Wildfire Model v.1

Documentation

Sigal Maya

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This document contains the wildfire microsimulation model. The wildfire microsimulation model defines an initial population and model parameters, and defines and runs a model to calculate health and cost outcomes. It consists of three sections: model inputs, defining functions, and running the simulation. Majority of the code is based on Krijkamp 2018.1

## 1) Model inputs

Naming conventions:

* Objects with prefix n. are numbers
* Objects with prefix v. are vectors
* Objects with prefix m. are matrices

### Define model design parameters

* n.i: Cohort size
* n.t: Time horizon
* cl: Cycle length (in years)
* v.n: Vector containing the names of possible health states
* n.s: Number of possible health states
* v.M\_1: Vector of length n.i containing initial health states of each individual (by default, everyone begins Healthy)
* d.c: Discount rate for costs
* d.e: Discount rate for health effects (default is equal to d.c)
* v.intn: Vector containing names of interventions to be assessed
* v.x: Vector containing names of individuals characteristics

### Define transition probabilities

All transition probabilities depend on whether a fire happens or not. p.fire changes over time, and also depends on rural/urban designation.

Individuals may:

* die immediately (p.HD)
* become acutely injured, e.g., burns, smoke inhalation, other injuries (p.Act)
* heal from acute injuries (p.ActH)
* become permanently injured from acute injuries, e.g., cancer or CVD due to smoke, amputation from extensive burns (p.ActPrm)
* die from acute injuries, e.g., heart attack after smoke inhalation, extensive burns (p.ActD)
* die from permanent injuries, e.g., die from cancer due to smoke (p.ActD)

Individuals with lung issues due to smoke (i.e, permanent injury) are more vulnerable to adverse outcomes during the next fire. Otherwise, transition probabilities remain the same over time.

Individual characteristics that are risk modifiers are:

* age
* sex

### Define cost and health effect inputs

Objects with prefix c. denote cost values. Objects with prefix u. denote health state utility values.

### Initialize population

Create a matrix containing individual characteristics for each person (m.x).

1. Give everyone an ID number from 1 to n.i.
2. Assign age. Currently based on a normal distribution with mean 48 and standard deviation 5.
3. Assign sex based on a binomial distribution. Currently, probability of female is 0.55.
4. Assign rural/urban designation based on a binomial distribution. Currently, probability of rural is 0.30.
5. Define previous wildfire exposure. By default everyone start with no prior exposure.

## 2) Define functions

### MicroSim

#### Usage:

MicroSim(v.M\_1, n.i, n.t, p.fire, v.n, m.x, cl, d.c, d.e, TR.out = TRUE, TS.out = TRUE, intn=FALSE, seed = 1)

#### Arguments:

* v.M\_1: vector of initial states for each individual
* n.i: number of individuals
* n.t: number of cycles
* p.fire: probability of fire in a given cycle
* v.n: vector of health state names
* m.x: vector or matrix with individual characteristics
* cl: cycle length
* d.c, d.e: discount rates for cost and health outcomes
* TR.out: should the output include a microsimulation trace?
* TS.out: should the output include a transition array between states?
* intn: is there an intervention? (scalar with Boolean value, could be vector of Booleans if some people receive intervention and some don’t)
* seed: starting seed number

The following functions are used:

* Probs(...): to estimate transition probabilities
* Costs(...): to estimate costs of state values
* Effs(...): to estimate health outcomes

