

epiworld

0.0-1

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Chapter 1

Example: 00-hello-world

Output from the program:

Running the model...

||||| done.

SIMULATION STUDY
Population size : 100000
Days (duration) : 100 (of 100)
Number of variants : 1
Last run elapsed t : 256.00ms
Rewiring : off
Virus(es):
- covid 19 (baseline prevalence: 5 seeds)
Tool(s):
- vaccine (baseline prevalence: 50.00%)
Model parameters:
Distribution of the population at time 100:
- Total healthy (S) : 99995 -> 97390
- Total recovered (S) : 0 -> 2554
- Total infected (I) : 5 -> 56
- Total removed (R) : 0 -> 0
(S): Susceptible, (I): Infected, (R): Recovered

Chapter 2

Benchmarking

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

Chapter 3

Contributor Code of Conduct

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

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

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

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

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

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

Chapter 4

epiworld c++ template library

4.1 Main features

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

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

4.2 Algorithm

Setup

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

Run

1. Distribute the tool(s) and virus(es)
2. For each t in 1 -> Duration:
 - Update status 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 = status, 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

MIT License

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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 $(N(i, t, s, k|u))_{k \in K}$, and
- Vaccinated and sick with variant $(N(i, t, s, k|v))_{k \in K}$.

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

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

Contributor Covenant Code of Conduct

8.1 Our Pledge

We as members, contributors, and leaders pledge to make participation in our community a harassment-free experience for everyone, regardless of age, body size, visible or invisible disability, ethnicity, sex characteristics, gender identity and expression, level of experience, education, socio-economic status, nationality, personal appearance, race, religion, or sexual identity and orientation.

We pledge to act and interact in ways that contribute to an open, welcoming, diverse, inclusive, and healthy community.

8.2 Our Standards

Examples of behavior that contributes to a positive environment for our community include:

- Demonstrating empathy and kindness toward other people
- Being respectful of differing opinions, viewpoints, and experiences
- Giving and gracefully accepting constructive feedback
- Accepting responsibility and apologizing to those affected by our mistakes, and learning from the experience
- Focusing on what is best not just for us as individuals, but for the overall community

Examples of unacceptable behavior include:

- The use of sexualized language or imagery, and sexual attention or advances of any kind
- Trolling, insulting or derogatory comments, and personal or political attacks
- Public or private harassment
- Publishing others' private information, such as a physical or email address, without their explicit permission
- Other conduct which could reasonably be considered inappropriate in a professional setting

8.3 Enforcement Responsibilities

Community leaders are responsible for clarifying and enforcing our standards of acceptable behavior and will take appropriate and fair corrective action in response to any behavior that they deem inappropriate, threatening, offensive, or harmful.

Community leaders have the right and responsibility to remove, edit, or reject comments, commits, code, wiki edits, issues, and other contributions that are not aligned to this Code of Conduct, and will communicate reasons for moderation decisions when appropriate.

8.4 Scope

This Code of Conduct applies within all community spaces, and also applies when an individual is officially representing the community in public spaces. Examples of representing our community include using an official e-mail address, posting via an official social media account, or acting as an appointed representative at an online or offline event.

8.5 Enforcement

Instances of abusive, harassing, or otherwise unacceptable behavior may be reported to the community leaders responsible for enforcement at g.vegayon@gmail.com. All complaints will be reviewed and investigated promptly and fairly.

All community leaders are obligated to respect the privacy and security of the reporter of any incident.

8.6 Enforcement Guidelines

Community leaders will follow these Community Impact Guidelines in determining the consequences for any action they deem in violation of this Code of Conduct:

8.6.1 1. Correction

Community Impact: Use of inappropriate language or other behavior deemed unprofessional or unwelcome in the community.

Consequence: A private, written warning from community leaders, providing clarity around the nature of the violation and an explanation of why the behavior was inappropriate. A public apology may be requested.

8.6.2 2. Warning

Community Impact: A violation through a single incident or series of actions.

Consequence: A warning with consequences for continued behavior. No interaction with the people involved, including unsolicited interaction with those enforcing the Code of Conduct, for a specified period of time. This includes avoiding interactions in community spaces as well as external channels like social media. Violating these terms may lead to a temporary or permanent ban.

8.6.3 3. Temporary Ban

Community Impact: A serious violation of community standards, including sustained inappropriate behavior.

Consequence: A temporary ban from any sort of interaction or public communication with the community for a specified period of time. No public or private interaction with the people involved, including unsolicited interaction with those enforcing the Code of Conduct, is allowed during this period. Violating these terms may lead to a permanent ban.

8.6.4 4. Permanent Ban

Community Impact: Demonstrating a pattern of violation of community standards, including sustained inappropriate behavior, harassment of an individual, or aggression toward or disparagement of classes of individuals.

Consequence: A permanent ban from any sort of public interaction within the community.

8.7 Attribution

This Code of Conduct is adapted from the [Contributor Covenant](https://www.contributor-covenant.org/version/2/0/code_of_conduct.html), version 2.0, available at https://www.contributor-covenant.org/version/2/0/code_of_conduct.html.

Community Impact Guidelines were inspired by [Mozilla's code of conduct enforcement ladder](#).

For answers to common questions about this code of conduct, see the FAQ at <https://www.contributor-covenant.org/faq>. Translations are available at <https://www.contributor-covenant.org/translations>.

Chapter 9

MIT License

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Chapter 10

epiworld 1.0

- Added a NEWS .md file to track changes to the package.

Chapter 11

Namespace Index

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Chapter 13

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13.1 File List

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Chapter 14

Namespace Documentation

14.1 epiworld::sampler Namespace Reference

Functions for sampling viruses.

Functions

- `template<typename TSeq = int>
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)

14.1.1 Detailed Description

Functions for sampling viruses.

14.1.2 Function Documentation

14.1.2.1 `make_sample_virus_neighbors()`

```
template<typename TSeq = 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;

14.1.2.2 make_update_susceptible()

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

Make a function to sample from neighbors.

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

Template Parameters

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

Parameters

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

Returns

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

14.1.2.3 sample_virus_single()

```
template<typename TSeq = 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;

14.2 sampler Namespace Reference

Functions for sampling viruses.

Functions

- `template<typename TSeq = int>`
`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)

14.2.1 Detailed Description

Functions for sampling viruses.

14.2.2 Function Documentation

14.2.2.1 `make_sample_virus_neighbors()`

```
template<typename TSeq = 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;

14.2.2.2 make_update_susceptible()

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

Make a function to sample from neighbors.

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

Template Parameters

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

Parameters

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

Returns

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

14.2.2.3 sample_virus_single()

```
template<typename TSeq = 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 15

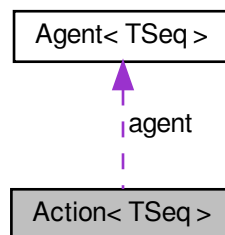
Class Documentation

15.1 Action< TSeq > Struct Template Reference

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

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

Collaboration diagram for Action< TSeq >:



Public Member Functions

- [Action](#) ([Agent](#)< TSeq > *agent_, VirusPtr< TSeq > virus_, ToolPtr< TSeq > tool_, [Entity](#)< TSeq > *entity_, epiworld_fast_int new_status_, 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_status**
- epiworld_fast_int **queue**
- ActionFun< TSeq > **call**
- int **idx_agent**
- int **idx_object**

15.1.1 Detailed Description

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

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

Template Parameters

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

15.1.2 Constructor & Destructor Documentation

15.1.2.1 Action()

```
template<typename TSeq >
Action< TSeq >::Action (
    Agent< TSeq > * agent_,
    VirusPtr< TSeq > virus_,
    ToolPtr< TSeq > tool_,
    Entity< TSeq > * entity_,
    epiworld_fast_int new_status_,
    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_↔ status_</i>	Next status
<i>queue_</i>	Effect on the queue
<i>call_</i>	The action call (if needed)
<i>idx_agent_↔ _</i>	Location of agent in object.
<i>idx_object_↔ _</i>	Location of object in agent.

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

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

15.2 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_status_, 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_status**
- epiworld_fast_int **queue**
- ActionFun< TSeq > **call**
- int **idx_agent**
- int **idx_object**

15.2.1 Detailed Description

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

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

Template Parameters

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

15.2.2 Constructor & Destructor Documentation

15.2.2.1 Action()

```
template<typename TSeq >
epiworld::Action< TSeq >::Action (
    Agent< TSeq > * agent_,
    VirusPtr< TSeq > virus_,
    ToolPtr< TSeq > tool_,
    Entity< TSeq > * entity_,
    epiworld_fast_int new_status_,
    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_↔ status_</i>	Next status
<i>queue_</i>	Efect on the queue
<i>call_</i>	The action call (if needed)
<i>idx_agent_↔ _</i>	Location of agent in object.
<i>idx_object_↔ _</i>	Location of object in agent.

