - quarantine_agents, 125
 - reset, 125
- ModelSEIR< TSeq >, 129
 - initial_states, 130
 - update_exposed_seir, 131
 - update_infected_seir, 131
- ModelSEIRCONN
 - epiworld::epimodels::ModelSEIRCONN< TSeq >, 132
 - ModelSEIRCONN< TSeq >, 135
- ModelSEIRCONN< TSeq >, 134
 - clone_ptr, 136
 - initial_states, 136
 - ModelSEIRCONN, 135
 - reset, 137
- ModelSEIRD
 - epiworld::epimodels::ModelSEIRD< TSeq >, 139, 140
 - ModelSEIRD< TSeq >, 142, 143
- ModelSEIRD< TSeq >, 141
 - ModelSEIRD, 142, 143
 - update_exposed_seir, 143
- ModelSEIRDCONN
 - epiworld::epimodels::ModelSEIRDCONN< TSeq >, 145
 - ModelSEIRDCONN< TSeq >, 148
- ModelSEIRDCONN< TSeq >, 147
 - clone_ptr, 149
 - initial_states, 149
 - ModelSEIRDCONN, 148
 - reset, 150
- ModelSEIRMixing
 - epiworld::epimodels::ModelSEIRMixing< TSeq >, 151, 152
 - ModelSEIRMixing< TSeq >, 155, 156
- ModelSEIRMixing< TSeq >, 154
 - clone_ptr, 156
 - initial_states, 157
 - ModelSEIRMixing, 155, 156
 - reset, 157

- ModelSIR< TSeq >, 159
 - initial_states, 161
- ModelSIRCONN
 - epiworld::epimodels::ModelSIRCONN< TSeq >, 163
 - ModelSIRCONN< TSeq >, 166
- ModelSIRCONN< TSeq >, 165
 - clone_ptr, 167
 - get_n_infected, 167
 - initial_states, 167
 - ModelSIRCONN, 166
 - reset, 168
- ModelSIRD
 - epiworld::epimodels::ModelSIRD< TSeq >, 169
 - ModelSIRD< TSeq >, 173
- ModelSIRD< TSeq >, 171
 - initial_states, 173
 - ModelSIRD, 173
- ModelSIRDCONN
 - epiworld::epimodels::ModelSIRDCONN< TSeq >, 175
 - ModelSIRDCONN< TSeq >, 178
- ModelSIRDCONN< TSeq >, 177
 - clone_ptr, 178
 - ModelSIRDCONN, 178
 - reset, 179
- ModelSIRLogit
 - epiworld::epimodels::ModelSIRLogit< TSeq >, 181
 - ModelSIRLogit< TSeq >, 184
- ModelSIRLogit< TSeq >, 183
 - clone_ptr, 185
 - ModelSIRLogit, 184
 - reset, 185
- ModelSIRMixing
 - epiworld::epimodels::ModelSIRMixing< TSeq >, 187, 188
 - ModelSIRMixing< TSeq >, 191, 192
- ModelSIRMixing< TSeq >, 190
 - clone_ptr, 192
 - initial_states, 192
 - ModelSIRMixing, 191, 192
 - reset, 193
- ModelSIS< TSeq >, 196
- ModelSISD< TSeq >, 199
- ModelSURV< TSeq >, 203
 - reset, 204
- Network< Nettype, Nodetype, Edgetype >, 205
- operator()
 - Agent< TSeq >, 46
 - epiworld::Agent< TSeq >, 51
- operator==
 - DataBase< TSeq >, 58, 59
 - epiworld::DataBase< TSeq >, 64
- PersonTools< TSeq >, 206
- Progress, 206
- quarantine_agents
 - epiworld::epimodels::ModelMeaslesQuarantine< TSeq >, 120
 - ModelMeaslesQuarantine< TSeq >, 125
- Queue< TSeq >, 207
- RandGraph, 208
- rbinomd
 - epiworld::Model< TSeq >, 95
 - Model< TSeq >, 110
- read_edgelist
 - AdjList, 42
 - epiworld::AdjList, 43
- record_virus
 - DataBase< TSeq >, 59
 - epiworld::DataBase< TSeq >, 64
- reproductive_number
