

epiworld

0.0-1

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Chapter 1

Example: 00-hello-world

Output from the program:

Running the model...

```
||||| done.
[epiworld-debug] DEBUGGING ON (compiled with EPI_DEBUG defined)

SIMULATION STUDY
Population size      : 10000
Number of entitites : 0
Days (duration)     : 100 (of 100)
Number of variants  : 1
Last run elapsed t   : 40.00ms
Rewiring             : off
Virus(es):
- covid 19 (baseline prevalence: 50 seeds)
Tool(s):
- vaccine (baseline prevalence: 50.00%)
- Immunity (covid 19) (originated in the model...)
Model parameters:
(none)
Distribution of the population at time 100:
- (0) Susceptible : 9950 -> 70
- (1) Exposed     : 50 -> 70
- (2) Recovered   : 0 -> 9271
- (3) Removed     : 0 -> 589
Transition Probabilities:
- Susceptible 0.95 0.05 0.00 0.00
- Exposed      0.00 0.85 0.14 0.01
- Recovered    0.00 0.00 1.00 0.00
- Removed      0.00 0.00 0.00 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.

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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 actions (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");
    covid19.set_infectiousness(.8);

    // Creating a tool
    epiworld::Tool<> vax("vaccine");
    vax.set_contagion_reduction(.95);
    // Creating a model
    epiworld::Model<> model;
    // Adding the tool and virus
    model.add_virus(covid19, .01);
    model.add_tool(vax, .5);
    // 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

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Chapter 6

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 7

EPI Simulator

7.1 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.

7.2 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.

7.3 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.

7.4 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

7.5 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.

7.5.1 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 8

Namespace Index

8.1 Namespace List

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

epiworld::sampler	Functions for sampling viruses	27
sampler	Functions for sampling viruses	30

Chapter 9

Hierarchical Index

9.1 Class Hierarchy

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

Action< TSeq >	35
epiworld::Action< TSeq >	37
AdjList	38
epiworld::AdjList	40
Agent< TSeq >	41
epiworld::Agent< TSeq >	45
AgentsSample< TSeq >	49
epiworld::AgentsSample< TSeq >	50
DataBase< TSeq >	52
epiworld::DataBase< TSeq >	56
Entities< TSeq >	59
epiworld::Entities< TSeq >	60
Entities_const< TSeq >	61
epiworld::Entities_const< TSeq >	62
Entity< TSeq >	63
epiworld::Entity< TSeq >	64
epiworld::LFMCMC< TData >	65
LFMCMC< TData >	66
epiworld::Model< TSeq >	67
Model< TSeq >	79
epiworld::Model< EPI_DEFAULT_TSEQ >	67
ModelSEIRCONN< TSeq >	97
ModelSEIRCONNLogit< TSeq >	100
ModelSIRCONN< TSeq >	111
ModelSURV< TSeq >	118
epiworld::epimodels::ModelSEIRCONN< TSeq >	95
epiworld::epimodels::ModelSIRCONN< TSeq >	108
epiworld::epimodels::ModelSURV< TSeq >	116
epiworld::Model< int >	67
ModelSEIR< TSeq >	93
ModelSEIRD< TSeq >	103
ModelSIR< TSeq >	107
ModelSIS< TSeq >	114
epiworld::epimodels::ModelSEIR< TSeq >	91
epiworld::epimodels::ModelSEIRD< TSeq >	101

epiworld::epimodels::ModelSIR< TSeq >	105
epiworld::epimodels::ModelSIS< TSeq >	113
Network< Nettype, Nodetype, Edgetype >	120
epiworld::PersonTools< TSeq >	120
PersonTools< TSeq >	120
epiworld::Progress	120
Progress	121
epiworld::Queue< TSeq >	121
Queue< TSeq >	122
epiworld::QueueValues	123
QueueValues	123
RandGraph	123
epiworld::SAMPLETYPE	123
SAMPLETYPE	124
epiworld::Tool< TSeq >	124
Tool< TSeq >	125
epiworld::Tools< TSeq >	127
Tools< TSeq >	128
epiworld::Tools_const< TSeq >	129
Tools_const< TSeq >	129
epiworld::UserData< TSeq >	130
UserData< TSeq >	132
epiworld::vecHasher< T >	134
vecHasher< T >	134
epiworld::Virus< TSeq >	135
Virus< TSeq >	137
epiworld::Viruses< TSeq >	138
Viruses< TSeq >	139
epiworld::Viruses_const< TSeq >	140
Viruses_const< TSeq >	141

Chapter 10

Class Index

10.1 Class List

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

Action< TSeq >	
Action data for update an agent	35
epiworld::Action< TSeq >	
Action data for update an agent	37
AdjList	38
epiworld::AdjList	40
Agent< TSeq >	
Agent (agents)	41
epiworld::Agent< TSeq >	
Agent (agents)	45
AgentsSample< TSeq >	
Sample of agents	49
epiworld::AgentsSample< TSeq >	
Sample of agents	50
DataBase< TSeq >	
Statistical data about the process	52
epiworld::DataBase< TSeq >	
Statistical data about the process	56
Entities< TSeq >	
Set of Entities (useful for building iterators)	59
epiworld::Entities< TSeq >	
Set of Entities (useful for building iterators)	60
Entities_const< TSeq >	
Set of Entities (const) (useful for iterators)	61
epiworld::Entities_const< TSeq >	
Set of Entities (const) (useful for iterators)	62
Entity< TSeq >	63
epiworld::Entity< TSeq >	64
epiworld::LFMCMC< TData >	
Likelihood-Free Markov Chain Monte Carlo	65
LFMCMC< TData >	
Likelihood-Free Markov Chain Monte Carlo	66
epiworld::Model< TSeq >	
Core class of epiworld	67
Model< TSeq >	
Core class of epiworld	79

epiworld::epimodels::ModelSEIR< TSeq >	
Template for a Susceptible-Exposed-Infected-Removed (SEIR) model	91
ModelSEIR< TSeq >	
Template for a Susceptible-Exposed-Infected-Removed (SEIR) model	93
epiworld::epimodels::ModelSEIRCONN< TSeq >	95
ModelSEIRCONN< TSeq >	97
ModelSEIRCONNLogit< TSeq >	100
epiworld::epimodels::ModelSEIRD< TSeq >	
Template for a Susceptible-Exposed-Infected-Removed-Deceased (SEIRD) model	101
ModelSEIRD< TSeq >	
Template for a Susceptible-Exposed-Infected-Removed-Deceased (SEIRD) model	103
epiworld::epimodels::ModelSIR< TSeq >	
Template for a Susceptible-Infected-Removed (SIR) model	105
ModelSIR< TSeq >	
Template for a Susceptible-Infected-Removed (SIR) model	107
epiworld::epimodels::ModelSIRCONN< TSeq >	108
ModelSIRCONN< TSeq >	111
epiworld::epimodels::ModelSIS< TSeq >	
Template for a Susceptible-Infected-Susceptible (SIS) model	113
ModelSIS< TSeq >	
Template for a Susceptible-Infected-Susceptible (SIS) model	114
epiworld::epimodels::ModelSURV< TSeq >	116
ModelSURV< TSeq >	118
Network< Nettype, Nodetype, Edgetype >	120
epiworld::PersonTools< TSeq >	120
PersonTools< TSeq >	120
epiworld::Progress	
A simple progress bar	120
Progress	
A simple progress bar	121
epiworld::Queue< TSeq >	
Controls which agents are verified at each step	121
Queue< TSeq >	
Controls which agents are verified at each step	122
epiworld::QueueValues	123
QueueValues	123
RandGraph	123
epiworld::SAMPLETYPE	123
SAMPLETYPE	124
epiworld::Tool< TSeq >	
Tools for defending the agent against the virus	124
Tool< TSeq >	
Tools for defending the agent against the virus	125
epiworld::Tools< TSeq >	
Set of tools (useful for building iterators)	127
Tools< TSeq >	
Set of tools (useful for building iterators)	128
epiworld::Tools_const< TSeq >	
Set of Tools (const) (useful for iterators)	129
Tools_const< TSeq >	
Set of Tools (const) (useful for iterators)	129
epiworld::UserData< TSeq >	
Personalized data by the user	130
UserData< TSeq >	
Personalized data by the user	132
epiworld::vecHasher< T >	
Vector hasher	134

vecHasher< T >	
Vector hasher	134
epiworld::Virus< TSeq >	
Virus	135
Virus< TSeq >	
Virus	137
epiworld::Viruses< TSeq >	
Set of viruses (useful for building iterators)	138
Viruses< TSeq >	
Set of viruses (useful for building iterators)	139
epiworld::Viruses_const< TSeq >	
Set of Viruses (const) (useful for iterators)	140
Viruses_const< TSeq >	
Set of Viruses (const) (useful for iterators)	141

Chapter 11

File Index

11.1 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-actions-meat.hpp	??
include/epiworld/ agent-bones.hpp	??
include/epiworld/ agent-meat-state.hpp	
Sampling functions are getting big, so we keep them in a separate file	143
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-meat.hpp	??
include/epiworld/ epiworld-macros.hpp	??
include/epiworld/ epiworld.hpp	??
include/epiworld/ misc.hpp	??
include/epiworld/ model-bones.hpp	??
include/epiworld/ model-meat-print.hpp	??
include/epiworld/ model-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-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-meat.hpp	??

include/epiworld/ viruses-bones.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/ models.hpp	??
include/epiworld/models/ seir.hpp	??
include/epiworld/models/ seirconnected.hpp	??
include/epiworld/models/ seirconnected_logit.hpp	??
include/epiworld/models/ seird.hpp	??
include/epiworld/models/ sir.hpp	??
include/epiworld/models/ sirconnected.hpp	??
include/epiworld/models/ sis.hpp	??
include/epiworld/models/ surveillance.hpp	??
tests/ tests.hpp	??

Chapter 12

Namespace Documentation

12.1 epiworld::sampler Namespace Reference

Functions for sampling viruses.

Functions

- `template<typename 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 = int>`
`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 = int>`
`Virus< TSeq > * sample_virus_single (Agent< TSeq > *p, Model< TSeq > *m)`
Sample from neighbors pool of viruses (at most one)

12.1.1 Detailed Description

Functions for sampling viruses.

12.1.2 Function Documentation

12.1.2.1 `make_sample_virus_neighbors()`

```
template<typename TSeq = int>
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;

12.1.2.2 make_update_susceptible()

```
template<typename 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;

12.1.2.3 sample_virus_single()

```
template<typename TSeq = int>
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;

12.2 sampler Namespace Reference

Functions for sampling viruses.

