Package ‘MetaRVM’

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Title Meta-Population Compartmental Model for Respiratory Virus Diseases

Version 1.0.0

Description Simulates respiratory virus epidemics using meta-population compartmental models following Fadikar et. al. (2025) <doi:10.1101/2025.05.05.25327021>. 'MetaRVM' implements a stochastic
SEIRD (Susceptible-Exposed-Infected-Recovered-Dead) framework with demographic stratification by age, race, and geographic zones. It supports complex epidemiological scenarios including asymptomatic and presymptomatic transmission, hospitalization dynamics, vaccination schedules, and time-varying contact patterns via mixing matrices.

URL `https://RESUME-Epi.github.io/MetaRVM/`, `https://github.com/RESUME-Epi/MetaRVM`

BugReports `https://github.com/RESUME-Epi/MetaRVM/issues`

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Contents

`format_metarvm_output` *Format MetaRVM simulation output*

Description

This function formats raw MetaRVM simulation output by:

1. Converting time steps to calendar dates
2. Adding demographic attributes from population mapping
3. Handling different disease states appropriately:
   - Regular states (S, E, I, etc.): Keep values at integer time points
   - New count states (n_ prefix): Sum pairs to get daily counts

Usage

```
format_metarvm_output(sim_output, config)
```

Arguments

`sim_output`	data.table containing raw simulation output from `meta_sim`
`config`	MetaRVMConfig object or config list containing parameters

Value

data.table with formatted output including calendar dates and demographics

Note

This function is used for formatting the `meta_sim` output when `MetaRVM` function is called.

`metaRVM` *Run a MetaRVM epidemic simulation*

Description

`metaRVM()` is the high-level entry point for running a MetaRVM metapopulation respiratory virus simulation. It parses the configuration, runs one or more simulation instances (deterministic or stochastic), formats the ODIN/MetaRVM output into a tidy long table with calendar dates and demographic attributes, and returns a `MetaRVMResults` object for downstream analysis and plotting.

Usage

```
metaRVM(config_input)
```

Arguments

`config_input`	Configuration specification in one of three forms: • **Character string**: path to a YAML configuration file. • `MetaRVMConfig` **object**: pre-initialized configuration. • **Named list**: output from `parse_config()` with `return_object = FALSE`.

Details

The configuration input controls:

- **Population structure** (e.g., age, race, zone)
- **Disease parameters** (`ts`, `tv`, `ve`, `de`, `dp`, `da`, `ds`, `dh`, `dr`, `pea`, `psr`, `phr`, `dv`, etc.)
- **Mixing matrices** (weekday/weekend, day/night contact patterns)
- **Vaccination schedule** and immunity waning
- **Simulation settings** (start date, length, number of instances, stochastic vs. deterministic mode, checkpointing)

Internally, `metaRVM()`:

1. Parses the YAML configuration via `parse_config()`.
2. Calls the ODIN-based simulation engine `meta_sim()` for each instance.
3. Uses `format_metarvm_output()` to convert time steps to dates and attach demographic attributes.
4. Wraps the formatted output and metadata in a `MetaRVMResults` object that supports method chaining for subsetting, summarizing, and plotting.

Value

A `MetaRVMResults` R6 object with three key components:

$results A tidy `data.table` with one row per date–subpopulation–disease state–instance combination. Typical columns include:

- `date`: calendar date (`Date`)
- `age`, `race`, `zone`: demographic categories (if present in the population mapping)
- `disease_state`: compartment or flow label (e.g., `S`, `E`, `I_symp`, `H`, `R`, `D`, `n_SE`, `n_IsympH`, etc.)
- `value`: population count or daily flow
- `instance`: simulation instance index (1, 2, . . .)

$config The `MetaRVMConfig` object used for the run.

$run_info A list with metadata such as `n_instances`, `date_range`, `delta_t`, and checkpoint information.

Author(s)

Arindam Fadikar, Charles Macal, Ignacio Martinez-Moyano, Jonathan Ozik

References

Fadikar, A., et al. "Developing and deploying a use-inspired metapopulation modeling framework for detailed tracking of stratified health outcomes"

See Also

`parse_config()` for reading YAML configurations, MetaRVMConfig for configuration management, MetaRVMResults for analysis and plotting, `meta_sim()` for the low-level simulation engine.