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

- epiworld.hpp

15.3 AdjList Class Reference

Public Member Functions

- [AdjList](#) (const std::vector< unsigned int > &source, const std::vector< unsigned int > &target, int size, bool directed)
Construct a new Adj List object.
- void [read_edgelist](#) (std::string fn, int size, int skip=0, bool directed=true)
Read an edgelist.
- std::map< unsigned int, unsigned int > **operator()** (unsigned int i) const
- void **print** (unsigned int 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< unsigned int, unsigned int > > & get_dat ()`
- `bool is_directed () const`
true if the network is directed.

15.3.1 Constructor & Destructor Documentation

15.3.1.1 AdjList()

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

Construct a new Adj List object.

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

Parameters

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

15.3.2 Member Function Documentation

15.3.2.1 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>	<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 files:

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

15.4 epiworld::AdjList Class Reference

Public Member Functions

- [AdjList](#) (const std::vector< unsigned int > &source, const std::vector< unsigned int > &target, int size, bool directed)
Construct a new Adj List object.
- void [read_edgelist](#) (std::string fn, int size, int skip=0, bool directed=true)
Read an edgelist.
- std::map< unsigned int, unsigned int > **operator()** (unsigned int i) const
- void **print** (unsigned int 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< unsigned int, unsigned int > > & **get_dat** ()
- bool [is_directed](#) () const
true if the network is directed.
- [AdjList](#) (const std::vector< unsigned int > &source, const std::vector< unsigned int > &target, bool directed, int min_id=-1, int max_id=-1)
Construct a new Adj List object.
- void **read_edgelist** (std::string fn, int skip=0, bool directed=true, int min_id=-1, int max_id=-1)
- std::map< unsigned int, unsigned int > **operator()** (unsigned int i) const
- void **print** (unsigned int limit=20u) const
- unsigned int **get_id_max** () const
- unsigned int **get_id_min** () const
- size_t **vcount** () const
- size_t **ecount** () const
- std::map< unsigned int, std::map< unsigned int, unsigned int > > & **get_dat** ()
- bool **is_directed** () const

15.4.1 Constructor & Destructor Documentation

15.4.1.1 AdjList() [1/2]

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

Construct a new Adj List object.

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

Parameters

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

15.4.1.2 AdjList() [2/2]

```
AdjList::AdjList (
    const std::vector< unsigned int > & source,
    const std::vector< unsigned int > & target,
    bool directed,
    int min_id = -1,
    int max_id = -1 ) [inline]
```

Construct a new Adj List object.

It will create an adjacency list object with `maxid - minid + 1` nodes. If `min_id` and `max_id` are not specified (both `< 0`), then the program will try to figure them out automatically by looking at the range of the observed ids.

Parameters

<i>source</i>	Unsigned int vector with the source
<i>target</i>	Unsigned int vector with the target
<i>directed</i>	Bool true if the network is directed
<i>min_id</i>	int min id.
<i>max_id</i>	int max id.

15.4.2 Member Function Documentation**15.4.2.1 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`

15.5 Agent< TSeq > Class Template Reference

[Agent](#) (agents)

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

Public Member Functions

- **Agent** (const [Agent](#)< TSeq > &p)
- int [get_id](#) () const
Id of the individual.
- `std::mt19937` * **get_rand_engine** ()
- [Model](#)< TSeq > * **get_model** ()
- [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)
- `std::vector`< [Agent](#)< TSeq > * > & **get_neighbors** ()
- void **change_status** (`epiworld_fast_uint` new_status, `epiworld_fast_int` queue=0)
- const `epiworld_fast_uint` & **get_status** () const
- void **reset** ()
- bool **has_tool** (unsigned int t) const
- bool **has_tool** (std::string name) const
- bool **has_virus** (unsigned int t) const
- bool **has_virus** (std::string name) const
- void **print** (bool compressed=false) const
- [Entities](#)< TSeq > **get_entities** ()
- const [Entities_const](#)< TSeq > **get_entities** () 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>Status after the change</i>
queue	

- void **add_tool** (ToolPtr< TSeq > tool, epiworld_fast_int status_new=-99, epiworld_fast_int queue=-99)
- void **add_tool** ([Tool](#)< TSeq > tool, epiworld_fast_int status_new=-99, epiworld_fast_int queue=-99)
- void **add_virus** (VirusPtr< TSeq > virus, epiworld_fast_int status_new=-99, epiworld_fast_int queue=-99)
- void **add_virus** ([Virus](#)< TSeq > virus, epiworld_fast_int status_new=-99, epiworld_fast_int queue=-99)
- void **add_entity** ([Entity](#)< TSeq > &entity, epiworld_fast_int status_new=-99, epiworld_fast_int queue=-99)
- void **rm_tool** (epiworld_fast_uint tool_idx, epiworld_fast_int status_new=-99, epiworld_fast_int queue=-99)
- void **rm_tool** (ToolPtr< TSeq > &tool, epiworld_fast_int status_new=-99, epiworld_fast_int queue=-99)
- void **rm_virus** (epiworld_fast_uint virus_idx, epiworld_fast_int status_new=-99, epiworld_fast_int queue=-99)
- void **rm_virus** (VirusPtr< TSeq > &virus, epiworld_fast_int status_new=-99, epiworld_fast_int queue=-99)
- void **rm_entity** (epiworld_fast_uint entity_idx, epiworld_fast_int status_new=-99, epiworld_fast_int queue=-99)
- void **rm_entity** ([Entity](#)< TSeq > &entity, epiworld_fast_int status_new=-99, epiworld_fast_int queue=-99)
- void **rm_agent_by_virus** (epiworld_fast_uint virus_idx, epiworld_fast_int status_new=-99, epiworld_fast_int queue=-99)
Agent removed by virus.
- void **rm_agent_by_virus** (VirusPtr< TSeq > &virus, 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)
 - epiworld_double **get_transmission_reduction** (VirusPtr< TSeq > v)
 - epiworld_double **get_recovery_enhancer** (VirusPtr< TSeq > v)
 - epiworld_double **get_death_reduction** (VirusPtr< TSeq > v)
-
- double & **operator()** (size_t j)
Access the j-th column of the agent.
 - double & **operator[]** (size_t j)

Friends

- class **Model**< TSeq >
- class **Virus**< TSeq >
- class **Viruses**< TSeq >
- class **Viruses_const**< TSeq >
- class **Tool**< TSeq >
- class **Tools**< 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)

15.5.1 Detailed Description

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

[Agent](#) (agents)

Template Parameters

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

15.5.2 Member Function Documentation

15.5.2.1 operator()()

```
template<typename TSeq = int>
double& Agent< TSeq >::operator() (
    size_t j )
```

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&

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

- include/epiworld/agent-bones.hpp

15.6 epiworld::Agent< TSeq > Class Template Reference

[Agent](#) (agents)

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

Public Member Functions

- **Agent** (const [Agent](#)< TSeq > &p)
- int [get_id](#) () const
Id of the individual.
- std::mt19937 * [get_rand_engine](#) ()
- [Model](#)< TSeq > * [get_model](#) ()
- 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)
- std::vector< [Agent](#)< TSeq > * > & [get_neighbors](#) ()
- void [change_status](#) (epiworld_fast_uint new_status, epiworld_fast_int queue=0)
- const epiworld_fast_uint & [get_status](#) () const
- void [reset](#) ()
- bool [has_tool](#) (unsigned int t) const
- bool [has_tool](#) (std::string name) const
- bool [has_virus](#) (unsigned int t) const
- bool [has_virus](#) (std::string name) const
- void [print](#) (bool compressed=false) const
- [Entities](#)< TSeq > [get_entities](#) ()
- const [Entities_const](#)< TSeq > [get_entities](#) () 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>Status after the change</i>
queue	

- void **add_tool** (ToolPtr< TSeq > tool, epiworld_fast_int status_new=-99, epiworld_fast_int queue=-99)
- void **add_tool** ([Tool](#)< TSeq > tool, epiworld_fast_int status_new=-99, epiworld_fast_int queue=-99)
- void **add_virus** (VirusPtr< TSeq > virus, epiworld_fast_int status_new=-99, epiworld_fast_int queue=-99)
- void **add_virus** ([Virus](#)< TSeq > virus, epiworld_fast_int status_new=-99, epiworld_fast_int queue=-99)
- void **add_entity** ([Entity](#)< TSeq > &entity, epiworld_fast_int status_new=-99, epiworld_fast_int queue=-99)
- void **rm_tool** (epiworld_fast_uint tool_idx, epiworld_fast_int status_new=-99, epiworld_fast_int queue=-99)
- void **rm_tool** (ToolPtr< TSeq > &tool, epiworld_fast_int status_new=-99, epiworld_fast_int queue=-99)
- void **rm_virus** (epiworld_fast_uint virus_idx, epiworld_fast_int status_new=-99, epiworld_fast_int queue=-99)
- void **rm_virus** (VirusPtr< TSeq > &virus, epiworld_fast_int status_new=-99, epiworld_fast_int queue=-99)
- void **rm_entity** (epiworld_fast_uint entity_idx, epiworld_fast_int status_new=-99, epiworld_fast_int queue=-99)
- void **rm_entity** ([Entity](#)< TSeq > &entity, epiworld_fast_int status_new=-99, epiworld_fast_int queue=-99)
- void **rm_agent_by_virus** (epiworld_fast_uint virus_idx, epiworld_fast_int status_new=-99, epiworld_fast_int queue=-99)
Agent removed by virus.
- void **rm_agent_by_virus** (VirusPtr< TSeq > &virus, 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)
 - epiworld_double **get_transmission_reduction** (VirusPtr< TSeq > v)
 - epiworld_double **get_recovery_enhancer** (VirusPtr< TSeq > v)
 - epiworld_double **get_death_reduction** (VirusPtr< TSeq > v)
-
- double & **operator()** (size_t j)
Access the j-th column of the agent.
 - double & **operator[]** (size_t j)

Friends

- class **Model**< TSeq >
- class **Virus**< TSeq >
- class **Viruses**< TSeq >
- class **Viruses_const**< TSeq >
- class **Tool**< TSeq >
- class **Tools**< 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)

15.6.1 Detailed Description

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

[Agent](#) (agents)

Template Parameters

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

15.6.2 Member Function Documentation

15.6.2.1 operator()()

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

Access the j-th column of the agent.