Functions

- `template<typename 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 = int> 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 = int> Virus< TSeq > * sample_virus_single (Agent< TSeq > *p, Model< TSeq > *m)`
Sample from neighbors pool of viruses (at most one)

12.2.1 Detailed Description

Functions for sampling viruses.

12.2.2 Function Documentation

12.2.2.1 [make_sample_virus_neighbors\(\)](#)

```
template<typename TSeq = int>
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;

12.2.2.2 make_update_susceptible()

```
template<typename 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;

12.2.2.3 sample_virus_single()

```
template<typename TSeq = int>
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 13

Class Documentation

13.1 Action< TSeq > Struct Template Reference

Action data for update an agent.

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

Public Member Functions

- Action (Agent< TSeq > *agent_, VirusPtr< TSeq > virus_, ToolPtr< TSeq > tool_, Entity< TSeq > *entity_, epiworld_fast_int new_state_, epiworld_fast_int queue_, ActionFun< TSeq > call_, int idx_agent_, int idx_object_)

Construct a new Action object.

Public Attributes

- Agent< TSeq > * agent
- VirusPtr< TSeq > virus
- ToolPtr< TSeq > tool
- Entity< TSeq > * entity
- epiworld_fast_int new_state
- epiworld_fast_int queue
- ActionFun< TSeq > call
- int idx_agent
- int idx_object

13.1.1 Detailed Description

```
template<typename TSeq>
struct Action< TSeq >
```

Action data for update an agent.

Template Parameters

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

13.1.2 Constructor & Destructor Documentation

13.1.2.1 Action()

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

Construct a new [Action](#) 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

13.2 epiworld::Action< TSeq > Struct Template Reference

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

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

Public Member Functions

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

Construct a new [Action](#) object.

Public Attributes

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

13.2.1 Detailed Description

```
template<typename TSeq>
struct epiworld::Action< TSeq >
```

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

Template Parameters

TSeq	
----------------------	--

13.2.2 Constructor & Destructor Documentation

13.2.2.1 Action()

```
template<typename TSeq >
epiworld::Action< TSeq >::Action (
    Agent< TSeq > * agent_,
```

```

VirusPtr< TSeq > virus_,
ToolPtr< TSeq > tool_,
Entity< TSeq > * entity_,
epiworld_fast_int new_state_,
epiworld_fast_int queue_,
ActionFun< TSeq > call_,
int idx_agent_,
int idx_object_ ) [inline]

```

Construct a new [Action](#) 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

13.3 AdjList Class Reference

Public Member Functions

- [AdjList](#) (const std::vector< epiworld_fast_uint > &source, const std::vector< epiworld_fast_uint > &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< epiworld_fast_uint, epiworld_fast_uint > **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< epiworld_fast_uint, epiworld_fast_uint > > & **get_dat** ()
- bool [is_directed](#) () const
true if the network is directed.

13.3.1 Constructor & Destructor Documentation

13.3.1.1 AdjList()

```
AdjList::AdjList (
    const std::vector< epiworld_fast_uint > & source,
    const std::vector< epiworld_fast_uint > & 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

13.3.2 Member Function Documentation

13.3.2.1 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

13.4 epiworld::AdjList Class Reference

Public Member Functions

- [AdjList](#) (const std::vector< epiworld_fast_uint > &source, const std::vector< epiworld_fast_uint > &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< epiworld_fast_uint, epiworld_fast_uint > **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< epiworld_fast_uint, epiworld_fast_uint > > & **get_dat** ()
- bool [is_directed](#) () const
true if the network is directed.

13.4.1 Constructor & Destructor Documentation

13.4.1.1 AdjList()

```
AdjList::AdjList (
    const std::vector< epiworld_fast_uint > & source,
    const std::vector< epiworld_fast_uint > & 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

13.4.2 Member Function Documentation

13.4.2.1 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

13.5 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** (int i)
- [Viruses](#)< TSeq > **get_viruses** ()
- const [Viruses_const](#)< TSeq > **get_viruses** () const
- size_t **get_n_viruses** () const noexcept
- 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_variant** ()
- 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 epiworld_fast_uint & **get_state** () const
- void **reset** ()
- bool **has_tool** (epiworld_fast_uint t) const
- bool **has_tool** (std::string name) const
- bool **has_virus** (epiworld_fast_uint t) const
- bool **has_virus** (std::string name) const
- void **print** ([Model](#)< TSeq > *model, bool compressed=false) const
- [Entities](#)< TSeq > **get_entities** ()
*Access the *j*-th column of the agent.*
- 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
status_new	state after the change
queue	

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

- void [rm_agent_by_virus](#) (epiworld_fast_uint virus_idx, [Model](#)< TSeq > *model, epiworld_fast_int status_new=-99, epiworld_fast_int queue=-99)
Agent removed by virus.
- void [rm_agent_by_virus](#) (VirusPtr< TSeq > &virus, [Model](#)< TSeq > *model, epiworld_fast_int status_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)

Friends

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

13.5.1 Detailed Description

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

[Agent](#) (agents)

Template Parameters

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

13.5.2 Member Function Documentation

13.5.2.1 `get_entities()`

```
template<typename TSeq >
Entities< TSeq > Agent< TSeq >::get_entities  [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

j	
-----	--

Returns

`double&`

13.5.2.2 `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>	

13.5.3 Friends And Related Function Documentation

13.5.3.1 default_rm_entity

```
template<typename TSeq >
void default_rm_entity (
    Action< 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

13.6 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** (int i)
- [Viruses](#)< TSeq > **get_viruses** ()
- const [Viruses_const](#)< TSeq > **get_viruses** () const
- size_t **get_n_viruses** () const noexcept
- 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_variant** ()
- 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 epiworld_fast_uint & **get_state** () const
- void **reset** ()
- bool **has_tool** (epiworld_fast_uint t) const
- bool **has_tool** (std::string name) const
- bool **has_virus** (epiworld_fast_uint t) const
- bool **has_virus** (std::string name) const
- void **print** ([Model](#)< TSeq > *model, bool compressed=false) const

- **Entities**< TSeq > **get_entities** ()
Access the *j*-th column of the agent.
- 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>
status_new	<i>state after the change</i>
queue	

- void **add_tool** (ToolPtr< TSeq > tool, **Model**< TSeq > *model, epiworld_fast_int status_new=-99, epiworld_fast_int queue=-99)
- void **add_tool** (**Tool**< TSeq > tool, **Model**< TSeq > *model, epiworld_fast_int status_new=-99, epiworld_fast_int queue=-99)
- void **add_virus** (VirusPtr< TSeq > virus, **Model**< TSeq > *model, epiworld_fast_int status_new=-99, epiworld_fast_int queue=-99)
- void **add_virus** (**Virus**< TSeq > virus, **Model**< TSeq > *model, epiworld_fast_int status_new=-99, epiworld_fast_int queue=-99)
- void **add_entity** (**Entity**< TSeq > &entity, **Model**< TSeq > *model, epiworld_fast_int status_new=-99, epiworld_fast_int queue=-99)
- void **rm_tool** (epiworld_fast_uint tool_idx, **Model**< TSeq > *model, epiworld_fast_int status_new=-99, epiworld_fast_int queue=-99)
- void **rm_tool** (ToolPtr< TSeq > &tool, **Model**< TSeq > *model, epiworld_fast_int status_new=-99, epiworld_fast_int queue=-99)
- void **rm_virus** (epiworld_fast_uint virus_idx, **Model**< TSeq > *model, epiworld_fast_int status_new=-99, epiworld_fast_int queue=-99)
- void **rm_virus** (VirusPtr< TSeq > &virus, **Model**< TSeq > *model, epiworld_fast_int status_new=-99, epiworld_fast_int queue=-99)
- void **rm_entity** (epiworld_fast_uint entity_idx, **Model**< TSeq > *model, epiworld_fast_int status_new=-99, epiworld_fast_int queue=-99)
- void **rm_entity** (**Entity**< TSeq > &entity, **Model**< TSeq > *model, epiworld_fast_int status_new=-99, epiworld_fast_int queue=-99)
- void **rm_agent_by_virus** (epiworld_fast_uint virus_idx, **Model**< TSeq > *model, epiworld_fast_int status_new=-99, epiworld_fast_int queue=-99)
Agent removed by virus.
- void **rm_agent_by_virus** (VirusPtr< TSeq > &virus, **Model**< TSeq > *model, epiworld_fast_int status_new=-99, epiworld_fast_int queue=-99)
Agent removed by virus.

Get the rates (multipliers) for the agent

Parameters

v	<i>A pointer to a virus.</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)

Friends

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

13.6.1 Detailed Description

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

[Agent](#) (agents)

Template Parameters

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

13.6.2 Member Function Documentation

13.6.2.1 get_entities()