Examples

```
options(odin.verbose = FALSE)
example_config <- system.file("extdata", "example_config.yaml",
                              package = "MetaRVM")

# Run a single-instance simulation from a YAML file
results <- metaRVM(example_config)

# Print a high-level summary
results

# Access the tidy results table
head(results$results)

# Summarize and plot hospitalizations and deaths by age and race
results$summarize(
  group_by       = c("age", "race"),
  disease_states = c("H", "D"),
  stats          = c("median", "quantile"),
```

```
  quantiles      = c(0.25, 0.75)
)$plot()

# Using a pre-parsed configuration object
cfg <- parse_config(example_config, return_object = TRUE)
results2 <- metaRVM(cfg)
```

`MetaRVMCheck` *MetaRVM Checkpoint Class*

Description

R6 class to handle MetaRVM checkpoint data. This class is a simplified version of MetaRVMConfig tailored for storing and accessing simulation checkpoints.

Details

The `MetaRVMCheck` class is designed to hold the state of a simulation at a specific time point, allowing for continuation or analysis. It stores all necessary parameters and population states.

Super class

`MetaRVM::MetaRVMConfig` -> `MetaRVMCheck`

Public fields

`check_data` List containing all parsed checkpoint data

Methods

Public methods:

- `MetaRVMCheck$new()`
- `MetaRVMCheck$clone()`

Method `new()`**:** Initialize a new MetaRVMCheck object

Usage:

`MetaRVMCheck$new(input)`

Arguments:

`input` A list containing checkpoint data.

Returns: A new `MetaRVMCheck` object.

Method `clone()`**:** The objects of this class are cloneable with this method.

Usage:

`MetaRVMCheck$clone(deep = FALSE)`

Arguments:

`deep` Whether to make a deep clone.

Author(s)

Arindam Fadikar

`MetaRVMConfig` *MetaRVM Configuration Class*

Description

R6 class to handle MetaRVM configuration data with validation and methods. This class encapsulates all configuration parameters needed for MetaRVM simulations, providing methods for parameter access, validation, and introspection.

Details

The MetaRVMConfig class stores parsed configuration data from YAML files and provides structured access to simulation parameters. It automatically validates configuration completeness and provides convenient methods for accessing demographic categories, population mappings, and other simulation settings.

Public fields

`config_file` Path to the original YAML config file (if applicable)

`config_data` List containing all parsed configuration parameters

Methods

Public methods:

- `MetaRVMConfig$new()`
- `MetaRVMConfig$get()`
- `MetaRVMConfig$get_all()`
- `MetaRVMConfig$list_parameters()`
- `MetaRVMConfig$parameter_summary()`
- `MetaRVMConfig$set()`
- `MetaRVMConfig$print()`
- `MetaRVMConfig$get_pop_map()`
- `MetaRVMConfig$get_age_categories()`
- `MetaRVMConfig$get_race_categories()`
- `MetaRVMConfig$get_zones()`
- `MetaRVMConfig$clone()`

Method `new()`**:** Initialize a new MetaRVMConfig object

Usage:

```
MetaRVMConfig$new(input)
```

Arguments:

`input` Either a file path (character) or parsed config list

Returns: New MetaRVMConfig object (invisible)

Method `get()`**:** Get a configuration parameter

Usage:

`MetaRVMConfig$get(param)`

Arguments:

`param` Parameter name

Returns: The requested parameter value

Method `get_all()`**:** Get all configuration parameters as a list

Usage:

`MetaRVMConfig$get_all()`

Returns: Named list of all configuration parameters

Method `list_parameters()`**:** List all available parameter names

Usage:

`MetaRVMConfig$list_parameters()`

Returns: Character vector of parameter names

Method `parameter_summary()`**:** Show summary of parameter types and sizes

Usage:

`MetaRVMConfig$parameter_summary()`

Returns: Data frame with parameter information

Method `set()`**:** Set a configuration parameter

Usage:

`MetaRVMConfig$set(param, value)`

Arguments:

`param` Character string. Parameter name to set
`value` The value to assign to the parameter

Returns: Self (invisible) for method chaining

Method `print()`**:** Print summary of configuration

Usage:

`MetaRVMConfig$print()`

Returns: Self (invisible)

Method `get_pop_map()`**:** Get population mapping data

Usage:

`MetaRVMConfig$get_pop_map()`

Returns: data.table containing population mapping with demographic categories

Method `get_age_categories()`**:** Get available age categories

Usage:

`MetaRVMConfig$get_age_categories()`

Returns: Character vector of unique age categories, or NULL if no population mapping available

Method `get_race_categories()`**:** Get available race categories

Usage:

`MetaRVMConfig$get_race_categories()`

Returns: Character vector of unique race categories, or NULL if no population mapping available

Method `get_zones()`**:** Get available zones

Usage:

`MetaRVMConfig$get_zones()`

Returns: Character vector of unique zone identifiers, or NULL if no population mapping available

Method `clone()`**:** The objects of this class are cloneable with this method.

Usage:

`MetaRVMConfig$clone(deep = FALSE)`

Arguments:

`deep` Whether to make a deep clone.

Author(s)

Arindam Fadikar

Examples

```
# Initialize from YAML file
example_config <- system.file("extdata", "example_config.yaml", package = "MetaRVM")
config <- MetaRVMConfig$new(example_config)

# Access parameters
config$get("N_pop")
config$get("start_date")

# Get demographic categories
ages <- config$get_age_categories()
races <- config$get_race_categories()
zones <- config$get_zones()
```

`MetaRVMResults` *MetaRVM Results Class*

Description

R6 class to handle MetaRVM simulation results with comprehensive analysis and visualization methods. This class stores formatted simulation results and provides methods for data summarization, subsetting, and visualization with flexible demographic groupings.

Details

The MetaRVMResults class automatically formats raw simulation output upon initialization, converting time steps to calendar dates and adding demographic attributes. It provides methods for flexible data summarization across any combination of age, race, and geographic zone categories, plus method chaining for streamlined analysis workflows.

Public fields

`config` MetaRVMConfig object used to generate these results

`results` data.table containing formatted simulation results

`run_info` List containing run metadata

Methods

Public methods:

- `MetaRVMResults$new()`
- `MetaRVMResults$print()`
- `MetaRVMResults$subset_data()`
- `MetaRVMResults$summarize()`
- `MetaRVMResults$clone()`

Method `new()`**:** Initialize a new MetaRVMResults object

Usage:

```
MetaRVMResults$new(
  raw_results,
  config,
  run_info = NULL,
  formatted_results = NULL
)
```

Arguments:

`raw_results` Raw simulation results data.table

`config` MetaRVMConfig object used for the simulation

`run_info` Optional metadata about the run

`formatted_results` formatted simulation results data.table

Returns: New MetaRVMResults object (invisible)

Method `print()`**:** Print summary of results

Usage:

```
MetaRVMResults$print()
```

Returns: Self (invisible)

Method `subset_data()`**:** Subset the data based on any combination of parameters

Usage:

```
MetaRVMResults$subset_data(
  ages = NULL,
  races = NULL,
  zones = NULL,
  disease_states = NULL,
  date_range = NULL,
  instances = NULL,
  exclude_p_columns = TRUE
)
```

Arguments:

`ages`	Vector of age categories to include (default: all)
`races`	Vector of race categories to include (default: all)
`zones`	Vector of zones to include (default: all)
`disease_states`	Vector of disease states to include (default: all, excludes p_ columns)
`date_range`	Vector of two dates start_date, and end_date for filtering (default: all)
`instances`	Vector of instance numbers to include (default: all)
`exclude_p_columns`	Logical, whether to exclude p_ columns (default: TRUE)

Returns: MetaRVMResults object with subset of results

Method `summarize()`**:** Summarize results across specified demographic characteristics

Usage:

```
MetaRVMResults$summarize(
  group_by,
  disease_states = NULL,
  date_range = NULL,
  stats = c("mean", "median", "sd"),
  quantiles = c(0.25, 0.75),
  exclude_p_columns = TRUE
)
```

Arguments:

`group_by`	Vector of demographic variables to group by: c("age", "race", "zone")
`disease_states`	Vector of disease states to include (default: all, excludes p_ columns)
`date_range`	Optional date range for filtering
`stats`	Vector of statistics to calculate: c("mean", "median", "sd", "min", "max", "sum", "quantile"). If NULL, returns all instances

`quantiles` Vector of quantiles to calculate if "quantile" is in stats (default: c(0.25, 0.75))

`exclude_p_columns` Logical, whether to exclude p_ columns (default: TRUE)

Returns: data.table with summarized time series data or all instances if stats = NULL

Method `clone()`**:** The objects of this class are cloneable with this method.