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

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

Parameters

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

Returns

double&

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

- epiworld.hpp

15.7 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** ([Entity](#)< TSeq > &entity_, size_t n, bool truncate=false)
- **AgentsSample** ([Agent](#)< TSeq > &agent_, size_t n, bool truncate=false)
- std::vector< [Agent](#)< TSeq > * >::iterator **begin** ()
- std::vector< [Agent](#)< TSeq > * >::iterator **end** ()
- [Agent](#)< TSeq > * **operator[]** (size_t n)
- [Agent](#)< TSeq > * **operator()** (size_t n)
- const size_t **size** () const noexcept

15.7.1 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>	
-------------	--

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

- include/epiworld/agentssample-bones.hpp

15.8 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](#) ([Entity](#)< TSeq > &entity_, size_t n, bool truncate=false)
- [AgentsSample](#) ([Agent](#)< TSeq > &agent_, size_t n, bool truncate=false)
- std::vector< [Agent](#)< TSeq > * >::iterator **begin** ()
- std::vector< [Agent](#)< TSeq > * >::iterator **end** ()
- [Agent](#)< TSeq > * **operator[]** (size_t n)
- [Agent](#)< TSeq > * **operator()** (size_t n)
- const size_t **size** () const noexcept

15.8.1 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>	
-------------	--

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

- epiworld.hpp

15.9 DataBase< TSeq > Class Template Reference

Statistical data about the process.

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

Public Member Functions

- **DataBase** ([Model](#)< TSeq > &m)
- 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 **set_model** ([Model](#)< TSeq > &m)
- [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) 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 **reset** ()
- void **set_user_data** (std::vector< std::string > names)
- void **add_user_data** (std::vector< epiworld_double > x)
- void **add_user_data** (unsigned int j, epiworld_double x)
- [UserData](#)< TSeq > & **get_user_data** ()
- std::vector< epiworld_double > [transition_probability](#) (bool print=true) const
Calculates the transition probabilities.

Get recorded information from the model

Parameters

what	<i>std::string, The status, 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 > *status=nullptr, std::vector< int > *counts=nullptr) const
- void **get_today_variant** (std::vector< std::string > &status, std::vector< int > &id, std::vector< int > &counts) const
- void **get_hist_total** (std::vector< int > *date, std::vector< std::string > *status, std::vector< int > *counts) const
- void **get_hist_variant** (std::vector< int > &date, std::vector< int > &id, std::vector< std::string > &status, 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

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)

15.9.1 Detailed Description

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

Statistical data about the process.

Template Parameters

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

15.9.2 Member Function Documentation

15.9.2.1 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.
----------	---

15.9.2.2 reproductive_number()

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

Computes the reproductive number of each case.

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

Parameters

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

15.9.2.3 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

15.10 epiworld::DataBase< TSeq > Class Template Reference

Statistical data about the process.

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

Public Member Functions

- **DataBase** ([Model](#)< TSeq > &m)
- 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 [set_model](#) ([Model](#)< TSeq > &m)
- [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) 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 **reset** ()
- void **set_user_data** (std::vector< std::string > names)
- void **add_user_data** (std::vector< epiworld_double > x)
- void **add_user_data** (unsigned int j, epiworld_double x)
- [UserData](#)< TSeq > & **get_user_data** ()
- std::vector< epiworld_double > [transition_probability](#) (bool print=true) const
Calculates the transition probabilities.
- **DataBase** (int freq=1)
- void [record_variant](#) ([Virus](#)< TSeq > *v)
Registering a new variant.
- void **set_seq_hasher** (std::function< std::vector< int >(TSeq)> fun)
- void **set_model** ([Model](#)< TSeq > &m)
- [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 **up_exposed** ([Virus](#)< TSeq > *v, epiworld_fast_uint new_status)
- void **down_exposed** ([Virus](#)< TSeq > *v, epiworld_fast_uint prev_status)
- void **state_change** (epiworld_fast_uint prev_status, epiworld_fast_uint new_status)
- void **record_transition** (epiworld_fast_uint from, epiworld_fast_uint to)
- int [get_today_total](#) (std::string what) const
Get recorded information from the model.
- int **get_today_total** (epiworld_fast_uint what) const
- void **get_today_total** (std::vector< std::string > *status=nullptr, std::vector< int > *counts=nullptr) const
- void **get_today_variant** (std::vector< std::string > &status, std::vector< int > &id, std::vector< int > &counts) const
- void **get_hist_total** (std::vector< int > *date, std::vector< std::string > *status, std::vector< int > *counts) const
- void **get_hist_variant** (std::vector< int > &date, std::vector< int > &id, std::vector< std::string > &status, std::vector< int > &counts) const
- void [write_data](#) (std::string fn_variant_info, std::string fn_variant_hist, std::string fn_total_hist, std::string fn_transmission, std::string fn_transition) const
@]
- void **record_transmission** (int i, int j, int variant)
- size_t **get_nvariants** () const
- void **reset** ()
- void **set_user_data** (std::vector< std::string > names)
- void **add_user_data** (std::vector< epiworld_double > x)
- void **add_user_data** (unsigned int j, epiworld_double x)
- [UserData](#)< TSeq > & **get_user_data** ()

Get recorded information from the model

Parameters

what	<i>std::string, The status, 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 > *status=nullptr, std::vector< int > *counts=nullptr) const
 - void **get_today_variant** (std::vector< std::string > &status, std::vector< int > &id, std::vector< int > &counts) const
 - void **get_hist_total** (std::vector< int > *date, std::vector< std::string > *status, std::vector< int > *counts) const
 - void **get_hist_variant** (std::vector< int > &date, std::vector< int > &id, std::vector< std::string > &status, 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

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)

15.10.1 Detailed Description

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

Statistical data about the process.

Template Parameters

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

15.10.2 Member Function Documentation

15.10.2.1 get_today_total()

```
template<typename TSeq >
int epiworld::DataBase< TSeq >::get_today_total (
    std::string what ) const
```

Get recorded information from the model.

Parameters

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

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 @[

15.10.2.2 record_variant() [1/2]

```
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.
----------	---

15.10.2.3 record_variant() [2/2]

```
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 host, the numbers simply move around. From the parent variant to the new variant. And the total number of infected does not change.
----------	--

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

Parameters

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

15.10.2.5 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

15.11 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

Friends

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

15.11.1 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

15.12 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

Friends

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

15.12.1 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

15.13 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

Friends

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

15.13.1 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

15.14 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

Friends

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

15.14.1 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

15.15 Entity< TSeq > Class Template Reference

Public Member Functions

- **Entity** (std::string name)
- void **add_agent** ([Agent](#)< TSeq > &p)
- void **add_agent** ([Agent](#)< TSeq > *p)
- 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_status (epiworld_fast_int init, epiworld_fast_int post)`
- `void set_queue (epiworld_fast_int init, epiworld_fast_int post)`
- `void get_status (epiworld_fast_int *init, epiworld_fast_int *post)`
- `void get_queue (epiworld_fast_int *init, epiworld_fast_int *post)`

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)`

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

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

15.16 epiworld::Entity< TSeq > Class Template Reference

Public Member Functions

- `Entity (std::string name)`
- `void add_agent (Agent< TSeq > &p)`
- `void add_agent (Agent< TSeq > *p)`
- `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_status (epiworld_fast_int init, epiworld_fast_int post)`
- `void set_queue (epiworld_fast_int init, epiworld_fast_int post)`
- `void get_status (epiworld_fast_int *init, epiworld_fast_int *post)`
- `void get_queue (epiworld_fast_int *init, epiworld_fast_int *post)`

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)

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

- epiworld.hpp

15.17 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)
- const size_t **get_n_samples** ()
- const size_t **get_n_statistics** ()
- const size_t **get_n_parameters** ()
- const epiworld_double **get_epsilon** ()
- 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)
- void **print** ()

Random number generation

Parameters

eng	
-----	--

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

15.17.1 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

15.18 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)
- const size_t **get_n_samples** ()
- const size_t **get_n_statistics** ()
- const size_t **get_n_parameters** ()
- const epiworld_double **get_epsilon** ()
- 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)`
- `void print ()`

Random number generation

Parameters

<code>eng</code>	
------------------	--

- `void set_rand_engine (std::mt19937 &eng)`
- `std::mt19937 * get_rand_engine ()`
- `void seed (unsigned int s)`
- `void set_rand_gamma (epiworld_double alpha, epiworld_double beta)`
- `epiworld_double runif ()`
- `epiworld_double rnorm ()`
- `epiworld_double rgamma ()`
- `epiworld_double runif (epiworld_double lb, epiworld_double ub)`
- `epiworld_double rnorm (epiworld_double mean, epiworld_double sd)`
- `epiworld_double rgamma (epiworld_double alpha, epiworld_double beta)`

15.18.1 Detailed Description

```
template<typename TData>
class LFMC MC< TData >
```

Likelihood-Free Markov Chain Monte Carlo.