```
template<typename TSeq >
Entities< TSeq > Agent< TSeq >::get_entities [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&

13.6.2.2 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>	

13.6.3 Friends And Related Function Documentation

13.6.3.1 default_rm_entity

```
template<typename TSeq >
void default_rm_entity (
    Action< 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

13.7 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, bool truncate=false)
- [AgentsSample](#) ([Model](#)< TSeq > *model, [Entity](#)< TSeq > &entity_, size_t n, bool truncate=false)
- [AgentsSample](#) ([Model](#)< TSeq > *model, [Agent](#)< TSeq > &agent_, size_t n, 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

13.7.1 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>	
-------------	--

13.7.2 Constructor & Destructor Documentation

13.7.2.1 AgentsSample()

```
template<typename TSeq >
AgentsSample< TSeq >::AgentsSample (
    Model< TSeq > * model,
```

```

    Agent< TSeq > & agent_,
    size_t n,
    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

13.8 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, bool truncate=false)
- **AgentsSample** ([Model](#)< TSeq > *model, [Entity](#)< TSeq > &entity_, size_t n, bool truncate=false)
- [AgentsSample](#) ([Model](#)< TSeq > *model, [Agent](#)< TSeq > &agent_, size_t n, 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

13.8.1 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>	
-------------	--

13.8.2 Constructor & Destructor Documentation

13.8.2.1 AgentsSample()

```
template<typename TSeq >
AgentsSample< TSeq >::AgentsSample (
    Model< TSeq > * model,
    Agent< TSeq > & agent_,
    size_t n,
    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

13.9 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_variant](#) ([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_variant_info, std::string fn_variant_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 variant, int i_expo_date)
- size_t [get_n_variants](#) () const
- size_t [get_n_tools](#) () const
- 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) 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_variant](#), the current counts of what for each variant.

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

In [get_hist_variant](#), the time series of what for each variant.

In [get_hist_total_date](#) and [get_hist_variant_date](#) the corresponding dates

- 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_variant** (std::vector< std::string > &state, std::vector< int > &id, 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_variant** (std::vector< int > &date, std::vector< int > &id, std::vector< std::string > &state, std::vector< int > &counts) 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
 - void **generation_time** (std::string fn) const

Friends

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

13.9.1 Detailed Description

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

Statistical data about the process.

Template Parameters

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

13.9.2 Member Function Documentation

13.9.2.1 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]
```

Calculates the generating time

Parameters

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

13.9.2.2 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,

13.9.2.3 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,

13.9.2.4 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

13.9.2.5 record_variant()

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

Registering a new variant.

Parameters

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

13.9.2.6 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 R0 (basic reproductive number) or Rt/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.
-----------	--

13.9.2.7 transition_probability()

```
template<typename TSeq >
```

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

Calculates the transition probabilities.

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

13.10 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_variant](#) ([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_variant_info, std::string fn_variant_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 variant, int i_expo_date)
- size_t [get_n_variants](#) () const
- size_t [get_n_tools](#) () const
- 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) 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_variant, the current counts of what for each variant.

In get_hist_total, the time series of what

In get_hist_variant, the time series of what for each variant.

In get_hist_total_date and get_hist_variant_date the corresponding dates

- 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_variant** (std::vector< std::string > &state, std::vector< int > &id, 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_variant** (std::vector< int > &date, std::vector< int > &id, std::vector< std::string > &state, std::vector< int > &counts) 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
 - void **generation_time** (std::string fn) const

Friends

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

13.10.1 Detailed Description

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

Statistical data about the process.

Template Parameters

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

13.10.2 Member Function Documentation

13.10.2.1 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]
```

Calculates the generating time

Parameters

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

13.10.2.2 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

13.10.2.3 record_variant()

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

Registering a new variant.

Parameters

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

13.10.2.4 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 R0 (basic reproductive number) or Rt/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.
-----------	--

13.10.2.5 transition_probability()

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

Calculates the transition probabilities.

Returns

`std::vector< epiworld_double >`

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

- epiworld.hpp

13.11 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 >

13.11.1 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

13.12 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 >

13.12.1 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

13.13 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 >

13.13.1 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

13.14 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 >

13.14.1 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

13.15 Entity< TSeq > Class Template Reference

Public Member Functions

- **Entity** (std::string name)
- void **add_agent** (Agent< TSeq > &p, Model< TSeq > *model)
- void **add_agent** (Agent< TSeq > *p, Model< TSeq > *model)
- void **rm_agent** (size_t idx)
- 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
- Agent< TSeq > * **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

Friends

- class Agent< TSeq >
- class AgentsSample< TSeq >
- class Model< TSeq >
- void **default_add_entity** (Action< TSeq > &a, Model< TSeq > *m)
- void **default_rm_entity** (Action< TSeq > &a, Model< TSeq > *m)

13.15.1 Friends And Related Function Documentation

13.15.1.1 default_rm_entity

```
template<typename TSeq >
void default_rm_entity (
    Action< 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

< 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

13.16 epiworld::Entity< TSeq > Class Template Reference

Public Member Functions

- **Entity** (std::string name)
- void **add_agent** ([Agent](#)< TSeq > &p, [Model](#)< TSeq > *model)
- void **add_agent** ([Agent](#)< TSeq > *p, [Model](#)< TSeq > *model)
- void **rm_agent** (size_t idx)
- 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
- [Agent](#)< TSeq > * **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