Usage:

```
MetaRVMResults$clone(deep = FALSE)
```

Arguments:

`deep` Whether to make a deep clone.

Author(s)

Arindam Fadikar

Examples

```
options(odin.verbose = FALSE)
example_config <- system.file("extdata", "example_config.yaml", package = "MetaRVM")
# Run simulation
results_obj <- metaRVM(example_config)
# Access formatted results
head(results_obj$results)

# Subset data with multiple filters
subset_data <- results_obj$subset_data(
  age = c("18-49", "50-64"),
  disease_state = c("H", "D"),
  date_range = c(as.Date("2024-01-01"), as.Date("2024-02-01"))
)

# Method chaining for analysis and visualization
results_obj$subset_data(disease_state = "H")$summarize(
  group_by = c("age", "race"),
  stats = c("median", "quantile"),
  quantiles = c(0.25, 0.75)
)$plot()
```

`MetaRVMSummary` *MetaRVM Summary Class*

Description

R6 class for summarized MetaRVM results with plotting capabilities and method chaining support. This class stores summarized simulation data and provides visualization methods that automatically adapt based on the data structure and grouping variables.

Details

The MetaRVMSummary class is designed to work seamlessly with method chaining from MetaRVMResults. It stores either summary statistics (mean, median, quantiles, etc.) or individual instance data, and provides intelligent plotting methods that automatically determine appropriate visualizations based on the data structure and demographic groupings.

The class supports two data types:

- **Summary data**: Contains aggregated statistics across simulation instances
- **Instance data**: Contains individual trajectory data for each simulation instance

Plotting behavior adapts automatically:

- Single grouping variable: Facets by demographic category, colors by disease state
- Two grouping variables: Grid layout with both demographics as facet dimensions
- Three grouping variables: Grid layout with first two as facets, third as color

Public Fields

`data` data.table containing summarized results

`config` MetaRVMConfig object from original simulation

`type` Character string indicating data type ("summary" or "instances")

Public fields

`data` Summarized data

`config` Original MetaRVMConfig object

`type` Type of summary ("instances" or "summary")

Methods

Public methods:

- `MetaRVMSummary$new()`
- `MetaRVMSummary$print()`
- `MetaRVMSummary$plot()`
- `MetaRVMSummary$clone()`

Method `new()`**:** Initialize MetaRVMSummary object

Usage:

`MetaRVMSummary$new(data, config, type)`

Arguments:

`data` data.table containing summarized or instance data
`config` MetaRVMConfig object from original simulation
`type` Character string indicating data type ("summary" or "instances")

Returns: New MetaRVMSummary object (invisible)

Method `print()`**:** Print summary of the data object

Usage:

```
MetaRVMSummary$print()
```

Returns: Self (invisible)

Method `plot()`**:** Plot method that shows median with quantile bands

Usage:

```
MetaRVMSummary$plot(ci_level = 0.95, theme = theme_minimal(), title = NULL)
```

Arguments:

`ci_level` Confidence level for empirical quantiles (default: 0.95). Only used if quantile columns are not pre-specified

`theme` ggplot2 theme function (default: theme_minimal())

`title` Optional custom plot title

Details: This method creates time series plots with automatic layout adaptation based on grouping variables:

- For summary data: Shows median lines with quantile confidence bands
- Automatically determines faceting strategy based on number of grouping variables
- Uses disease states for color differentiation when appropriate

The method requires specific data structure:

- Summary data must contain 'median_value' and quantile columns (e.g., 'q25', 'q75')
- Instance data must contain 'instance' column for individual trajectory grouping

Returns: ggplot object

Method `clone()`**:** The objects of this class are cloneable with this method.

Usage:

```
MetaRVMSummary$clone(deep = FALSE)
```

Arguments:

`deep` Whether to make a deep clone.