Template Parameters

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

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

- `include/epiworld/math/lfmc mc/lfmc mc-bones.hpp`
- `include/epiworld/math/lfmc mc/lfmc mc-meat-print.hpp`
- `include/epiworld/math/lfmc mc/lfmc mc-meat.hpp`

15.19 `epiworld::Model< TSeq >` Class Template Reference

Core class of `epiworld`.

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

Public Member Functions

- [DataBase](#)< TSeq > & **get_db** ()
 - epiworld_double & **operator**() (std::string pname)
 - size_t **size** () const
 - size_t **get_n_variants** () const
 - size_t **get_n_tools** () const
 - unsigned int **get_ndays** () const
 - unsigned int **get_n_replicates** () const
 - void **set_ndays** (unsigned int 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) const
- Wrapper of DataBase::write_data*
- std::map< std::string, epiworld_double > & **params** ()
 - void [reset](#) ()
- Reset the model.*
- void **print** () 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_status_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.*
- **Model** (const [Model](#)< TSeq > &m)
 - **Model** ([Model](#)< TSeq > &&m)
 - [Model](#)< TSeq > & **operator=** (const [Model](#)< TSeq > &m)
 - void **clone_population** (std::vector< [Person](#)< TSeq > > &p, std::map< int, int > &p_ids, bool &d, [Model](#)< TSeq > *m=nullptr) const
 - void **clone_population** (const [Model](#)< TSeq > &m)
 - void [set_backup](#) ()
- Set the backup object.*
- void **restore_backup** ()
 - [DataBase](#)< TSeq > & [get_db](#) ()
- @]*
- epiworld_double & **operator**() (std::string pname)
 - size_t **size** () const
 - void [set_rand_engine](#) (std::mt19937 &eng)
- Random number generation.*
- std::mt19937 * **get_rand_engine** ()
 - void **seed** (unsigned int s)
 - void **set_rand_gamma** (epiworld_double alpha, epiworld_double beta)
 - epiworld_double **runif** ()
 - epiworld_double **rnorm** ()

- `epiworld_double rnorm` (`epiworld_double` mean, `epiworld_double` sd)
 - `epiworld_double rgamma` ()
 - `epiworld_double rgamma` (`epiworld_double` alpha, `epiworld_double` beta)
 - void `add_virus` (`Virus< TSeq > v`, `epiworld_double` preval)
- @]
- void `add_virus_n` (`Virus< TSeq > v`, unsigned int preval)
 - void `add_tool` (`Tool< TSeq > t`, `epiworld_double` preval)
 - void `add_tool_n` (`Tool< TSeq > t`, unsigned int preval)
 - void `pop_from_adjlist` (std::string fn, int skip=0, bool directed=false, int min_id=-1, int max_id=-1)
- Accessing population of the model.*
- void `pop_from_adjlist` (`AdjList` al)
 - bool `is_directed` () const
 - std::vector< `Person< TSeq >` > * `get_population` ()
 - void `pop_from_random` (unsigned int n=1000, unsigned int k=5, bool d=false, `epiworld_double` p=.01)
 - void `init` (unsigned int ndays, unsigned int seed)
- @]
- void `update_status` ()
 - void `mutate_variant` ()
 - void `next` ()
 - void `run` ()
 - void `run_multiple` (unsigned int nexperiments, std::function< void(`Model< TSeq >` *)> fun, bool `reset`, bool verbose)
 - void `record_variant` (`Virus< TSeq >` *v)
- @]
- int `get_nvariants` () const
 - unsigned int `get_ndays` () const
 - void `set_ndays` (unsigned int ndays)
 - bool `get_verbose` () const
 - void `verbose_off` ()
 - void `verbose_on` ()
 - int `today` () const
 - void `set_rewire_fun` (std::function< void(std::vector< `Person< TSeq >` > *, `Model< TSeq >` *, `epiworld_double`)> fun)
- Rewire the network preserving the degree sequence.*
- void `set_rewire_prop` (`epiworld_double` prop)
 - `epiworld_double` `get_rewire_prop` () const
 - void `rewire` ()
 - void `set_update_susceptible` (`UpdateFun< TSeq >` fun)
- @]
- void `set_update_exposed` (`UpdateFun< TSeq >` fun)
 - void `set_update_removed` (`UpdateFun< TSeq >` fun)
 - void `write_data` (std::string fn_variant_info, std::string fn_variant_hist, std::string fn_total_hist, std::string fn_transmission, std::string fn_transition) const
- Wrapper of `DataBase::write_data`*
- void `write_edgelist` (std::string fn) const
- Export the network data in edgelist form.*
- void `write_edgelist` (std::vector< unsigned int > &source, std::vector< unsigned int > &target) const
 - std::map< std::string, `epiworld_double` > & `params` ()
- @]
- void `reset` ()
- Reset the model.*
- void `print` () const
 - `Model< TSeq >` && `clone` () const

- void [add_status_susceptible](#) (epiworld_fast_uint s, std::string lab)
Adds extra statuses to the model.
- void **add_status_exposed** (epiworld_fast_uint s, std::string lab)
- void **add_status_removed** (epiworld_fast_uint s, std::string lab)
- void **add_status_susceptible** (std::string lab)
- void **add_status_exposed** (std::string lab)
- void **add_status_removed** (std::string lab)
- const std::vector< epiworld_fast_uint > & **get_status_susceptible** () const
- const std::vector< epiworld_fast_uint > & **get_status_exposed** () const
- const std::vector< epiworld_fast_uint > & **get_status_removed** () const
- const std::vector< std::string > & **get_status_susceptible_labels** () const
- const std::vector< std::string > & **get_status_exposed_labels** () const
- const std::vector< std::string > & **get_status_removed_labels** () const
- void **print_status_codes** () const
- epiworld_fast_uint **get_default_susceptible** () const
- epiworld_fast_uint **get_default_exposed** () const
- epiworld_fast_uint **get_default_removed** () const
- void [reset_status_codes](#) (std::vector< epiworld_fast_uint > codes, std::vector< std::string > names, bool verbose=true)
- @]
- epiworld_double [add_param](#) (epiworld_double initial_val, std::string pname)
Setting and accessing parameters from the model.
- epiworld_double **set_param** (std::string pname)
- epiworld_double **get_param** (unsigned int k)
- epiworld_double **get_param** (std::string pname)
- epiworld_double **par** (unsigned int k)
- epiworld_double **par** (std::string pname)
- void [get_elapsed](#) (std::string unit="auto", epiworld_double *last_elapsed=nullptr, epiworld_double *total_elapsed=nullptr, unsigned int *n_replicates=nullptr, std::string *unit_abbr=nullptr, bool print=true) const
- @]
- void [set_user_data](#) (std::vector< std::string > names)
Set the user data object.
- void **add_user_data** (unsigned int j, epiworld_double x)
- void **add_user_data** (std::vector< epiworld_double > x)
- [UserData](#)< TSeq > & **get_user_data** ()
- void [add_global_action](#) (std::function< void([Model](#)< TSeq > *)> fun, int date)
- @]
- void **run_global_actions** ()
- void **clear_status_set** ()
- void **toggle_visited** ()
- void **queuing_on** ()
- void **queuing_off** ()
- bool **is_queuing_on** () const
- [Queue](#)< TSeq > & **get_queue** ()

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** ()
- void **restore_backup** ()

Random number generation

Parameters

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

- void **set_rand_engine** (std::mt19937 &eng)
- std::mt19937 * **get_rand_engine** ()
- void **seed** (unsigned int s)
- void **set_rand_gamma** (epiworld_double alpha, epiworld_double beta)
- epiworld_double **runif** ()
- epiworld_double **rnorm** ()
- epiworld_double **rnorm** (epiworld_double mean, epiworld_double sd)
- epiworld_double **rgamma** ()
- epiworld_double **rgamma** (epiworld_double alpha, epiworld_double beta)

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, unsigned int 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, unsigned int preval)
- void **add_tool_fun** ([Tool](#)< TSeq > t, ToolToAgentFun< TSeq > fun)
- void **add_entity** ([Entity](#)< TSeq > e, epiworld_double preval)
- void **add_entity_n** ([Entity](#)< TSeq > e, unsigned int preval)
- void **add_entity_fun** ([Entity](#)< TSeq > e, EntityToAgentFun< TSeq > fun)

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 <i>fn</i>.</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** ()
- void **agents_smallworld** (unsigned int n=1000, unsigned int k=5, bool d=false, epiworld_double p=.01)

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 **init** (unsigned int ndays, unsigned int seed)
- void **update_status** ()
- void **mutate_variant** ()
- void **next** ()
- void **run** ()
Runs the simulation (after initialization)
- void **run_multiple** (unsigned int nexperiments, std::function< void(size_t, **Model**< TSeq > *)> fun=make_save_run< TSeq >(), bool **reset**=true, bool verbose=true)

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< unsigned int > &source, std::vector< unsigned int > &target) const

Manage status (states) in the model

The functions `get_status` return the current values for the statuses included in the model.