Friends

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

13.16.1 Friends And Related Function Documentation

13.16.1.1 default_rm_entity

```
template<typename TSeq >
void default_rm_entity (
    Action< 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

13.17 epiworld::LFMCMC< TData > Class Template Reference

Likelihood-Free Markov Chain Monte Carlo.

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

Public Member Functions

- void **run** (std::vector< epiworld_double > param_init, size_t n_samples_, epiworld_double epsilon_)
- **LFMCMC** (TData &observed_data_)
- void **set_observed_data** (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)
- size_t **get_n_samples** () const
- size_t **get_n_statistics** () const
- size_t **get_n_parameters** () const
- epiworld_double **get_epsilon** () const
- const std::vector< epiworld_double > & **get_params_now** ()
- const std::vector< epiworld_double > & **get_params_prev** ()
- const std::vector< epiworld_double > & **get_params_init** ()
- const std::vector< epiworld_double > & **get_statistics_obs** ()
- const std::vector< epiworld_double > & **get_statistics_hist** ()
- const std::vector< bool > & **get_statistics_accepted** ()
- const std::vector< epiworld_double > & **get_posterior_if_prob** ()
- const std::vector< epiworld_double > & **get_drawn_prob** ()
- std::vector< TData > * **get_sampled_data** ()
- void **set_par_names** (std::vector< std::string > names)
- void **set_stats_names** (std::vector< std::string > names)
- std::vector< epiworld_double > **get_params_mean** ()
- std::vector< epiworld_double > **get_stats_mean** ()
- void **print** ()

Random number generation

Parameters

eng	
-----	--

- void **set_rand_engine** (std::mt19937 &eng)
- 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)

13.17.1 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

13.18 LFMCMC< TData > Class Template Reference

Likelihood-Free Markov Chain Monte Carlo.

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

Public Member Functions

- void **run** (std::vector< epiworld_double > param_init, size_t n_samples_, epiworld_double epsilon_)
- **LFMCMC** (TData &observed_data_)
- void **set_observed_data** (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)
- size_t **get_n_samples** () const
- size_t **get_n_statistics** () const
- size_t **get_n_parameters** () const
- epiworld_double **get_epsilon** () const
- const std::vector< epiworld_double > & **get_params_now** ()
- const std::vector< epiworld_double > & **get_params_prev** ()
- const std::vector< epiworld_double > & **get_params_init** ()
- const std::vector< epiworld_double > & **get_statistics_obs** ()
- const std::vector< epiworld_double > & **get_statistics_hist** ()
- const std::vector< bool > & **get_statistics_accepted** ()
- const std::vector< epiworld_double > & **get_posterior_if_prob** ()
- const std::vector< epiworld_double > & **get_drawn_prob** ()
- std::vector< TData > * **get_sampled_data** ()
- void **set_par_names** (std::vector< std::string > names)
- void **set_stats_names** (std::vector< std::string > names)
- std::vector< epiworld_double > **get_params_mean** ()
- std::vector< epiworld_double > **get_stats_mean** ()
- void **print** ()

Random number generation

Parameters

eng	
-----	--

- void **set_rand_engine** (std::mt19937 &eng)
- 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)

13.18.1 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:

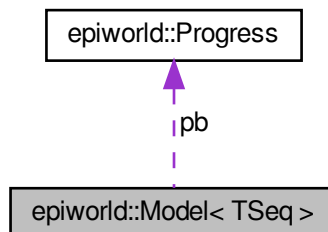
- include/epiworld/math/lfmcmc/lfmcmc-bones.hpp
- include/epiworld/math/lfmcmc/lfmcmc-meat-print.hpp
- include/epiworld/math/lfmcmc/lfmcmc-meat.hpp

13.19 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** ()
- 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.
- size_t **get_n_variants** () const
- size_t **get_n_tools** () const
- epiworld_fast_uint **get_ndays** () const
- epiworld_fast_uint **get_n_replicates** () const
- void **set_ndays** (epiworld_fast_uint ndays)
- bool **get_verbose** () const
- void **verbose_off** ()
- void **verbose_on** ()
- int [today](#) () const
The current time of the model.
- void [write_data](#) (std::string fn_variant_info, std::string fn_variant_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** ()
- void [reset](#) ()
Reset the model.
- void **print** (bool lite=false) const
- [Model](#)< TSeq > && **clone** () const
- void **get_elapsed** (std::string unit="auto", epiworld_double *last_elapsed=nullptr, epiworld_double *total_↵
elapsed=nullptr, std::string *unit_abbrev=nullptr, bool print=true) const
- void [add_global_action](#) (std::function< void([Model](#)< TSeq > *)> fun, int date=-99)
Set a global action.
- void **run_global_actions** ()
- void **clear_state_set** ()
- const std::vector< VirusPtr< TSeq > > & **get_viruses** () const
- const std::vector< ToolPtr< TSeq > > & **get_tools** () const
- void [set_agents_data](#) (double *data_, size_t ncols_)
Set the agents data object.
- 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

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::mt19937 &eng)
- 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)
- 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)

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, epiworld_double preval)
- void **add_virus_n** ([Virus](#)< TSeq > v, epiworld_fast_uint preval)
- void **add_virus_fun** ([Virus](#)< TSeq > v, VirusToAgentFun< TSeq > fun)
- void **add_tool** ([Tool](#)< TSeq > t, epiworld_double preval)
- void **add_tool_n** ([Tool](#)< TSeq > t, epiworld_fast_uint preval)
- void **add_tool_fun** ([Tool](#)< TSeq > t, ToolToAgentFun< TSeq > fun)
- 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_pos)

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 <code>fn</code>.</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_adjlist** ([AdjList](#) al)
- bool **is_directed** () const
- std::vector< [Agent](#)< TSeq > & **get_agents** ()
- std::vector< [Entity](#)< TSeq > & **get_entities** ()

- void **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_variant** ()
- void **next** ()
- virtual void **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< epiworld_fast_uint > &source, std::vector< epiworld_fast_uint > &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_state** () const
- const std::vector< UpdateFun< TSeq > > & **get_state_fun** () const
- void **print_state_codes** () const

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)
- void **read_params** (std::string fn)
- epiworld_double **get_param** (epiworld_fast_uint k)
- epiworld_double **get_param** (std::string pname)
- epiworld_double **par** (epiworld_fast_uint k)
- epiworld_double **par** (std::string pname)

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.)
- void [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 **chrono_start** ()
- void **chrono_end** ()
- void [actions_add](#) ([Agent](#)< TSeq > *agent_, [VirusPtr](#)< TSeq > virus_, [ToolPtr](#)< TSeq > tool_, [Entity](#)< TSeq > *entity_, epiworld_fast_uint new_state_, epiworld_fast_int queue_, [ActionFun](#)< TSeq > call_, int idx_agent_, int idx_object_)
Construct a new [Action](#) object.
- void [actions_run](#) ()
Executes the stored action.

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< epiworld_double > prevalence_virus = {}`
Initial prevalence_virus of each virus.
- `std::vector< bool > prevalence_virus_as_proportion = {}`
- `std::vector< VirusToAgentFun< TSeq > > viruses_dist_funs = {}`
- `std::vector< ToolPtr< TSeq > > tools = {}`
- `std::vector< epiworld_double > prevalence_tool = {}`
- `std::vector< bool > prevalence_tool_as_proportion = {}`
- `std::vector< ToolToAgentFun< TSeq > > tools_dist_funs = {}`
- `std::vector< Entity< TSeq > > entities = {}`
- `std::vector< Entity< TSeq > > entities_backup = {}`
- `std::mt19937 engine`
- `std::uniform_real_distribution runifd = std::uniform_real_distribution<> (0.0, 1.0)`
- `std::normal_distribution rnormd = std::normal_distribution<> (0.0)`
- `std::gamma_distribution rgammad = std::gamma_distribution<> ()`
- `std::lognormal_distribution rlognormald = std::lognormal_distribution<> ()`
- `std::exponential_distribution rexp = std::exponential_distribution<> ()`
- `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 > > status_fun = {}`
- `std::vector< std::string > status_labels = {}`
- `epiworld_fast_uint nstatus = 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< std::function< void(Model< TSeq > *)> > > global_action_functions`
- `std::vector< int > global_action_dates`
- `Queue< TSeq > queue`
- `bool use_queuing = true`
- `std::vector< Action< TSeq > > actions = {}`
Variables used to keep track of the actions 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 * population_data = nullptr`
- `size_t population_data_n_features = 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)=delete
 - **Model** ([Model](#)< TSeq > &&m)
 - [Model](#)< TSeq > & **operator=** (const [Model](#)< TSeq > &m)
 - virtual ~**Model** ()
 - void **clone_population** (std::vector< [Agent](#)< TSeq > > &other_population, std::vector< [Entity](#)< TSeq > > &other_entities, [Model](#)< TSeq > *other_model, bool &other_directed) const
 - void **clone_population** (const [Model](#)< TSeq > &other_model)

13.19.1 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.)
-------------	---

13.19.2 Member Function Documentation

13.19.2.1 actions_add()

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

Construct a new [Action](#) 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.

13.19.2.2 actions_run()

```
template<typename TSeq >
void Model< TSeq >::actions_run [inline], [protected]
```

Executes the stored action.

Parameters

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

13.19.2.3 add_global_action()

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

```
std::function< void(Model< TSeq > *)> fun,
int date = -99 ) [inline]
```

Set a global action.

Parameters

<i>fun</i>	A function to be called on the prescribed dates
<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.

13.19.2.4 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 [ModelSIRCONN< TSeq >](#), [ModelSEIRCONN< TSeq >](#), [epiworld::epimodels::ModelSEIRCONN< TSeq >](#), and [epiworld::epimodels::ModelSIRCONN< TSeq >](#).

13.19.2.5 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.

13.19.2.6 reset()

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

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

13.19.2.7 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
--------------	---------------------------------

13.19.2.8 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()</code> * <code>ncols_</code> .
<i>ncols</i> ↔ —	Number of features included in the data.

13.19.2.9 set_name()

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

Set the name object.

Parameters

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

13.19.2.10 write_data()

```
template<typename TSeq >
void Model< TSeq >::write_data (
    std::string fn_variant_info,
    std::string fn_variant_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_variant_info</i>	Filename. Information about the variant.
<i>fn_variant_hist</i>	Filename. History of the variant.
<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

13.19.3 Member Data Documentation

13.19.3.1 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:

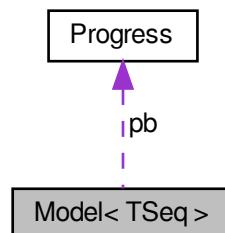
- epiworld.hpp

13.20 Model< TSeq > Class Template Reference

Core class of epiworld.

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

Collaboration diagram for Model< TSeq >:



Public Member Functions

- [DataBase< TSeq >](#) & **get_db** ()
- 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.
- size_t **get_n_variants** () const
- size_t **get_n_tools** () const
- epiworld_fast_uint **get_ndays** () const
- epiworld_fast_uint **get_n_replicates** () const

- void **set_ndays** (epiworld_fast_uint ndays)
- bool **get_verbose** () const
- void **verbose_off** ()
- void **verbose_on** ()
- int **today** () const

The current time of the model.

- void **write_data** (std::string fn_variant_info, std::string fn_variant_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** ()
- void **reset** ()

Reset the model.

- void **print** (bool lite=false) const
- **Model**< TSeq > && **clone** () 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_global_action** (std::function< void(**Model**< TSeq > *)> fun, int date=-99)

Set a global action.

- void **run_global_actions** ()
- void **clear_state_set** ()
- const std::vector< VirusPtr< TSeq > > & **get_viruses** () const
- const std::vector< ToolPtr< TSeq > > & **get_tools** () const
- void **set_agents_data** (double *data_, size_t ncols_)

Set the agents data object.

- 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

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::mt19937 &eng)
- 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)
- 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`)

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, `epiworld_double` preval)
- void **add_virus_n** ([Virus](#)< TSeq > v, `epiworld_fast_uint` preval)
- void **add_virus_fun** ([Virus](#)< TSeq > v, `VirusToAgentFun`< TSeq > fun)
- void **add_tool** ([Tool](#)< TSeq > t, `epiworld_double` preval)
- void **add_tool_n** ([Tool](#)< TSeq > t, `epiworld_fast_uint` preval)
- void **add_tool_fun** ([Tool](#)< TSeq > t, `ToolToAgentFun`< TSeq > fun)
- 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_pos)

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_adjlist** ([AdjList](#) al)
- `bool` **is_directed** () const
- `std::vector`< [Agent](#)< TSeq > > & **get_agents** ()
- `std::vector`< [Entity](#)< TSeq > > & **get_entities** ()
- void **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>
------	--

Parameters

ndays	Number of days (steps) of the simulation.
fun	In the case of <code>run_multiple</code> , a function that is called after each experiment.