Author(s)

Arindam Fadikar

Examples

```
options(odin.verbose = FALSE)
example_config <- system.file("extdata", "example_config_dist.yaml", package = "MetaRVM")
# Run simulation
results <- metaRVM(example_config)
# Typically created through method chaining
summary_obj <- results$subset_data(disease_state = "H")$summarize(
  group_by = c("age", "race"),
  stats = c("median", "quantile"),
  quantiles = c(0.25, 0.75)
)
```

```
# Direct plotting
summary_obj$plot()

# Plot with custom ggplot theme and confidence level
summary_obj$plot(theme = ggplot2::theme_bw())
```

`meta_sim` *Metapopulation Respiratory Virus Model Simulator*

Description

The core simulation engine that implements a stochastic compartmental SEIRD (Susceptible-Exposed-Infected-Recovered-Dead) model for respiratory virus epidemics across multiple demographic subpopulations. The function compiles and executes an ODIN-based differential equation model with time-varying contact patterns, vaccination dynamics, and complex disease progression pathways.

Usage

```
meta_sim(
  N_pop,
  ts,
  tv,
  S0,
  I0,
  P0,
  R0,
  H0 = rep(0, N_pop),
  D0 = rep(0, N_pop),
  Ia0 = rep(0, N_pop),
  Ip0 = rep(0, N_pop),
  E0 = rep(0, N_pop),
  V0 = rep(0, N_pop),
  m_weekday_day,
  m_weekday_night,
  m_weekend_day,
  m_weekend_night,
  start_day = 0,
  delta_t,
  vac_mat,
  dv,
  de,
  pea,
  dp,
  da,
  ds,
```

```
  psr,
  dh,
  phr,
  dr,
  ve,
  nsteps,
  is.stoch = FALSE,
  seed = NULL,
  do_chk = FALSE,
  chk_time_steps = NULL,
  chk_file_names = NULL
)
```

Arguments

`N_pop`	Integer. Number of demographic subpopulations in the model
`ts`	Numeric vector or scalar. Transmission rate for symptomatic individuals in susceptible population. If scalar, applied to all subpopulations
`tv`	Numeric vector or scalar. Transmission rate for symptomatic individuals in vaccinated population. If scalar, applied to all subpopulations
`S0`	Numeric vector of length N_pop. Initial number of susceptible individuals in each subpopulation
`I0`	Numeric vector of length N_pop. Initial number of symptomatic infected individuals in each subpopulation
`P0`	Numeric vector of length N_pop. Total population sizes for each subpopulation
`R0`	Numeric vector of length N_pop. Initial number of recovered individuals in each subpopulation
`H0`	Numeric vector of length N_pop. Initial number of hospitalized individuals in each subpopulation (default: rep(0, N_pop))
`D0`	Numeric vector of length N_pop. Initial number of deceased individuals in each subpopulation (default: rep(0, N_pop))
`Ia0`	Numeric vector of length N_pop. Initial number of asymptomatic infected individuals in each subpopulation (default: rep(0, N_pop))
`Ip0`	Numeric vector of length N_pop. Initial number of presymptomatic infected individuals in each subpopulation (default: rep(0, N_pop))
`E0`	Numeric vector of length N_pop. Initial number of exposed individuals in each subpopulation (default: rep(0, N_pop))
`V0`	Numeric vector of length N_pop. Initial number of vaccinated individuals in each subpopulation
`m_weekday_day`	Numeric matrix (N_pop × N_pop). Contact mixing matrix for weekday daytime (6 AM - 6 PM) interactions
`m_weekday_night`	Numeric matrix (N_pop × N_pop). Contact mixing matrix for weekday nighttime (6 PM - 6 AM) interactions