Parameters

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

Returns

*add_status** returns nothing.
*get_status_** returns a vector of pairs with the statuses and their labels.

- void **add_status** (std::string lab, UpdateFun< TSeq > fun=nullptr)
- const std::vector< std::string > & **get_status** () const
- const std::vector< UpdateFun< TSeq > > & **get_status_fun** () const
- void **print_status_codes** () const

Set the user data object

Parameters

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

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

Queuing system

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

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

Get the susceptibility reduction object

Parameters

v	
---	--

Returns

epiworld_double

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

Friends

- class **Agent**< TSeq >
- class **AgentsSample**< TSeq >
- class **DataBase**< TSeq >
- class **Queue**< TSeq >
- class **Person**< 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.

- `std::vector< epiworld_double > array_double_tmp`
- `std::vector< Virus< TSeq > * > array_virus_tmp`
- `Model ()`
- `Model (const Model< TSeq > &m)`
- `Model (Model< TSeq > &&m)`
- `Model< TSeq > & operator= (const Model< TSeq > &m)`
- `void clone_population (std::vector< Agent< TSeq > > &p, bool &d, Model< TSeq > *m=nullptr) const`
- `void clone_population (const Model< TSeq > &m)`

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 `unsigned int` 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

<i>initial_val</i>	
<i>pname</i>	Name of the parameter to add or to fetch
<i>fn</i>	Path to the file containing parameters

Returns

The current value of the parameter in the model.

- `epiworld_double * p0`
- `epiworld_double * p1`
- `epiworld_double * p2`
- `epiworld_double * p3`
- `epiworld_double * p4`
- `epiworld_double * p5`
- `epiworld_double * p6`
- `epiworld_double * p7`
- `epiworld_double * p8`
- `epiworld_double * p9`
- `epiworld_double * p10`

- epiworld_double * **p11**
- epiworld_double * **p12**
- epiworld_double * **p13**
- epiworld_double * **p14**
- epiworld_double * **p15**
- epiworld_double * **p16**
- epiworld_double * **p17**
- epiworld_double * **p18**
- epiworld_double * **p19**
- epiworld_double * **p20**
- epiworld_double * **p21**
- epiworld_double * **p22**
- epiworld_double * **p23**
- epiworld_double * **p24**
- epiworld_double * **p25**
- epiworld_double * **p26**
- epiworld_double * **p27**
- epiworld_double * **p28**
- epiworld_double * **p29**
- epiworld_double * **p30**
- epiworld_double * **p31**
- epiworld_double * **p32**
- epiworld_double * **p33**
- epiworld_double * **p34**
- epiworld_double * **p35**
- epiworld_double * **p36**
- epiworld_double * **p37**
- epiworld_double * **p38**
- epiworld_double * **p39**
- unsigned int **npar_used** = 0u
- epiworld_double **add_param** (epiworld_double initial_val, std::string pname)
- void **read_params** (std::string fn)
- epiworld_double **get_param** (unsigned int k)
- epiworld_double **get_param** (std::string pname)
- epiworld_double **par** (unsigned int k)
- epiworld_double **par** (std::string pname)

15.19.1 Detailed Description

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

Core class of epiworld.

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

Template Parameters

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

15.19.2 Member Function Documentation

15.19.2.1 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.

15.19.2.2 add_param()

```
template<typename TSeq = bool>
epiworld_double epiworld::Model< TSeq >::add_param (
    epiworld_double initial_val,
    std::string pname )
```

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 `unsigned int` 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 function `set_param()` can be used when the parameter already exists in the model.

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

Parameters

<i>initial_val</i>	
<i>pname</i>	Name of the parameter to add or to fetch

Returns

The current value of the parameter in the model. @

15.19.2.3 add_status_susceptible()

```
template<typename TSeq >
void Model< TSeq >::add_status_susceptible (
    epiworld_fast_uint s,
    std::string lab ) [inline]
```

Adds extra statuses to the model.

Adding values of *s* that are already present in the model will result in an error.

The functions `get_status_*` return the current values for the statuses included in the model.

Parameters

<i>s</i>	unsigned int Code of the status
<i>lab</i>	std::string Name of the status.

Returns

`add_status*` returns nothing.

`get_status_*` returns a vector of pairs with the statuses and their labels. @

15.19.2.4 init()

```
template<typename TSeq = bool>
void epiworld::Model< TSeq >::init (
    unsigned int ndays,
    unsigned int seed )
```

@

Functions to run the model

Parameters

<i>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. @

15.19.2.5 pop_from_adjlist()

```
template<typename TSeq >
void Model< TSeq >::pop_from_adjlist (
    std::string fn,
```

```

    int skip = 0,
    bool directed = false,
    int min_id = -1,
    int max_id = -1 ) [inline]

```

Accessing population of the model.

Parameters

<i>fn</i>	std::string Filename of the edgelist file.
<i>skip</i>	int Number of lines to skip in <i>fn</i> .
<i>directed</i>	bool Whether the graph is directed or not.
<i>min_id</i>	int Minimum id number (if negative, the program will try to guess from the data.)
<i>max_id</i>	int Maximum id number (if negative, the program will try to guess from the data.)
<i>al</i>	AdjList to read into the model. @[

15.19.2.6 reset() [1/2]

```

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

15.19.2.7 reset() [2/2]

```

template<typename TSeq = bool>
void epiworld::Model< TSeq >::reset ( )

```

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

15.19.2.8 reset_status_codes()

```
template<typename TSeq >
void Model< TSeq >::reset_status_codes (
    std::vector< epiworld_fast_uint > codes,
    std::vector< std::string > names,
    bool verbose = true ) [inline]
```

@]

Reset all the status codes of the model

The default values are those specified in the enum STATUS.

Parameters

<i>codes</i>	In the following order: Susceptible, Infected, Removed
<i>names</i>	Names matching the codes
<i>verbose</i>	When <code>true</code> , it will print the new mappings.

15.19.2.9 run_multiple()

```
template<typename TSeq >
void Model< TSeq >::run_multiple (
    unsigned int n_experiments,
    std::function< void(size_t, Model< TSeq > *)> fun = make_save_run<TSeq>(),
    bool reset = true,
    bool verbose = true ) [inline]
```

Parameters

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

15.19.2.10 set_agents_data()

```
template<typename TSeq >
void Model< TSeq >::set_agents_data (
    double * data_,
    size_t n_cols_ ) [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.

15.19.2.11 set_backup()

```
template<typename TSeq = bool>
void epiworld::Model< TSeq >::set_backup ( )
```

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. @[

15.19.2.12 set_rand_engine()

```
template<typename TSeq = bool>
void epiworld::Model< TSeq >::set_rand_engine (
    std::mt19937 & eng )
```

Random number generation.

Parameters

<i>eng</i>	@[
------------	----

15.19.2.13 set_rewire_fun()

```
template<typename TSeq >
void Model< TSeq >::set_rewire_fun (
    std::function< void(std::vector< Person< TSeq >> *, Model< TSeq > *, epiworld↔
_double)> fun ) [inline]
```

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

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

Returns

A rewired version of the network. @

15.19.2.14 set_user_data()

```
template<typename TSeq = bool>
void epiworld::Model< TSeq >::set_user_data (
    std::vector< std::string > names )
```

Set the user data object.

Parameters

<i>names</i>	@
--------------	---

15.19.2.15 write_data() [1/2]

```
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 ) 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 (status)
<i>fn_transmission</i>	Filename. Transmission history.
<i>fn_transition</i>	Filename. Markov transition history.
<i>fn_reproductive_number</i>	Filename. Case by case reproductive number

15.19.2.16 write_data() [2/2]

```
template<typename TSeq >
void Model< TSeq >::write_data (
    std::string fn_variant_info,
    std::string fn_variant_hist,
    std::string fn_total_hist,
    std::string fn_transmission,
    std::string fn_transition ) 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_total_hist</i>	Filename. Aggregated history (status)
<i>fn_transmission</i>	Filename. Transmission history.
<i>fn_transition</i>	Filename. Markov transition history.