- void **update_state** ()
- void **mutate_variant** ()
- void **next** ()
- virtual void **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	Proportion of ties to be rewired.
------------	-----------------------------------

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	std::string. File name.
source	Integer vector
target	Integer vector

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< epiworld_fast_uint > &source, std::vector< epiworld_fast_uint > &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	std::string 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_state** () const
- const std::vector< UpdateFun< TSeq > > & **get_state_fun** () const
- void **print_state_codes** () const

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)
- void **read_params** (`std::string` fn)
- `epiworld_double` **get_param** (`epiworld_fast_uint` k)
- `epiworld_double` **get_param** (`std::string` pname)
- `epiworld_double` **par** (`epiworld_fast_uint` k)
- `epiworld_double` **par** (`std::string` pname)

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.)
- void [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 **chrono_start** ()
- void **chrono_end** ()
- void [actions_add](#) ([Agent](#)< TSeq > *agent_, [VirusPtr](#)< TSeq > virus_, [ToolPtr](#)< TSeq > tool_, [Entity](#)< TSeq > *entity_, epiworld_fast_uint new_state_, epiworld_fast_int queue_, [ActionFun](#)< TSeq > call_, int idx_agent_, int idx_object_)
Construct a new [Action](#) object.
- void [actions_run](#) ()
Executes the stored action.

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< epiworld_double > [prevalence_virus](#) = {}
Initial prevalence_virus of each virus.
- std::vector< bool > **prevalence_virus_as_proportion** = {}
- std::vector< [VirusToAgentFun](#)< TSeq > > **viruses_dist_funs** = {}
- std::vector< [ToolPtr](#)< TSeq > > **tools** = {}
- std::vector< epiworld_double > **prevalence_tool** = {}

- `std::vector< bool > prevalence_tool_as_proportion = {}`
 - `std::vector< ToolToAgentFun< TSeq > > tools_dist_funs = {}`
 - `std::vector< Entity< TSeq > > entities = {}`
 - `std::vector< Entity< TSeq > > entities_backup = {}`
 - `std::mt19937 engine`
 - `std::uniform_real_distribution runifd = std::uniform_real_distribution<> (0.0, 1.0)`
 - `std::normal_distribution rnormd = std::normal_distribution<>(0.0)`
 - `std::gamma_distribution rgammad = std::gamma_distribution<>()`
 - `std::lognormal_distribution rlognormald = std::lognormal_distribution<>()`
 - `std::exponential_distribution rexp = std::exponential_distribution<>()`
 - `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 > > status_fun = {}`
 - `std::vector< std::string > status_labels = {}`
 - `epiworld_fast_uint nstatus = 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< std::function< void(Model< TSeq > *)> > global_action_functions`
 - `std::vector< int > global_action_dates`
 - `Queue< TSeq > queue`
 - `bool use_queueing = true`
 - `std::vector< Action< TSeq > > actions = {}`
- Variables used to keep track of the actions 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 * population_data = nullptr`
- `size_t population_data_n_features = 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)=delete
 - **Model** ([Model](#)< TSeq > &&m)
 - [Model](#)< TSeq > & **operator=** (const [Model](#)< TSeq > &m)
 - virtual ~**Model** ()
 - void **clone_population** (std::vector< [Agent](#)< TSeq > > &other_population, std::vector< [Entity](#)< TSeq > > &other_entities, [Model](#)< TSeq > *other_model, bool &other_directed) const
 - void **clone_population** (const [Model](#)< TSeq > &other_model)

13.20.1 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.)
-------------	---

13.20.2 Member Function Documentation

13.20.2.1 actions_add()

```
template<typename TSeq >
void Model< TSeq >::actions_add (
    Agent< TSeq > * agent_,
    VirusPtr< TSeq > virus_,
```



```

ToolPtr< TSeq > tool_,
Entity< TSeq > * entity_,
epiworld_fast_uint new_state_,
epiworld_fast_int queue_,
ActionFun< TSeq > call_,
int idx_agent_,
int idx_object_ ) [inline], [protected]

```

Construct a new [Action](#) 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.

13.20.2.2 actions_run()

```

template<typename TSeq >
void Model< TSeq >::actions_run [inline], [protected]

```

Executes the stored action.

Parameters

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

13.20.2.3 add_global_action()

```

template<typename TSeq >
void Model< TSeq >::add_global_action (
    std::function< void(Model< TSeq > *)> fun,
    int date = -99 ) [inline]

```

Set a global action.

Parameters

<i>fun</i>	A function to be called on the prescribed dates
<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.

13.20.2.4 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>	
-------------	--

13.20.2.5 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.

13.20.2.6 reset()

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

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

13.20.2.7 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
--------------	---------------------------------

13.20.2.8 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.

13.20.2.9 set_name()

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

Set the name object.

Parameters

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

13.20.2.10 write_data()

```
template<typename TSeq >
void Model< TSeq >::write_data (
    std::string fn_variant_info,
    std::string fn_variant_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_variant_info</i>	Filename. Information about the variant.
<i>fn_variant_hist</i>	Filename. History of the variant.
<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

13.20.3 Member Data Documentation

13.20.3.1 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:

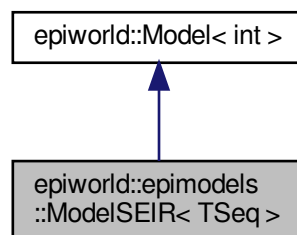
- include/epiworld/agent-bones.hpp
- include/epiworld/model-bones.hpp
- include/epiworld/model-meat-print.hpp
- include/epiworld/model-meat.hpp

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

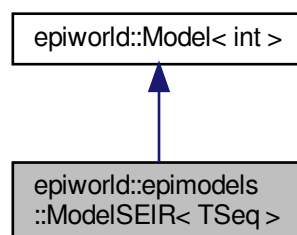
Template for a Susceptible-Exposed-Infected-Removed (SEIR) model.

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

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



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



Public Member Functions

- **ModelSEIR** ([ModelSEIR](#)< TSeq > &model, std::string vname, epiworld_double prevalence, epiworld_double infectiousness, epiworld_double incubation_days, epiworld_double recovery)
- **ModelSEIR** (std::string vname, epiworld_double prevalence, epiworld_double infectiousness, epiworld_double incubation_days, epiworld_double recovery)

Public Attributes

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

Additional Inherited Members

13.21.1 Detailed Description

```
template<typename TSeq = int>
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>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

13.21.2 Member Data Documentation

13.21.2.1 update_exposed_seir

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

Initial value:

```
= [] (
    epiworld::Agent<TSeq> * p,
    epiworld::Model<TSeq> * m
) -> void {
    if (m->runif() < 1.0/(m->par("Incubation days")))
        p->change_state(m, ModelSEIR<TSeq>::INFECTED);
    return;
}
```

13.21.2.2 update_infected_seir

```
template<typename TSeq = int>
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("Immune recovery")))
        p->rm_virus(0, m);
    return;
}
```

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

- epiworld.hpp

13.22 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, std::string vname, epiworld_double prevalence, epiworld_double infectiousness, epiworld_double incubation_days, epiworld_double recovery)
- **ModelSEIR** (std::string vname, epiworld_double prevalence, epiworld_double infectiousness, epiworld_double incubation_days, epiworld_double recovery)

Public Attributes

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

Additional Inherited Members

13.22.1 Detailed Description

```
template<typename TSeq = int>
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>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

13.22.2 Member Data Documentation

13.22.2.1 update_exposed_seir

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

Initial value:

```
= [] (
    epiworld::Agent<TSeq> * p,
    epiworld::Model<TSeq> * m
) -> void {
    if (m->runif() < 1.0/(m->par("Incubation days")))
        p->change_state(m, ModelSEIR<TSeq>::INFECTED);
    return;
}
```


13.22.2.2 update_infected_seir

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

Initial value:

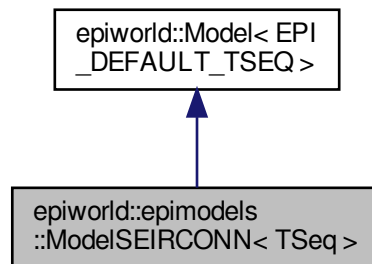
```
= [] (
    epiworld::Agent<TSeq> * p,
    epiworld::Model<TSeq> * m
) -> void {
    if (m->runif() < (m->par("Immune recovery")))
        p->rm_virus(0, m);
    return;
}
```

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

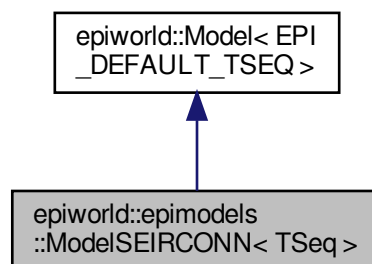
- include/epiworld/models/seir.hpp

13.23 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, std::string vname, epiworld_fast_uint n, epiworld_double prevalence, epiworld_double reproductive_number, epiworld_double prob_transmission, epiworld_double incubation_days, epiworld_double prob_recovery)
Template for a Susceptible-Exposed-Infected-Removed (SEIR) model.
- **ModelSEIRCONN** (std::string vname, epiworld_fast_uint n, epiworld_double prevalence, epiworld_double reproductive_number, epiworld_double prob_transmission, epiworld_double incubation_days, epiworld_double prob_recovery)
- void [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.

Public Attributes

- std::vector< [epiworld::Agent](#)<> * > **tracked_agents_infected** = {}
- std::vector< [epiworld::Agent](#)<> * > **tracked_agents_infected_next** = {}
- bool **tracked_started** = false
- int **tracked_ninfected** = 0
- int **tracked_ninfected_next** = 0

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

13.23.1 Constructor & Destructor Documentation

13.23.1.1 ModelSEIRCONN()

```
template<typename TSeq >
ModelSEIRCONN< TSeq >::ModelSEIRCONN (
    ModelSEIRCONN< TSeq > & model,
    std::string vname,
    epiworld_fast_uint n,
    epiworld_double prevalence,
    epiworld_double reproductive_number,
    epiworld_double prob_transmission,
    epiworld_double incubation_days,
    epiworld_double prob_recovery ) [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>reproductive_number</i>	Reproductive number (beta)
<i>prob_transmission</i>	Probability of transmission
<i>prob_recovery</i>	Probability of recovery

13.23.2 Member Function Documentation

13.23.2.1 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>	
-------------	--

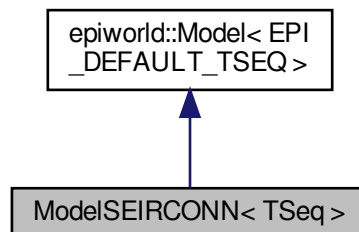
Reimplemented from [epiworld::Model< EPI_DEFAULT_TSEQ >](#).