`m_weekend_day`	Numeric matrix (N_pop × N_pop). Contact mixing matrix for weekend daytime (6 AM - 6 PM) interactions
`m_weekend_night`	Numeric matrix (N_pop × N_pop). Contact mixing matrix for weekend nighttime (6 PM - 6 AM) interactions
`start_day`	Start day of the week expressed as an integer value between 0 and 6, 0 being Monday. Default simulation start day is Monday.
`delta_t`	Positive numeric. Discrete time increment in days (typically 0.5)
`vac_mat`	Numeric matrix. Vaccination schedule with dimensions (nsteps × (1 + N_pop)). First column contains time indices, remaining columns contain vaccination counts for each subpopulation at each time step
`dv`	Numeric vector or scalar. Mean duration (days) in vaccinated state before immunity waning. If scalar, applied to all subpopulations
`de`	Numeric vector or scalar. Mean duration (days) in exposed state. If scalar, applied to all subpopulations
`pea`	Numeric vector or scalar. Proportion of exposed individuals becoming asymptomatic infectious (vs. presymptomatic), values between 0 and 1. If scalar, applied to all subpopulations. If scalar, applied to all subpopulations
`dp`	Numeric vector or scalar. Mean duration (days) in presymptomatic infectious state. If scalar, applied to all subpopulations
`da`	Numeric vector or scalar. Mean duration (days) in asymptomatic infectious state. If scalar, applied to all subpopulations
`ds`	Numeric vector or scalar. Mean duration (days) in symptomatic infectious state. If scalar, applied to all subpopulations
`psr`	Numeric vector or scalar. Proportion of symptomatic individuals recovering directly (vs. hospitalization), values between 0 and 1. If scalar, applied to all subpopulations. If scalar, applied to all subpopulations
`dh`	Numeric vector or scalar. Mean duration (days) in hospitalized state. If scalar, applied to all subpopulations
`phr`	Numeric vector or scalar. Proportion of hospitalized individuals recovering (vs. death). , values between 0 and 1. If scalar, applied to all subpopulations.
`dr`	Numeric vector or scalar. Mean duration (days) of immunity in recovered state. If scalar, applied to all subpopulations
`ve`	Numeric vector or scalar. Vaccine effectiveness (proportion) , values between 0 and 1. If scalar, applied to all subpopulations
`nsteps`	Integer. Total number of discrete time evolution steps in simulation
`is.stoch`	Logical. Whether to run stochastic simulation (TRUE) or deterministic simulation (FALSE). Default: FALSE
`seed`	Integer or NULL. Random seed for reproducibility. Only used when is.stoch = TRUE. Default: NULL
`do_chk`	Logical. Whether to save model checkpoint at simulation end. Default: FALSE
`chk_time_steps`	Integer vector or NULL. Time steps at which to save checkpoints.
`chk_file_names`	List of character vectors or NULL. File names for checkpoints. Each element of the list corresponds to a time step in `chk_time_steps`.

Details

The model implements a metapopulation epidemiological framework with the following features:

Compartmental Structure:

- **S**: Susceptible individuals
- **E**: Exposed (incubating) individuals
- **I_presymp**: Presymptomatic infectious individuals
- **I_asymp**: Asymptomatic infectious individuals
- **I_symp**: Symptomatic infectious individuals
- **H**: Hospitalized individuals
- **R**: Recovered individuals
- **D**: Deceased individuals
- **V**: Vaccinated individuals
- **P**: Total living population (excludes deaths)

Disease Progression Pathways:

1. **S → E**: Exposure through contact with infectious individuals
2. **E → I_asymp/I_presymp**: Progression to infectious states (proportion pea)
3. **I_presymp → I_symp**: Development of symptoms
4. **I_asymp → R**: Direct recovery from asymptomatic state
5. **I_symp → R/H**: Recovery or hospitalization (proportion psr)
6. **H → R/D**: Hospital discharge or death (proportion phr)
7. **R → S**: Loss of immunity
8. **S → V**: Vaccination
9. **V → S/E**: Vaccine waning or breakthrough infection

Mixing Patterns: Contact patterns vary by:

- Day of week: Weekday vs. weekend patterns
- Time of day: Day (6 AM - 6 PM) vs. night (6 PM - 6 AM) patterns
- Each pattern specified by N_pop × N_pop contact matrix

Force of Infection: Transmission occurs through contact between susceptible/vaccinated individuals and all infectious compartments (I_presymp + I_asymp + I_symp), modified by:

- Population-specific transmission rates (ts, tv)
- Time-varying contact patterns
- Vaccine effectiveness for breakthrough infections

Stochastic vs. Deterministic Mode:

- **Deterministic**: Uses exact differential equations
- **Stochastic**: Adds demographic stochasticity via binomial draws