#### Details:

1. Vectors of discount weights for costs and health effects at each cycle are calculated using the formula .
2. Matrices for tracking fires (m.fire), health states (m.M), costs (m.C), and health outcomes (m.E) are initialized.
3. Run the microsimulation algorithm.
   1. For i = 1 to n.i, calculate initial costs health effects.
   2. For t = 1 to c.t, calculate the probability of fire given t (using rr.fire.over.time)
   3. Determine whether a fire happens for individual i at cycle t given p.fire and urban/rural designation
   4. Create vector of transition probabilities v.p for individual i at cycle t, using the Probs(...) function, based on prior health state, whether a fire is experienced, and individual characteristics.
   5. Determine which health state the individual will have next using v.p.
   6. Determine costs and health outcomes based on new health state, whether there is an intervention, and individual characteristics. + Increase age by one.
   7. Set prior exposure to TRUE if a fire has been experienced.
   8. Close loop for cycles.
   9. Close loop for individuals.
4. Results are returned as a list:
   1. m.M: A matrix of size n.i x n.t+1 containing the health state occupied by each individual at each cycle.
   2. m.C: A matrix of size n.i x n.t+1 containing the costs incurred by each individual at each cycle.
   3. m.E: A matrix of size n.i x n.t+1 containing the health outcomes (QALYs) for each individual at each cycle.
   4. tc: Vector of total discounted costs per individual.
   5. te: Vector of total discounted QALYs per individual.
   6. tc\_hat: Mean discounted costs
   7. te\_hat: Mean discounted QALYs
   8. m.fire: Matrix of size n.i x n.t containing fire exposure of each individual at each cycle.
   9. m.x: Matrix containing the individual characteristics of each individual at the end of the time horizon n.t.
   10. TS: A matrix illustrating the state transitions of each individual n.i at each cycle n.t.
   11. TR: A matrix of size n.txv.n containing the health state distribution trace.

### Probs

#### Usage:

Probs(M\_it, m.fire\_it, m.chars\_i)

#### Arguments:

* M\_it: health state occupied by individual i at cycle t (i.e., m.M[i,t+1])
* m.fire\_it: fire experience of individual i at cycle t (i.e., m.fire[i,t])
* m.chars\_i: vector of individual characteristics of individual i (i.e., m.x[i, ])

#### Details:

1. Initialize a vector of length n.s to hold state transition probabilities.
2. Calculate p.PrmD conditional on prior wildfire smoke exposure.
3. Calculate all transitions conditional on the occurrence of a fire.
4. Assign transition probabilities conditional on current health state.
5. Return vector of transition probabilities for individual i at cycle t.

### Costs

#### Usage:

Costs(M\_it, intervention = FALSE)

#### Arguments:

* M\_it: health state occupied by individual i at cycle t (i.e., m.M[i,t+1])
* intervention: is there an intervention? (i.e., intn)

#### Details:

1. Define variable to hold costs.
2. Assign cost associated with current health state.
3. Return cost for individual i at cycle t.

Note: In the future, this should also include individual characteristics.

### Effs

#### Usage:

Effs(M\_it, intervention = FALSE, m.chars = NULL, cl=1)

#### Arguments:

* M\_it: health state occupied by individual i at cycle t (i.e., m.M[i,t+1])
* intervention: is there an intervention? (i.e., intn)
* m.chars: individual characteristics of individual i at cycle t (i.e., m.x[i, ])

#### Details:

1. Define variable to hold utilities.
2. Assign utility associated with current health state conditional on intervention.
3. Calculate QALYs using .
4. Return QALYs for individual i at cycle t.

*Note:* Individual characteristics are not yet being used. Future revisions should include the effect of other factors.

## 3) Run simulation

Run the MicroSim() function with a given intervention mix.

## 4) Future revisions

* Future revisions should add code to automatically generate figures and tables of interest from simulation results.
* Include social networks and interaction that may affect health outcomes.
* Combine this with a second model of a different health outcome.
* The model currently uses a hypothetical, closed cohort. It needs to be revised to model an open cohort with births, deaths, and immigration. It also needs to incorporate real data.
* All data in the model are placeholders. They need to be updated to contain real values.

## References

1. Krijkamp EM, Alarid-Escudero F, Enns EA, Jalal HJ, Hunink MGM, Pechlivanoglou P. Microsimulation Modeling for Health Decision Sciences Using R: A Tutorial. Med Decis Making. 2018;38(3):400-22. doi: 10.1177/0272989X18754513.