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

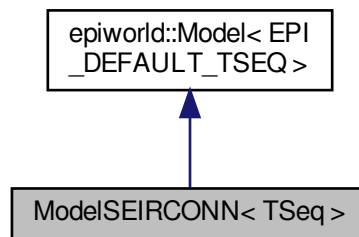
- [epiworld.hpp](#)

13.24 ModelSEIRCONN< TSeq > Class Template Reference

Inheritance diagram for ModelSEIRCONN< TSeq >:



Collaboration diagram for ModelSEIRCONN< TSeq >:



Public Member Functions

- [ModelSEIRCONN](#) ([ModelSEIRCONN](#)< TSeq > &model, std::string vname, epiworld_fast_uint n, epiworld_double prevalence, epiworld_double reproductive_number, epiworld_double prob_transmission, epiworld_double incubation_days, epiworld_double prob_recovery)
Template for a Susceptible-Exposed-Infected-Removed (SEIR) model.
- **ModelSEIRCONN** (std::string vname, epiworld_fast_uint n, epiworld_double prevalence, epiworld_double reproductive_number, epiworld_double prob_transmission, epiworld_double incubation_days, epiworld_double prob_recovery)
- void [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.

Public Attributes

- std::vector< [epiworld::Agent](#)<> * > **tracked_agents_infected** = {}
- std::vector< [epiworld::Agent](#)<> * > **tracked_agents_infected_next** = {}
- bool **tracked_started** = false
- int **tracked_ninfected** = 0
- int **tracked_ninfected_next** = 0

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

13.24.1 Constructor & Destructor Documentation

13.24.1.1 ModelSEIRCONN()

```
template<typename TSeq >
ModelSEIRCONN< TSeq >::ModelSEIRCONN (
    ModelSEIRCONN< TSeq > & model,
    std::string vname,
    epiworld_fast_uint n,
    epiworld_double prevalence,
    epiworld_double reproductive_number,
    epiworld_double prob_transmission,
    epiworld_double incubation_days,
    epiworld_double prob_recovery ) [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>reproductive_number</i>	Reproductive number (beta)
<i>prob_transmission</i>	Probability of transmission
<i>prob_recovery</i>	Probability of recovery

13.24.2 Member Function Documentation

13.24.2.1 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 >](#).

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

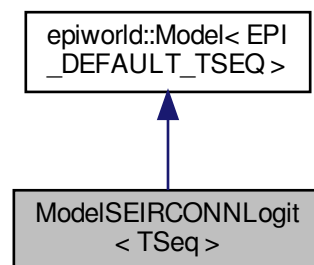
- include/epiworld/models/seirconnected.hpp

13.25 ModelSEIRCONNLogit< TSeq > Class Template Reference

Inheritance diagram for ModelSEIRCONNLogit< TSeq >:



Collaboration diagram for ModelSEIRCONNLogit< TSeq >:



Public Member Functions

- [ModelSEIRCONNLogit](#) ([ModelSEIRCONNLogit](#)< TSeq > &model, std::string vname, epiworld_fast_uint n, epiworld_double prevalence, epiworld_double reproductive_number, epiworld_double prob_transmission, epiworld_double incubation_days, epiworld_double prob_recovery, double *covars, std::vector< double > logit_params)

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

- **ModelSEIRCONNLogit** (std::string vname, epiworld_fast_uint n, epiworld_double prevalence, epiworld_double reproductive_number, epiworld_double prob_transmission, epiworld_double incubation_days, epiworld_double prob_recovery double *covars, std::vector< double > logit_params)

Public Attributes

- std::vector< [epiworld::Agent](#)<> * > **tracked_agents_infected** = {}
- std::vector< [epiworld::Agent](#)<> * > **tracked_agents_infected_next** = {}
- bool **tracked_started** = false
- int **tracked_ninfected** = 0
- int **tracked_ninfected_next** = 0

Additional Inherited Members

13.25.1 Constructor & Destructor Documentation

13.25.1.1 ModelSEIRCONNLogit()

```
template<typename TSeq >
ModelSEIRCONNLogit< TSeq >::ModelSEIRCONNLogit (
    ModelSEIRCONNLogit< TSeq > & model,
    std::string vname,
    epiworld_fast_uint n,
    epiworld_double prevalence,
    epiworld_double reproductive_number,
    epiworld_double prob_transmission,
    epiworld_double incubation_days,
    epiworld_double prob_recovery,
    double * covars,
    std::vector< double > logit_params ) [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>reproductive_number</i>	Reproductive number (beta)
<i>prob_transmission</i>	Probability of transmission
<i>prob_recovery</i>	Probability of recovery

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

- include/epiworld/models/seirconnected_logit.hpp

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

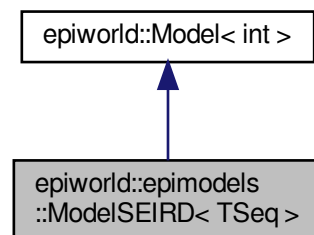
Template for a Susceptible-Exposed-Infected-Removed-Deceased (SEIRD) model.

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

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



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



Public Member Functions

- **ModelSEIRD** ([ModelSEIRD](#)< TSeq > &model, std::string vname)
- **ModelSEIRD** (std::string vname, epiworld_double prevalence, epiworld_double incu_shape, epiworld_double incu_rate, epiworld_double infe_shape, epiworld_double infe_rate, epiworld_double p_hosp, epiworld_double p_hosp_rec, epiworld_double p_hosp_die, epiworld_double p_transmission, epiworld_double p_transmission_entity, size_t n_entities, size_t n_interactions)
- **ModelSEIRD** (std::string fn, std::string vname)

Protected Types

- enum **S** {
Susceptible , **Exposed** , **Infected** , **Hospitalized** ,
Recovered , **Deceased** }

Static Protected Member Functions

- static void **update_exposed** ([epiworld::Agent](#)< TSeq > *p, [epiworld::Model](#)< TSeq > *m)
- static void **update_infected** ([epiworld::Agent](#)< TSeq > *p, [epiworld::Model](#)< TSeq > *m)
- static void **update_hospitalized** ([epiworld::Agent](#)< TSeq > *p, [epiworld::Model](#)< TSeq > *m)
- static void **contact** ([Model](#)< TSeq > *m)

Transmission by contact outside home.

Additional Inherited Members

13.26.1 Detailed Description

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

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

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

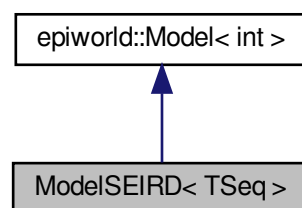
- [epiworld.hpp](#)

13.27 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, std::string vname)
- **ModelSEIRD** (std::string vname, epiworld_double prevalence, epiworld_double incu_shape, epiworld_double incu_rate, epiworld_double infe_shape, epiworld_double infe_rate, epiworld_double p_hosp, epiworld_double p_hosp_rec, epiworld_double p_hosp_die, epiworld_double p_transmission, epiworld_double p_transmission_entity, size_t n_entities, size_t n_interactions)
- **ModelSEIRD** (std::string fn, std::string vname)

Protected Types

- enum **S** {
Susceptible , **Exposed** , **Infected** , **Hospitalized** ,
Recovered , **Deceased** }

Static Protected Member Functions

- static void **update_exposed** ([epiworld::Agent](#)< TSeq > *p, [epiworld::Model](#)< TSeq > *m)
- static void **update_infected** ([epiworld::Agent](#)< TSeq > *p, [epiworld::Model](#)< TSeq > *m)
- static void **update_hospitalized** ([epiworld::Agent](#)< TSeq > *p, [epiworld::Model](#)< TSeq > *m)
- static void **contact** ([Model](#)< TSeq > *m)

Transmission by contact outside home.

Additional Inherited Members

13.27.1 Detailed Description

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

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

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

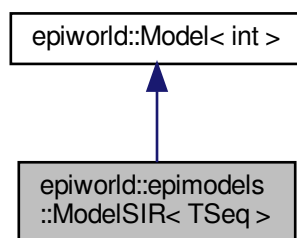
- include/epiworld/models/seird.hpp

13.28 epiworld::epimodels::ModelSIR< TSeq > Class Template Reference

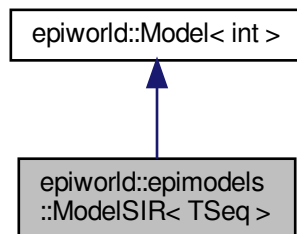
Template for a Susceptible-Infected-Removed (SIR) model.