 - DataBase< TSeq >, 60
 - epiworld::DataBase< TSeq >, 64
- reset
 - epiworld::epimodels::ModelMeaslesQuarantine< TSeq >, 120
 - epiworld::epimodels::ModelSEIRCONN< TSeq >, 134
 - epiworld::epimodels::ModelSEIRDCONN< TSeq >, 146
 - epiworld::epimodels::ModelSEIRMixing< TSeq >, 153
 - epiworld::epimodels::ModelSIRCONN< TSeq >, 164
 - epiworld::epimodels::ModelSIRDCONN< TSeq >, 176
 - epiworld::epimodels::ModelSIRLogit< TSeq >, 182
 - epiworld::epimodels::ModelSIRMixing< TSeq >, 189
 - epiworld::epimodels::ModelSURV< TSeq >, 202
 - epiworld::Model< TSeq >, 91
 - Model< TSeq >, 108
 - ModelMeaslesQuarantine< TSeq >, 125
 - ModelSEIRCONN< TSeq >, 137
 - ModelSEIRDCONN< TSeq >, 150
 - ModelSEIRMixing< TSeq >, 157
 - ModelSIRCONN< TSeq >, 168
 - ModelSIRDCONN< TSeq >, 179
 - ModelSIRLogit< TSeq >, 185
 - ModelSIRMixing< TSeq >, 193
 - ModelSURV< TSeq >, 204
- rexp
 - epiworld::Model< TSeq >, 95
 - Model< TSeq >, 110
- rgammad
 - epiworld::Model< TSeq >, 95
 - Model< TSeq >, 111
- rgeomd
 - epiworld::Model< TSeq >, 95
 - Model< TSeq >, 111
- rlognormald
 - epiworld::Model< TSeq >, 96

- Model< TSeq >, 111
- rnbinomd
 - epiworld::Model< TSeq >, 96
 - Model< TSeq >, 111
- rnormd
 - epiworld::Model< TSeq >, 96
 - Model< TSeq >, 111
- rpoissd
 - epiworld::Model< TSeq >, 96
 - Model< TSeq >, 112
- run_multiple
 - epiworld::Model< TSeq >, 92
 - Model< TSeq >, 108
- runifd
 - epiworld::Model< TSeq >, 96
 - Model< TSeq >, 112
- sample_virus_single
 - epiworld::sampler, 34
 - sampler, 37
- sampler, 36
 - make_sample_virus_neighbors, 36
 - make_update_susceptible, 37
 - sample_virus_single, 37
- SAMPLETYPE, 209
- set_agents_data
 - epiworld::Model< TSeq >, 92
 - Model< TSeq >, 109
- set_name
 - epiworld::Model< TSeq >, 94
 - Model< TSeq >, 109
- swap_neighbors
 - Agent< TSeq >, 48
 - epiworld::Agent< TSeq >, 51
- time_elapsed
 - epiworld::Model< TSeq >, 97
 - Model< TSeq >, 112
- Tool< TSeq >, 210
- ToolFunctions< TSeq >, 213
- Tools< TSeq >, 214
- Tools_const< TSeq >, 215
- transition_probability
 - DataBase< TSeq >, 60
 - epiworld::DataBase< TSeq >, 65
- update_exposed_seir
 - epiworld::epimodels::ModelSEIR< TSeq >, 128
 - epiworld::epimodels::ModelSEIRD< TSeq >, 140
 - ModelSEIR< TSeq >, 131
 - ModelSEIRD< TSeq >, 143
- update_infected_seir
 - epiworld::epimodels::ModelSEIR< TSeq >, 128
 - ModelSEIR< TSeq >, 131
- UserData
 - epiworld::UserData< TSeq >, 218
 - UserData< TSeq >, 219
- UserData< TSeq >, 218
 - UserData, 219
- vecHasher< T >, 220
- Virus< TSeq >, 223
- Viruses< TSeq >, 226
- Viruses_const< TSeq >, 227
- VirusFunctions< TSeq >, 229
- write_data
 - epiworld::Model< TSeq >, 94
 - Model< TSeq >, 110