15.19.2.17 write_edgelist()

```
template<typename TSeq = bool>
void epiworld::Model< TSeq >::write_edgelist (
    std::string fn ) const
```

Export the network data in edgelist form.

Parameters

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

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

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

- epiworld.hpp

15.20 Model< TSeq > Class Template Reference

Core class of epiworld.

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

Public Member Functions

- [DataBase](#)< TSeq > & **get_db** ()
- `epiworld_double` & **operator()** (std::string pname)
- `size_t` **size** () const
- `size_t` **get_n_variants** () const
- `size_t` **get_n_tools** () const
- unsigned int **get_ndays** () const
- unsigned int **get_n_replicates** () const
- void **set_ndays** (unsigned int 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) const
Wrapper of DataBase::write_data
- std::map< std::string, `epiworld_double` > & **params** ()
- void [reset](#) ()
Reset the model.
- void **print** () 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_status_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.

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** ()
- void **restore_backup** ()

Random number generation

Parameters

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

- void **set_rand_engine** (std::mt19937 &eng)
- std::mt19937 * **get_rand_engine** ()
- void **seed** (unsigned int 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, unsigned int 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, unsigned int preval)
- void **add_tool_fun** ([Tool](#)< TSeq > t, ToolToAgentFun< TSeq > fun)
- void **add_entity** ([Entity](#)< TSeq > e, epiworld_double preval)
- void **add_entity_n** ([Entity](#)< TSeq > e, unsigned int preval)
- void **add_entity_fun** ([Entity](#)< TSeq > e, EntityToAgentFun< TSeq > fun)

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 <i>fn</i>.</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** ()
- void **agents_smallworld** (unsigned int n=1000, unsigned int k=5, bool d=false, epiworld_double p=.01)

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 **init** (unsigned int ndays, unsigned int seed)
- void **update_status** ()
- void **mutate_variant** ()
- void **next** ()
- void **run** ()
Runs the simulation (after initialization)
- void **run_multiple** (unsigned int nexperiments, std::function< void(size_t, Model< TSeq > *)> fun=make_save_run< TSeq >(), bool **reset**=true, bool verbose=true)

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< unsigned int > &source, std::vector< unsigned int > &target) const

Manage status (states) in the model

The functions `get_status` return the current values for the statuses included in the model.

Parameters

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

Returns

*add_status** returns nothing.
*get_status_** returns a vector of pairs with the statuses and their labels.

- void **add_status** (std::string lab, UpdateFun< TSeq > fun=nullptr)
- const std::vector< std::string > & **get_status** () const
- const std::vector< UpdateFun< TSeq > > & **get_status_fun** () const
- void **print_status_codes** () const

Set the user data object

Parameters

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

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

Queuing system

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

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

Get the susceptibility reduction object

Parameters

v	
---	--

Returns

epiworld_double

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

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.

- `std::vector< epiworld_double > array_double_tmp`
- `std::vector< Virus< TSeq > * > array_virus_tmp`
- `Model ()`
- `Model (const Model< TSeq > &m)`
- `Model (Model< TSeq > &&m)`
- `Model< TSeq > & operator= (const Model< TSeq > &m)`
- `void clone_population (std::vector< Agent< TSeq > > &p, bool &d, Model< TSeq > *m=nullptr) const`
- `void clone_population (const Model< TSeq > &m)`

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 `unsigned int` 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

<i>initial_val</i>	
<i>pname</i>	Name of the parameter to add or to fetch
<i>fn</i>	Path to the file containing parameters

Returns

The current value of the parameter in the model.

- `epiworld_double * p0`
- `epiworld_double * p1`
- `epiworld_double * p2`
- `epiworld_double * p3`
- `epiworld_double * p4`
- `epiworld_double * p5`
- `epiworld_double * p6`
- `epiworld_double * p7`
- `epiworld_double * p8`
- `epiworld_double * p9`
- `epiworld_double * p10`

- `epiworld_double * p11`
- `epiworld_double * p12`
- `epiworld_double * p13`
- `epiworld_double * p14`
- `epiworld_double * p15`
- `epiworld_double * p16`
- `epiworld_double * p17`
- `epiworld_double * p18`
- `epiworld_double * p19`
- `epiworld_double * p20`
- `epiworld_double * p21`
- `epiworld_double * p22`
- `epiworld_double * p23`
- `epiworld_double * p24`
- `epiworld_double * p25`
- `epiworld_double * p26`
- `epiworld_double * p27`
- `epiworld_double * p28`
- `epiworld_double * p29`
- `epiworld_double * p30`
- `epiworld_double * p31`
- `epiworld_double * p32`
- `epiworld_double * p33`
- `epiworld_double * p34`
- `epiworld_double * p35`
- `epiworld_double * p36`
- `epiworld_double * p37`
- `epiworld_double * p38`
- `epiworld_double * p39`
- `unsigned int npar_used = 0u`
- `epiworld_double add_param (epiworld_double initial_val, std::string pname)`
- `void read_params (std::string fn)`
- `epiworld_double get_param (unsigned int k)`
- `epiworld_double get_param (std::string pname)`
- `epiworld_double par (unsigned int k)`
- `epiworld_double par (std::string pname)`

15.20.1 Detailed Description

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

Core class of epiworld.

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

Template Parameters

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

15.20.2 Member Function Documentation

15.20.2.1 add_global_action()

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

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.

15.20.2.2 reset()

```
template<typename TSeq = int>
void Model< TSeq >::reset ( )
```

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

15.20.2.3 run_multiple()

```
template<typename TSeq = int>
void Model< TSeq >::run_multiple (
    unsigned int n_experiments,
    std::function< void(size_t, Model< TSeq > *)> fun = make_save_run< TSeq >(),
    bool reset = true,
    bool verbose = true )
```

Parameters

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

15.20.2.4 set_agents_data()

```
template<typename TSeq = int>
void Model< TSeq >::set_agents_data (
    double * data_,
    size_t ncols_ )
```

Set the agents data object.

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

Parameters

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

15.20.2.5 write_data()

```
template<typename TSeq = int>
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 ) const
```

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 (status)
<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

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

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

15.21 Network< Nettype, Nodetype, Edgetype > Class Template Reference

Public Member Functions

- **NType** ()
- Edgetype **operator()** (int i, int j)
- bool **is_directed** () const
- size_t **vcount** () const
- size_t **ecount** () const
- void **add_edge** (int i, int j)
- void **rm_edge** (int i, int j)

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

- include/epiworld/network-bones.hpp

15.22 epiworld::Person< TSeq > Class Template Reference

Public Member Functions

- void **init** (epiworld_fast_uint baseline_status)
- void **add_tool** (int d, [Tool](#)< TSeq > tool)
- void **add_virus** ([Virus](#)< TSeq > *virus)
- void **rm_virus** ([Virus](#)< TSeq > *virus)
- epiworld_double **get_susceptibility_reduction** ([Virus](#)< TSeq > *v)
- epiworld_double **get_transmission_reduction** ([Virus](#)< TSeq > *v)
- epiworld_double **get_recovery_enhancer** ([Virus](#)< TSeq > *v)
- epiworld_double **get_death_reduction** ([Virus](#)< TSeq > *v)
- int **get_id** () const
- unsigned int **get_index** () const
- std::mt19937 * **get_rand_engine** ()
- [Model](#)< TSeq > * **get_model** ()
- [Virus](#)< TSeq > & **get_virus** (int i)
- [PersonViruses](#)< TSeq > & **get_viruses** ()
- [Tool](#)< TSeq > & **get_tool** (int i)
- [PersonTools](#)< TSeq > & **get_tools** ()
- void **mutate_variant** ()
- void **add_neighbor** ([Person](#)< TSeq > *p, bool check_source=true, bool check_target=true)
- std::vector< [Person](#)< TSeq > * > & **get_neighbors** ()
- void **update_status** ()
- const epiworld_fast_uint & **get_status** () const
- void **reset** ()
- void **set_update_susceptible** (UpdateFun< TSeq > fun)
- void **set_update_exposed** (UpdateFun< TSeq > fun)
- void **set_update_removed** (UpdateFun< TSeq > fun)
- bool **has_tool** (unsigned int t) const
- bool **has_tool** (std::string name) const
- bool **has_virus** (unsigned int t) const
- bool **has_virus** (std::string name) const
- bool **visited** () const
- void **toggle_visited** ()

Friends

- class **Model**< TSeq >
- class **Tool**< TSeq >
- class **Queue**< TSeq >

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

- rpackage/inst/include/epiworld.hpp

15.23 epiworld::PersonTools< TSeq > Class Template Reference

List of tools available for the individual to.