Vaccination Implementation: Vaccination is implemented as time-varying input with:

- Scheduled vaccination counts per time step and subpopulation
- Vaccine effectiveness reducing infection probability
- Waning immunity returning individuals to susceptible state

Value

Returns a data.table with the following structure:

step	Integer time step index (0 to nsteps)
time	Continuous simulation time (step × delta_t)
disease_state	Character vector of compartment names
population_id	Character vector of subpopulation identifiers
value	Numeric values representing population counts in each compartment

Available disease states in output:

- Core compartments: S, E, I_presymp, I_asymp, I_symp, H, R, D, V, P
- Derived outputs: I_all (total infectious), cum_V (cumulative vaccinations)
- Transition flows: n_SE, n_EI, n_HR, n_HD, etc. (new infections, hospitalizations, deaths)
- Debug outputs: p_SE, p_VE, I_eff (probabilities and effective populations)

Parameter Scaling

All duration parameters are automatically converted to rates (1/duration). Scalar parameters are automatically expanded to vectors of length N_pop. This allows flexible specification of homogeneous or heterogeneous parameters.

Checkpointing

When do_chk = TRUE, the function saves a checkpoint file containing:

- Final compartment states for simulation continuation
- All model parameters for reproducibility
- Vaccination schedule data
- Population structure information

Author(s)

Arindam Fadikar, Charles Macal, Ignacio Martinez-Moyano, Jonathan Ozik

References

- ODIN package: `https://mrc-ide.github.io/odin/`
- Fadikar, A., et al. "Developing and deploying a use-inspired metapopulation modeling framework for detailed tracking of stratified health outcomes"

See Also

`metaRVM` for high-level simulation interface with configuration files `parse_config` for configuration file processing `format_metarvm_output` for output formatting with demographics

Examples

```
options(odin.verbose = FALSE)
# Basic deterministic simulation
N_pop <- 2
nsteps <- 400

# Initialize populations
S0 <- rep(1000, N_pop)
I0 <- rep(10, N_pop)
P0 <- S0 + I0
R0 <- rep(0, N_pop)

# Contact matrices (simplified - identity matrices)
contact_matrix <- diag(N_pop)

# Basic vaccination schedule (10% vaccination)
vac_mat <- matrix(0, nrow = nsteps + 1, ncol = N_pop + 1)
vac_mat[, 1] <- 0:nsteps
vac_mat[1, 1 + (1:N_pop)] <- P0 * 0.1

# Run simulation
results <- meta_sim(
  N_pop = N_pop,
  ts = 0.5,
  tv = 0.1,
  S0 = S0,
  I0 = I0,
  P0 = P0,
  R0 = R0,
  m_weekday_day = contact_matrix,
  m_weekday_night = contact_matrix,
  m_weekend_day = contact_matrix,
  m_weekend_night = contact_matrix,
  delta_t = 0.5,
  vac_mat = vac_mat,
  dv = 365,
  de = 3,
  pea = 0.3,
  dp = 2,
  da = 7,
  ds = 7,
  psr = 0.95,
  dh = 10,
  phr = 0.9,
  dr = 180,
  ve = 0.8,
  nsteps = nsteps,
```

```
  is.stoch = FALSE
)
```

`parse_config` *Parse MetaRVM Configuration File*

Description

Reads and parses a YAML configuration file for MetaRVM simulations, extracting all necessary parameters for epidemic modeling including population data, disease parameters, mixing matrices, vaccination schedules, and simulation settings.

Usage

```
parse_config(config_file, return_object = FALSE)
```

Arguments

`config_file`	Character string. Path to a YAML configuration file containing model parameters and settings.
`return_object`	Logical. If `TRUE`, returns a `MetaRVMConfig` object for method chaining and enhanced functionality. If `FALSE` (default), returns a named list for backward compatibility.

Details

The function processes a YAML configuration file with the following main sections:

Simulation Configuration:

- `random_seed`: Optional random seed for reproducibility in case of stochastic simulations or stochastic parameters
- `nsim`: Number of simulation instances (default: 1)
- `start_date`: Simulation start date in MM/DD/YYYY format
- `length`: Simulation length in days
- `checkpoint_dir`: Optional checkpoint directory for saving intermediate results
- `checkpoint_dates`: Optional list of dates to save checkpoints.
- `restore_from`: Optional path to restore simulation from checkpoint

Population Data:

- `mapping`: CSV file path containing population mapping with demographic categories age, race, zone. The file must contains columns `population_id`, `age`, `race`, `zone`, where the `population_id` is defined using natural numbers.