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

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



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



Public Member Functions

- **ModelSIR** ([ModelSIR](#)< TSeq > &model, std::string vname, epiworld_double prevalence, epiworld_double infectiousness, epiworld_double recovery)
- **ModelSIR** (std::string vname, epiworld_double prevalence, epiworld_double infectiousness, epiworld_double recovery)

Additional Inherited Members

13.28.1 Detailed Description

```
template<typename TSeq = int>  
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_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:

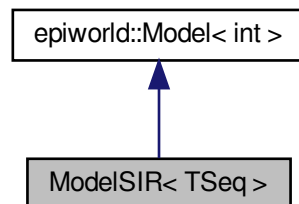
- epiworld.hpp

13.29 ModelSIR< TSeq > Class Template Reference

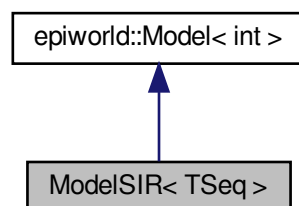
Template for a Susceptible-Infected-Removed (SIR) model.

```
#include <sir.hpp>
```

Inheritance diagram for ModelSIR< TSeq >:



Collaboration diagram for ModelSIR< TSeq >:



Public Member Functions

- **ModelSIR** ([ModelSIR](#)< TSeq > &model, std::string vname, epiworld_double prevalence, epiworld_double infectiousness, epiworld_double recovery)
- **ModelSIR** (std::string vname, epiworld_double prevalence, epiworld_double infectiousness, epiworld_double recovery)

Additional Inherited Members

13.29.1 Detailed Description

```
template<typename TSeq = int>
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 of the immune system

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

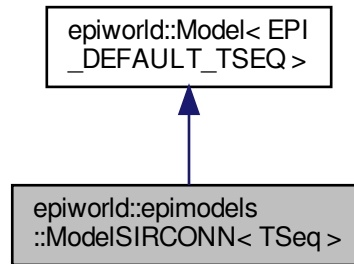
- include/epiworld/models/sir.hpp

13.30 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, std::string vname, epiworld_fast_uint n, epiworld_double prevalence, epiworld_double reproductive_number, epiworld_double prob_transmission, epiworld_double prob_recovery)
- *Template for a Susceptible-Infected-Removed (SIR) model.*
- **ModelSIRCONN** (std::string vname, epiworld_fast_uint n, epiworld_double prevalence, epiworld_double reproductive_number, epiworld_double prob_transmission, epiworld_double prob_recovery)
- void [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.*

Public Attributes

- std::vector< [epiworld::Agent](#)< TSeq > * > **tracked_agents_infected** = {}
- std::vector< [epiworld::Agent](#)< TSeq > * > **tracked_agents_infected_next** = {}
- bool **tracked_started** = false
- int **tracked_ninfected** = 0
- int **tracked_ninfected_next** = 0
- epiworld_double **tracked_current_infect_prob** = 0.0

Additional Inherited Members

13.30.1 Constructor & Destructor Documentation

13.30.1.1 ModelSIRCONN()

```
template<typename TSeq >
ModelSIRCONN< TSeq >::ModelSIRCONN (
    ModelSIRCONN< TSeq > & model,
    std::string vname,
    epiworld_fast_uint n,
    epiworld_double prevalence,
    epiworld_double reproductive_number,
    epiworld_double prob_transmission,
    epiworld_double prob_recovery ) [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>reproductive_number</i>	Reproductive number (beta)
<i>prob_transmission</i>	Probability of transmission
<i>prob_recovery</i>	Probability of recovery

13.30.2 Member Function Documentation

13.30.2.1 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>	
-------------	--

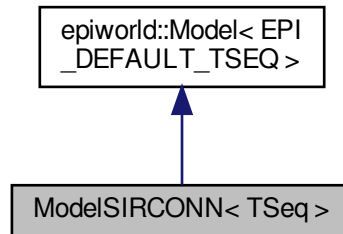
Reimplemented from [epiworld::Model< EPI_DEFAULT_TSEQ >](#).

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

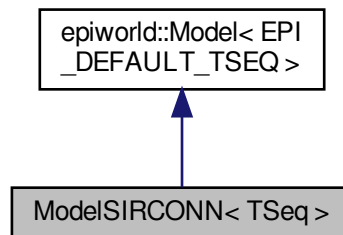
- [epiworld.hpp](#)

13.31 ModelSIRCONN< TSeq > Class Template Reference

Inheritance diagram for ModelSIRCONN< TSeq >:



Collaboration diagram for ModelSIRCONN< TSeq >:



Public Member Functions

- [ModelSIRCONN](#) ([ModelSIRCONN](#)< TSeq > &model, std::string vname, epiworld_fast_uint n, epiworld_double prevalence, epiworld_double reproductive_number, epiworld_double prob_transmission, epiworld_double prob_recovery)

Template for a Susceptible-Infected-Removed (SIR) model.

- **ModelSIRCONN** (std::string vname, epiworld_fast_uint n, epiworld_double prevalence, epiworld_double reproductive_number, epiworld_double prob_transmission, epiworld_double prob_recovery)
- void [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.

Public Attributes

- `std::vector< epiworld::Agent < TSeq > * > tracked_agents_infected = {}`
- `std::vector< epiworld::Agent < TSeq > * > tracked_agents_infected_next = {}`
- `bool tracked_started = false`
- `int tracked_ninfected = 0`
- `int tracked_ninfected_next = 0`
- `epiworld_double tracked_current_infect_prob = 0.0`

Additional Inherited Members

13.31.1 Constructor & Destructor Documentation

13.31.1.1 ModelSIRCONN()

```
template<typename TSeq >
ModelSIRCONN< TSeq >::ModelSIRCONN (
    ModelSIRCONN< TSeq > & model,
    std::string vname,
    epiworld_fast_uint n,
    epiworld_double prevalence,
    epiworld_double reproductive_number,
    epiworld_double prob_transmission,
    epiworld_double prob_recovery ) [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>reproductive_number</i>	Reproductive number (beta)
<i>prob_transmission</i>	Probability of transmission
<i>prob_recovery</i>	Probability of recovery

13.31.2 Member Function Documentation

13.31.2.1 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

copy	
------	--

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

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

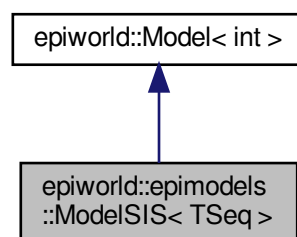
- include/epiworld/models/sirconnected.hpp

13.32 epiworld::epimodels::ModelSIS< TSeq > Class Template Reference

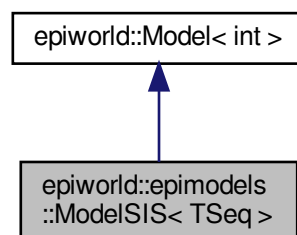
Template for a Susceptible-Infected-Susceptible (SIS) model.

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

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



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



Public Member Functions

- **ModelSIS** ([ModelSIS](#)< TSeq > &model, std::string vname, epiworld_double prevalence, epiworld_double infectiousness, epiworld_double recovery)
- **ModelSIS** (std::string vname, epiworld_double prevalence, epiworld_double infectiousness, epiworld_double recovery)

Additional Inherited Members

13.32.1 Detailed Description

```
template<typename TSeq = int>
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 of the immune system

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

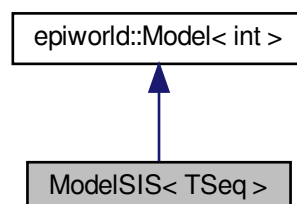
- epiworld.hpp

13.33 ModelSIS< TSeq > Class Template Reference

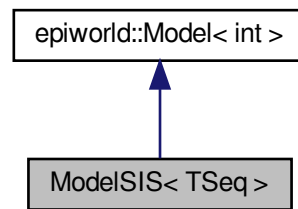
Template for a Susceptible-Infected-Susceptible (SIS) model.