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

Public Member Functions

- void **add_tool** (int date, [Tool](#)< TSeq > tool)
@]
- epiworld_double **get_susceptibility_reduction** ([Virus](#)< TSeq > *v)
- epiworld_double **get_transmission_reduction** ([Virus](#)< TSeq > *v)
- epiworld_double **get_recovery_enhancer** ([Virus](#)< TSeq > *v)
- epiworld_double **get_death_reduction** ([Virus](#)< TSeq > *v)
- 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)
- size_t **size** () const
- [Tool](#)< TSeq > & **operator()** (int i)
- [Person](#)< TSeq > * **get_person** ()
- [Model](#)< TSeq > * **get_model** ()
- void **reset** ()
- bool **has_tool** (unsigned int t) const
- bool **has_tool** (std::string name) const

Friends

- class **Person**< TSeq >
- class **Model**< TSeq >

15.23.1 Detailed Description

```
template<typename TSeq = bool>
class epiworld::PersonTools< TSeq >
```

List of tools available for the individual to.

Template Parameters

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

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

- epiworld.hpp

15.24 PersonTools< TSeq > Class Template Reference

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

- include/epiworld/config.hpp

15.25 epiworld::PersonViruses< TSeq > Class Template Reference

Set of viruses in host.

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

Public Member Functions

- void **add_virus** (epiworld_fast_uint new_status, [Virus](#)< TSeq > v)
- size_t **size** () const
- int **size_active** () const
- [Virus](#)< TSeq > & **operator()** (int i)
- void **mutate** ()
- void **reset** ()
- void **deactivate** ([Virus](#)< TSeq > &v)
- [Person](#)< TSeq > * **get_host** ()
- bool **has_virus** (unsigned int v) const
- bool **has_virus** (std::string vname) const

Friends

- class **Person**< TSeq >
- class **Model**< TSeq >

15.25.1 Detailed Description

```
template<typename TSeq = bool>
class epiworld::PersonViruses< TSeq >
```

Set of viruses in host.

Template Parameters

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

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

- rpackage/inst/include/epiworld.hpp

15.26 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** ()
- **Progress** (int n_, int width_)
- void **start** ()
- void **next** ()
- void **end** ()

15.26.1 Detailed Description

A simple progress bar.

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

- epiworld.hpp

15.27 Progress Class Reference

A simple progress bar.

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

Public Member Functions

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

15.27.1 Detailed Description

A simple progress bar.

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

- include/epiworld/progress.hpp

15.28 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[]** (unsigned int i)
- void **set_model** ([Model](#)< TSeq > *m)
- void **operator+=** ([Person](#)< TSeq > *p)
- void **operator-=** ([Person](#)< TSeq > *p)
- epiworld_fast_int **operator[]** (unsigned int i) const
- void **set_model** ([Model](#)< TSeq > *m)
- void **update** ()

15.28.1 Detailed Description

```
template<typename TSeq = int>
class epiworld::Queue< TSeq >
```

Controls which agents are verified at each step.

The idea is that only agents who are either in an infected state or have an infected neighbor should be checked. Otherwise it makes no sense (no chance to recover or capture the disease).

Template Parameters

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

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

- epiworld.hpp

15.29 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[]** (unsigned int i)
- void **set_model** ([Model](#)< TSeq > *m)

15.29.1 Detailed Description

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

Controls which agents are verified at each step.

The idea is that only agents who are either in an infected state or have an infected neighbor should be checked. Otherwise it makes no sense (no chance to recover or capture the disease).

Template Parameters

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

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

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

15.30 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

15.31 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_unique** (TSeq d)
- void **set_sequence** (std::shared_ptr< TSeq > d)
- std::shared_ptr< TSeq > **get_sequence** ()
- TSeq & **get_sequence_unique** ()
- 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_status** (epiworld_fast_int init, epiworld_fast_int post)
- void **set_queue** (epiworld_fast_int init, epiworld_fast_int post)
- void **get_status** (epiworld_fast_int *init, epiworld_fast_int *post)
- void **get_queue** (epiworld_fast_int *init, epiworld_fast_int *post)
- **Tool** (std::string name="unknown tool")
- void **set_sequence** (TSeq d)
- void **set_sequence_unique** (TSeq d)
- void **set_sequence** (std::shared_ptr< TSeq > d)
- std::shared_ptr< TSeq > **get_sequence** ()
- TSeq & **get_sequence_unique** ()
- epiworld_double [get_susceptibility_reduction](#) ([Virus](#)< TSeq > *v)
Get and set the tool functions.
- epiworld_double **get_transmission_reduction** ([Virus](#)< TSeq > *v)
- epiworld_double **get_recovery_enhancer** ([Virus](#)< TSeq > *v)
- epiworld_double **get_death_reduction** ([Virus](#)< TSeq > *v)
- 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)
- void [set_name](#) (std::string name)
@]
- std::string **get_name** () const
- [Person](#)< TSeq > * **get_person** ()
- unsigned int **get_id** () 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)
- *epiworld_double* **get_transmission_reduction** (VirusPtr< TSeq > v)
- *epiworld_double* **get_recovery_enhancer** (VirusPtr< TSeq > v)
- *epiworld_double* **get_death_reduction** (VirusPtr< TSeq > v)
- 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 >
- class **PersonTools**< TSeq >
- class **Person**< TSeq >
- void **default_add_tool** ([Action](#)< TSeq > &a, [Model](#)< TSeq > *m)
- void **default_rm_tool** ([Action](#)< TSeq > &a, [Model](#)< TSeq > *m)

15.31.1 Detailed Description

```
template<typename TSeq = bool>
class epiworld::Tool< TSeq >
```

[Tools](#) for defending the agent against the virus.

[Tools](#) for defending the host against the virus.

Template Parameters

<i>TSeq</i>	Type of sequence
-------------	------------------

15.31.2 Member Function Documentation

15.31.2.1 get_susceptibility_reduction()

```
template<typename TSeq >
epiworld_double Tool< TSeq >::get_susceptibility_reduction (
    Virus< TSeq > * v ) [inline]
```

Get and set the tool functions.

Parameters

<i>v</i>	The virus over which to operate
<i>fun</i>	the function to be used

Returns

epiworld_double @[

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

- epiworld.hpp

15.32 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_unique** (TSeq d)
- void **set_sequence** (std::shared_ptr< TSeq > d)
- std::shared_ptr< TSeq > **get_sequence** ()
- TSeq & **get_sequence_unique** ()
- 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_status** (epiworld_fast_int init, epiworld_fast_int post)
- void **set_queue** (epiworld_fast_int init, epiworld_fast_int post)
- void **get_status** (epiworld_fast_int *init, epiworld_fast_int *post)
- void **get_queue** (epiworld_fast_int *init, epiworld_fast_int *post)

Get and set the tool functions**Parameters**

<i>v</i>	<i>The virus over which to operate</i>
<i>fun</i>	<i>the function to be used</i>

Returns*epiworld_double*

- epiworld_double **get_susceptibility_reduction** (VirusPtr< TSeq > v)
- epiworld_double **get_transmission_reduction** (VirusPtr< TSeq > v)
- epiworld_double **get_recovery_enhancer** (VirusPtr< TSeq > v)
- epiworld_double **get_death_reduction** (VirusPtr< TSeq > v)
- 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)

15.32.1 Detailed Description

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

[Tools](#) for defending the agent against the virus.

Template Parameters

<i>TSeq</i>	Type of sequence
-------------	------------------

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

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

15.33 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 >

15.33.1 Detailed Description

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

Set of tools (useful for building iterators)

Template Parameters

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

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

- epiworld.hpp

15.34 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 >

15.34.1 Detailed Description

```
template<typename TSeq>
class Tools< TSeq >
```

Set of tools (useful for building iterators)

Template Parameters

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

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

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

15.35 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** ()
- std::vector< ToolPtr< TSeq > >::const_iterator **end** ()
- 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 >

15.35.1 Detailed Description

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

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

Template Parameters

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

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

- epiworld.hpp

15.36 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** ()
- std::vector< ToolPtr< TSeq > >::const_iterator **end** ()
- 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 >

15.36.1 Detailed Description

```
template<typename TSeq>
class Tools_const< TSeq >
```

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

Template Parameters

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

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

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

15.37 epiworld::UserData< TSeq > Class Template Reference

Personalized data by the user.

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


Public Member Functions

- **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)
- unsigned int **nrow** () const
- unsigned int **ncol** () const
- void **write** (std::string fn)
- void **print** () const
- **UserData** (std::vector< std::string > names)
- void **add** (std::vector< epiworld_double > x)
- void **add** (unsigned int j, epiworld_double x)
- epiworld_double & **operator()** (unsigned int i, unsigned int j)
- epiworld_double & **operator()** (unsigned int i, std::string name)
- 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)
- unsigned int **nrow** () const
- unsigned int **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** (unsigned int 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()** (unsigned int i, unsigned int j)
- epiworld_double & **operator()** (unsigned int i, std::string name)

Friends

- class **Model**< TSeq >
- class **DataBase**< TSeq >

15.37.1 Detailed Description

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

Personalized data by the user.

Template Parameters

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

15.37.2 Constructor & Destructor Documentation

15.37.2.1 UserData()

```
template<typename TSeq >
UserData< TSeq >::UserData (
    std::vector< std::string > names ) [inline]
```

Construct a new User Data object.