- `initialization`: CSV file with initial population states. The file must contains columns `population_id`, `N`, `S0`, `I0`, `V0`, `R0`.
- `vaccination`: CSV file with vaccination schedule over time. The first column must be dates in MM/DD/YYYY format. The rest of the columns must corresponds to respective subpopulations in the numeric order of population_id.

Mixing Matrices: Contact matrices for different time periods. Each CSV file must have a matrix of order (N_pop x N_pop), where, N_pop is the number of subpopulations. It is assumed that the i-th row and j-th column correspond to i-th and j-th subpopulations.

- `weekday_day`, `weekday_night`: Weekday contact patterns
- `weekend_day`, `weekend_night`: Weekend contact patterns

Disease Parameters: Epidemiological parameters (can be scalars or distributions):

- `ts`: Transmission rate for symptomatic individuals
- `tv`: Transmission rate for vaccinated individuals
- `ve`: Vaccine effectiveness
- `de, dp, da, ds, dh, dr`: Duration parameters for different disease states
- `pea, psr, phr`: Probability parameters for disease transitions

Sub-population Parameters: `sub_disease_params` allows specification of different parameter values for specific demographic categories (e.g., age groups, races).

The function supports stochastic parameters through distribution specifications with `dist`, `mu`, `sd`, `shape`, `rate`, etc.

Value

If `return_object` = `FALSE` (default), returns a named list containing:

N_pop Number of population groups

pop_map Data.table with population mapping and demographics

S_ini, E_ini, I_asymp_ini, I_presymp_ini, I_symp_ini, H_ini, D_ini, P_ini, V_ini, R_ini Initial compartment populations

vac_time_id, vac_counts, vac_mat Vaccination schedule data

m_wd_d, m_wd_n, m_we_d, m_we_n Contact mixing matrices

ts, tv, ve, dv, de, dp, da, ds, dh, dr, pea, psr, phr Disease parameter matrices (nsim × N_pop)

start_date Simulation start date as Date object

sim_length Simulation length in days

nsim Number of simulation instances

random_seed Random seed used (if any)

delta_t Time step size (fixed at 0.5)

chk_file_names, chk_time_steps, do_chk Checkpointing configuration

If `return_object` = `TRUE`, returns a `MetaRVMConfig` object with methods for parameter access and validation.

Parameter Distributions

Disease parameters can be specified as distributions for stochastic modeling:

- **lognormal**: `dist: "lognormal", mu: value, sd: value`
- **gamma**: `dist: "gamma", shape: value, rate: value`
- **uniform**: `dist: "uniform", min: value, max: value`
- **beta**: `dist: "beta", shape1: value, shape2: value`
- **gaussian**: `dist: "gaussian", mean: value, sd: value`

File Requirements

Population mapping file must contain columns:

- `population_id`: Unique identifier for each population group, natural numbers
- `age`: Age category (e.g., "0-4", "5-11", "12-17", "18-49", "50-64", "65+")
- `race`: Race/ethnicity category
- `zone`: Geographic zone identifier

Population initialization file must contain: `N` (total population), `S0`, `I0`, `V0`, `R0` (initial compartment counts)

Vaccination file must contain: `date` (MM/DD/YYYY format) and vaccination counts for each population group

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See Also

`metaRVM` for running simulations with parsed configuration `MetaRVMConfig` for the configuration object class `process_vac_data` for vaccination data processing

Examples

```
options(odin.verbose = FALSE)
example_config <- system.file("extdata", "example_config.yaml", package = "MetaRVM")
# Parse configuration file and return list (backward compatible)
config <- parse_config(example_config)

# Parse and return MetaRVMConfig object for method chaining
config_obj <- parse_config(example_config, return_object = TRUE)

# Access parameters from config object
config_obj$get("N_pop")
config_obj$list_parameters()

# Use with MetaRVM simulation
results <- metaRVM(config_obj)
```

Index