```
#include <sis.hpp>
```

Inheritance diagram for ModelSIS< TSeq >:



Collaboration diagram for ModelSIS< TSeq >:



Public Member Functions

- **ModelSIS** ([ModelSIS](#)< TSeq > &model, std::string vname, epiworld_double prevalence, epiworld_double infectiousness, epiworld_double recovery)
- **ModelSIS** (std::string vname, epiworld_double prevalence, epiworld_double infectiousness, epiworld_double recovery)

Additional Inherited Members

13.33.1 Detailed Description

```
template<typename TSeq = int>
class ModelSIS< TSeq >
```

Template for a Susceptible-Infected-Susceptible (SIS) model.

Parameters

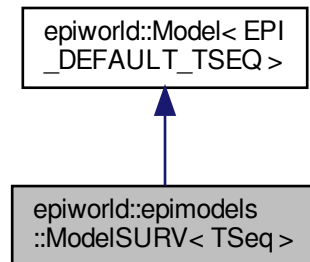
<i>vname</i>	std::string Name of the virus
<i>initial_prevalence</i>	epiworld_double Initial prevalence
<i>initial_efficiency</i>	epiworld_double Initial susceptibility_reduction of the immune system
<i>initial_recovery</i>	epiworld_double Initial recovery rate of the immune system

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

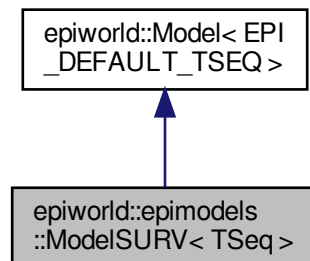
- include/epiworld/models/sis.hpp

13.34 epiworld::epimodels::ModelSURV< TSeq > Class Template Reference

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



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



Public Member Functions

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

<code>infect_period</code>	<i>Double. Shape parameter of a Gamma (<code>infected_period</code>, 1) distribution. This coincides with the expected number of infectious days.</i>
<code>prob_symptoms</code>	<i>Double. Probability of generating symptoms.</i>
<code>prop_vaccinated</code>	<i>Double. Probability of vaccination. Coincides with the initial prevalence of vaccinated individuals.</i>
<code>prop_vax_redux_transm</code>	<i>Double. Factor by which the vaccine reduces transmissibility.</i>
<code>prop_vax_redux_infect</code>	<i>Double. Factor by which the vaccine reduces the chances of becoming infected.</i>
<code>surveillance_prob</code>	<i>Double. Probability of testing an agent.</i>
<code>prob_transmission</code>	<i>Double. Raw transmission probability.</i>
<code>prob_death</code>	<i>Double. Raw probability of death for symptomatic individuals.</i>
<code>prob_noreinfect</code>	<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, `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** (`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)

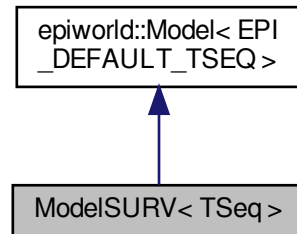
Additional Inherited Members

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

- `epiworld.hpp`

13.35 ModelSURV< TSeq > Class Template Reference

Inheritance diagram for ModelSURV< TSeq >:



Collaboration diagram for ModelSURV< TSeq >:



Public Member Functions

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>
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>

Parameters

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, 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** (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)

Additional Inherited Members

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

- include/epiworld/models/surveillance.hpp

13.36 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

13.37 epiworld::PersonTools< TSeq > Class Template Reference

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

- epiworld.hpp

13.38 PersonTools< TSeq > Class Template Reference

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

- include/epiworld/config.hpp

13.39 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** ()

13.39.1 Detailed Description

A simple progress bar.

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

- epiworld.hpp

13.40 Progress Class Reference

A simple progress bar.

```
#include <progress.hpp>
```

Public Member Functions

- **Progress** (int n_, int width_)
- void **start** ()
- void **next** ()
- void **end** ()

13.40.1 Detailed Description

A simple progress bar.

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

- include/epiworld/progress.hpp

13.41 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

Friends

- class **Model**< TSeq >

13.41.1 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`

13.42 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

Friends

- class **Model**< TSeq >

13.42.1 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`

13.43 epiworld::QueueValues Class Reference

Static Public Attributes

- static const int **NoOne** = 0
- static const int **OnlySelf** = 1
- static const int **Everyone** = 2

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

- epiworld.hpp

13.44 QueueValues Class Reference

Static Public Attributes

- static const int **NoOne** = 0
- static const int **OnlySelf** = 1
- static const int **Everyone** = 2

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

- include/epiworld/epiworld-macros.hpp

13.45 RandGraph Class Reference

Public Member Functions

- **RandGraph** (int N_)
- void **init** (int s)
- void **set_rand_engine** (std::mt19937 &e)
- epiworld_double **runif** ()

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

- include/epiworld/random_graph.hpp

13.46 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

13.47 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

13.48 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")
- void **set_sequence** (TSeq d)
- void **set_sequence** (std::shared_ptr< TSeq > d)
- std::shared_ptr< TSeq > **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

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** ([Action](#)< TSeq > &a, [Model](#)< TSeq > *m)
- void **default_rm_tool** ([Action](#)< TSeq > &a, [Model](#)< TSeq > *m)

13.48.1 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*

13.49 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")
- void **set_sequence** (TSeq d)
- void **set_sequence** (std::shared_ptr< TSeq > d)
- std::shared_ptr< TSeq > **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
- bool **operator==** (const [Tool](#)< std::vector< int >> &other) const
- 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** ([Action](#)< TSeq > &a, [Model](#)< TSeq > *m)
- void **default_rm_tool** ([Action](#)< TSeq > &a, [Model](#)< TSeq > *m)

13.49.1 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

13.50 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

Friends

- class **Tool**< TSeq >
- class **Agent**< TSeq >

13.50.1 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`

13.51 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

Friends

- class **Tool**< TSeq >
- class **Agent**< TSeq >

13.51.1 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`

13.52 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

Friends

- class **Tool**< TSeq >
- class **Agent**< TSeq >

13.52.1 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

13.53 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

Friends

- class **Tool**< TSeq >
- class **Agent**< TSeq >

13.53.1 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

13.54 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() - 1</code> .

- 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 - 1</code> .)
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 >

13.54.1 Detailed Description

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

Personalized data by the user.

Template Parameters

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

13.54.2 Constructor & Destructor Documentation**13.54.2.1 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

13.55 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>i</i>	Row (0 through <i>ndays</i> - 1.)
<i>j</i>	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 >

13.55.1 Detailed Description

```
template<typename TSeq>
class UserData< TSeq >
```

Personalized data by the user.

Template Parameters

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

13.55.2 Constructor & Destructor Documentation**13.55.2.1 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

13.56 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`

13.56.1 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`

13.57 vecHasher< T > Struct Template Reference

Vector hasher.

```
#include <misc.hpp>
```

Public Member Functions

- `std::size_t operator() (std::vector< T > const &dat) const noexcept`

13.57.1 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

13.58 epiworld::Virus< TSeq > Class Template Reference

[Virus.](#)

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

Public Member Functions

- **Virus** (std::string name="unknown virus")
- void **mutate** ([Model](#)< TSeq > *model)
- void **set_mutation** (MutFun< TSeq > fun)
- const TSeq * **get_sequence** ()
- void **set_sequence** (TSeq sequence)
- [Agent](#)< TSeq > * **get_agent** ()
- void **set_agent** ([Agent](#)< TSeq > *p, epiworld_fast_uint idx)
- 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
- std::vector< epiworld_double > & **get_data** ()
- bool **operator==** (const [Virus](#)< TSeq > &other) const
- bool **operator!=** (const [Virus](#)< TSeq > &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)
- 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_prob_infecting** (epiworld_double *prob)
- void **set_prob_recovery** (epiworld_double *prob)
- void **set_prob_death** (epiworld_double *prob)
- void **set_prob_infecting** (epiworld_double prob)
- void **set_prob_recovery** (epiworld_double prob)
- void **set_prob_death** (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)

Friends

- class **Agent**< TSeq >
- class **Model**< TSeq >
- class **DataBase**< TSeq >
- void **default_add_virus** ([Action](#)< TSeq > &a, [Model](#)< TSeq > *m)
- void **default_rm_virus** ([Action](#)< TSeq > &a, [Model](#)< TSeq > *m)

13.58.1 Detailed Description

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

[Virus](#).

Template Parameters

TSeq	
----------------------	--

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

13.59 Virus< TSeq > Class Template Reference

Virus.

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

Public Member Functions

- **Virus** (std::string name="unknown virus")
- void **mutate** (Model< TSeq > *model)
- void **set_mutation** (MutFun< TSeq > fun)
- const TSeq * **get_sequence** ()
- void **set_sequence** (TSeq sequence)
- Agent< TSeq > * **get_agent** ()
- void **set_agent** (Agent< TSeq > *p, epiworld_fast_uint idx)
- 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
- std::vector< epiworld_double > & **get_data** ()
- bool **operator==** (const Virus< TSeq > &other) const
- bool **operator!=** (const Virus< TSeq > &other) const
- bool **operator==** (const Virus< std::vector< int >> &other) const
- 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)
- 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_prob_infecting** (epiworld_double *prob)
- void **set_prob_recovery** (epiworld_double *prob)
- void **set_prob_death** (epiworld_double *prob)
- void **set_prob_infecting** (epiworld_double prob)
- void **set_prob_recovery** (epiworld_double prob)
- void **set_prob_death** (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)

Friends

- class **Agent**< TSeq >
- class **Model**< TSeq >
- class **DataBase**< TSeq >
- void **default_add_virus** ([Action](#)< TSeq > &a, [Model](#)< TSeq > *m)
- void **default_rm_virus** ([Action](#)< TSeq > &a, [Model](#)< TSeq > *m)

13.59.1 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

13.60 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

Friends

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

13.60.1 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

13.61 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

Friends

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

13.61.1 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

13.62 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

Friends

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

13.62.1 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

13.63 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

Friends

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

13.63.1 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

Chapter 14

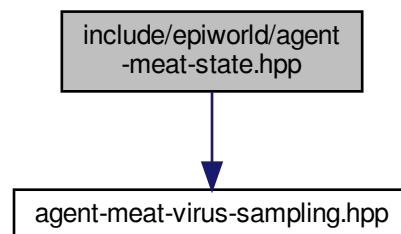
File Documentation

14.1 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)`

14.1.1 Detailed Description

Sampling functions are getting big, so we keep them in a separate file.

Author

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Version

0.1

Date

2022-06-15

Copyright

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