Parameters

<i>names</i>	A vector of names. The length of the vector sets the number of columns to record.
--------------	---

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

- epiworld.hpp

15.38 UserData< TSeq > Class Template Reference

Personalized data by the user.

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

Public Member Functions

- **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)
- unsigned int **nrow** () const
- unsigned int **ncol** () const
- void **write** (std::string fn)
- void **print** () const

Append data

Parameters

x	A vector of length <code>ncol()</code> (if vector), otherwise a <code>epiworld_double</code> .
j	Index of the data point, from 0 to <code>ncol()</code> - 1.

- void **add** (std::vector< epiworld_double > x)
- void **add** (unsigned int j, epiworld_double x)

Access data

Parameters

i	Row (0 through <code>ndays</code> - 1.)
j	Column (0 through <code>ncols()</code>).

Returns

`epiworld_double&`

- `epiworld_double & operator()` (unsigned int i, unsigned int j)
- `epiworld_double & operator()` (unsigned int i, std::string name)

Friends

- class **Model**< TSeq >
- class **DataBase**< TSeq >

15.38.1 Detailed Description

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

Personalized data by the user.

Template Parameters

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

15.38.2 Constructor & Destructor Documentation

15.38.2.1 UserData()

```
template<typename TSeq >
UserData< TSeq >::UserData (
    std::vector< std::string > names ) [inline]
```

Construct a new User Data object.

Parameters

<i>names</i>	A vector of names. The length of the vector sets the number of columns to record.
--------------	---

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

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

15.39 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`
- `std::size_t operator() (std::vector< T > const &dat) const noexcept`

15.39.1 Detailed Description

```
template<typename T>
struct epiworld::vecHasher< T >
```

Vector hasher.

Template Parameters

<i>T</i>	
----------	--

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

- epiworld.hpp

15.40 vecHasher< T > Struct Template Reference

Vector hasher.

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

Public Member Functions

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

15.40.1 Detailed Description

```
template<typename T>
struct vecHasher< T >
```

Vector hasher.

Template Parameters

<i>T</i>	
----------	--

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

- include/epiworld/misc.hpp

15.41 epiworld::Virus< TSeq > Class Template Reference

[Virus](#).

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

Public Member Functions

- **Virus** (std::string name="unknown virus")
- void **mutate** ()
- 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)
- [Model](#)< TSeq > * **get_model** ()
- 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** ()
- **Virus** (std::string name="unknown virus")
- void **mutate** ()
- void **set_mutation** (MutFun< TSeq > fun)
- const TSeq * **get_sequence** ()
- void **set_sequence** (TSeq sequence)
- [Person](#)< TSeq > * **get_host** ()
- [Model](#)< TSeq > * **get_model** ()
- void **set_date** (int d)
- int **get_date** () const
- void **set_id** (int idx)
- int **get_id** () const
- bool **is_active** () const
- void **deactivate** ()
- epiworld_double [get_prob_infecting](#) ()
- Get and set the tool functions.*
- epiworld_double **get_prob_recovery** ()
- epiworld_double **get_prob_death** ()
- void **post_recovery** ()
- 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)
- void [set_name](#) (std::string name)
- @]
- std::string **get_name** () const
- std::vector< epiworld_double > & **get_data** ()

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** ()
- epiworld_double **get_prob_recovery** ()
- epiworld_double **get_prob_death** ()
- void **post_recovery** ()
- 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 status and queue

After applied, viruses can change the status 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 status or in queue.

Parameters

init	<i>After the virus/tool is added to the agent.</i>
end	<i>After the virus/tool is removed.</i>
removed	<i>After the agent (Agent) is removed.</i>

- void **set_status** (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_status** (epiworld_fast_int *init, epiworld_fast_int *end, epiworld_fast_int *removed=-99)
- void **get_queue** (epiworld_fast_int *init, epiworld_fast_int *end, epiworld_fast_int *removed=-99)

Friends

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

15.41.1 Detailed Description

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

[Virus.](#)

Template Parameters

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

Raw transmissibility of a virus should be a function of its genetic sequence. Nonetheless, transmissibility can be reduced as a result of having one or more tools to fight the virus. Because of this, transmissibility should be a function of the agent.

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 host.

15.41.2 Member Function Documentation

15.41.2.1 get_prob_infecting()

```
template<typename TSeq = bool>
epiworld_double epiworld::Virus< TSeq >::get_prob_infecting ( )
```

Get and set the tool functions.

Parameters

<i>v</i>	The virus over which to operate
<i>fun</i>	the function to be used

Returns

epiworld_double @[

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

- epiworld.hpp

15.42 Virus< TSeq > Class Template Reference

[Virus.](#)

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

Public Member Functions

- **Virus** (std::string name="unknown virus")
- void **mutate** ()
- 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)
- [Model](#)< TSeq > * **get_model** ()
- 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** ()

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** ()
- epiworld_double **get_prob_recovery** ()
- epiworld_double **get_prob_death** ()
- void **post_recovery** ()
- 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 status and queue

After applied, viruses can change the status 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 status or in queue.

Parameters

init	<i>After the virus/tool is added to the agent.</i>
end	<i>After the virus/tool is removed.</i>
removed	<i>After the agent (Agent) is removed.</i>

- void **set_status** (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_status** (epiworld_fast_int *init, epiworld_fast_int *end, epiworld_fast_int *removed=-99)
- void **get_queue** (epiworld_fast_int *init, epiworld_fast_int *end, epiworld_fast_int *removed=-99)

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)

15.42.1 Detailed Description

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

[Virus](#).

Template Parameters

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

Raw transmissibility of a virus should be a function of its genetic sequence. Nonetheless, transmissibility can be reduced as a result of having one or more tools to fight the virus. Because of this, transmissibility should be a function of the agent.

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

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

15.43 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 >::iterator **begin** ()
- std::vector< VIRUSPTR >::iterator **end** ()
- VIRUSPTR & **operator()** (size_t i)
- VIRUSPTR & **operator[]** (size_t i)
- size_t **size** () const noexcept

Friends

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

15.43.1 Detailed Description

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

Set of viruses (useful for building iterators)

Template Parameters

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

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

- epiworld.hpp

15.44 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 >::iterator **begin** ()
- std::vector< VIRUSPTR >::iterator **end** ()
- VIRUSPTR & **operator()** (size_t i)
- VIRUSPTR & **operator[]** (size_t i)
- size_t **size** () const noexcept

Friends

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

15.44.1 Detailed Description

```
template<typename TSeq>
class Viruses< TSeq >
```

Set of viruses (useful for building iterators)

Template Parameters

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

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

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

15.45 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 >::const_iterator **begin** ()
- std::vector< VIRUSPTR >::const_iterator **end** ()
- const VIRUSPTR & **operator()** (size_t i)
- const VIRUSPTR & **operator[]** (size_t i)
- size_t **size** () const noexcept

Friends

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

15.45.1 Detailed Description

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

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

Template Parameters

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

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

- epiworld.hpp

15.46 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 >::const_iterator **begin** ()
- std::vector< VIRUSPTR >::const_iterator **end** ()
- const VIRUSPTR & **operator**() (size_t i)
- const VIRUSPTR & **operator**[] (size_t i)
- size_t **size** () const noexcept

Friends

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

15.46.1 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 16

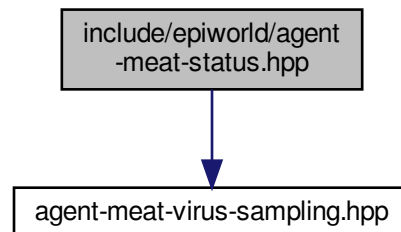
File Documentation

16.1 include/epiworld/agent-meat-status.hpp File Reference

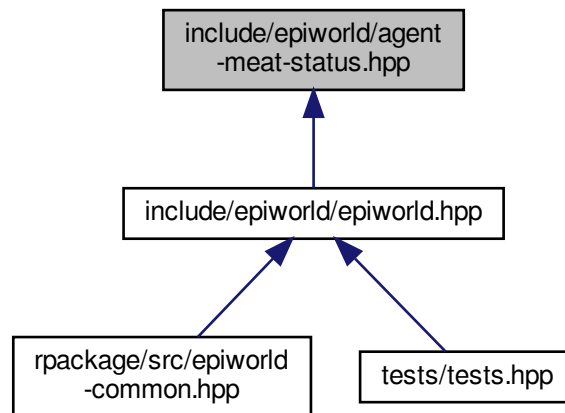
Sampling functions are getting big, so we keep them in a separate file.

```
#include "agent-meat-virus-sampling.hpp"
```

Include dependency graph for agent-meat-status.hpp:



This graph shows which files directly or indirectly include this file:



Functions

- `template<typename TSeq = int>`
`void default_update_susceptible (Agent< TSeq > *p, Model< TSeq > *m)`
- `template<typename TSeq = int>`
`void default_update_exposed (Agent< TSeq > *p, Model< TSeq > *m)`

16.1.1 Detailed Description

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

Author

George G. Vega Yon (g.vegayon en gmail)

Version

0.1

Date

2022-06-15

Copyright

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