A Tutorial on Time-Dependent Cohort State-Transition Models in R using a Cost-Effectiveness Analysis Example

Appendix

Fernando Alarid-Escudero, PhD* Eline Krijkamp, MSc† Eva A. Enns, PhD‡ Alan Yang, MSc§
Myriam G.M. Hunink, PhD†¶ Petros Pechlivanoglou, PhD‖ Hawre Jalal, MD, PhD**

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Cohort tutorial model components

This table contains an overview of the key model components used in the code for the Sick-Sicker example from the DARTH manuscript: "A Tutorial on Time-Dependent Cohort State-Transition Models in R". The first column gives the mathematical notation for some of the model components that are used in the equations in the manuscript. The second column gives a description of the model component with the R name in the third column. The forth gives the data structure, e.g. scalar, list, vector, matrix etc, with the according dimensions of this data structure in the fifth column. The final column indicated the type of data that is stored in the data structure, e.g. numeric (5.2,6.3,7.4), category (A,B,C), integer (5,6,7), logical (TRUE, FALSE).

Element	Description	R name	Data structure	Dimensions	Data type
n_t	Time horizon	`n_cycles`	scalar		numeric
	Cycle length	`cycle_length`	scalar		numeric
v_s	Names of the health states	`v_names_states`	vector	`n_states` x 1	character
n_s	Number of health states	`n_states`	scalar		numeric

*Division of Public Administration, Center for Research and Teaching in Economics (CIDE), Aguascalientes, AGS, Mexico
†Department of Epidemiology and Department of Radiology, Erasmus University Medical Center, Rotterdam, The Netherlands
‡Division of Health Policy and Management, University of Minnesota School of Public Health, Minneapolis, MN, USA
§The Hospital for Sick Children, Toronto
¶Center for Health Decision Sciences, Harvard T.H. Chan School of Public Health, Boston, USA
‖The Hospital for Sick Children, Toronto and University of Toronto, Toronto, Ontario, Canada
**University of Pittsburgh, Pittsburgh, PA, USA

Element	Description	R name	Data structure	Dimensions	Data type
$n_{S_{tunnels}}$	Number of health states with tunnels	`n_states_tunnels` scalar		numeric	
v_{str}	Names of the strategies	`v_names_str`	scalar		character
n_{str}	Number of strategies	`n_str`	scalar		character
d_c	Discount rate for costs	`d_c`	scalar		numeric
d_e	Discount rate for effects	`d_e`	scalar		numeric
$\mathbf{d_c}$	Discount weights vector for costs	`v_dwc`	vector	(`n_t` x 1) + 1	numeric
$\mathbf{d_e}$	Discount weights vector for effects	`v_dwe`	vector	(`n_t` x 1) + 1	numeric
	Sequence of cycle numbers	`v_cycles`	vector	(`n_t` x 1) + 1	numeric
$\mathbf{wcc}$	Within-cycle correction weights	`v_wcc`	vector	(`n_t` x 1) + 1	numeric
age_0	Age at baseline	`n_age_init`	scalar		numeric
age	Maximum age of follow up	`n_age_max`	scalar		numeric
M	Cohort trace matrix	`m_M`	matrix	(`n_t` + 1) x `n_states`	numeric
$M_{tunnels}$	Aggregated Cohort trace for state-dependency	`m_M_tunnels`	matrix	(`n_t` + 1) x `n_states`	numeric
	List of the cohort trace matrix for all strategies	`l_m_M`	list		numeric
m_0	Initial state vector	`v_m_init`	vector	1 x `n_states`	numeric
m_t	State vector in cycle t	`v_mt`	vector	1 x `n_states`	numeric
	Life table input				
	State vector in cycle t	`lt_usa_2005`	list		numeric
	Vector of age-specific mortality rates	`v_r_mort_by_age`	vector		numeric
	Transition probabilities				
$p_{[H,S1]}$	From Healthy to Sick conditional on surviving	`p_HS1`	scalar		numeric
$p_{[S1,H]}$	From Sick to Healthy conditional on surviving	`p_S1H`	scalar		numeric
$p_{[S1,S2]}$	From Sick to Sicker conditional on surviving	`p_S1S2`	scalar		numeric
$r_{[H,D]}$	Constant rate of dying when Healthy (all-cause mortality rate)	`r_HD`	scalar		numeric
$r_{[S1,S2]}$	Constant rate of becoming Sicker when Sick	`r_S1S2`	scalar		numeric
$r_{[S1,S2]_{trtB}}$	Constant rate of becoming Sicker when Sick for treatment B	`r_S1S2_trtB`	scalar		numeric
$hr_{[S1,H]}$	Hazard ratio of death in Sick vs Healthy	`hr_S1`	scalar		numeric
$hr_{[S2,H]}$	Hazard ratio of death in Sicker vs Healthy	`hr_S2`	scalar		numeric
$hr_{[S1,S2]_{trtB}}$	Hazard ratio of becoming Sicker when Sick under treatment B	`hr_S1S2_trtB`	scalar		numeric
$p_{[S1,S2]_{trtB}}$	probability to become Sicker when Sick under treatment B conditional on surviving	`p_S1S2_trtB`	scalar		numeric

Element	Description	R name	Data structure	Dimensions	Data type
	Weibull parameters for transition probability of becoming Sicker when Sick conditional on surviving				
λ	scale of the Weibull hazard function	`p_S1S2_scale`	scalar		numeric
γ	shape of the Weibull hazard function	`p_S1S2_shape`	scalar		numeric
	Simulation-time dependent mortality				
$r_{[H,D,t]}$	Age-specific background mortality rates	`v_r_HDage`	vector	`n_t` x 1	numeric
$r_{[S1,D,t]}$	Age-specific mortality rates in the Sick state	`v_r_S1Dage`	vector	`n_t` x 1	numeric
$r_{[S2,D,t]}$	Age-specific mortality rates in the Sicker state	`v_r_S2Dage`	vector	`n_t` x 1	numeric
$p_{[H,D,t]}$	Age-specific mortality risk in the Healthy state	`v_p_HDage`	vector	`n_t` x 1	numeric
$p_{[S1,D,t]}$	Age-specific mortality rates in the Sick state	`v_p_S1Dage`	vector	`n_t` x 1	numeric
$p_{[S2,D,t]}$	Age-specific mortality rates in the Sicker state	`v_p_S2Dage`	vector	`n_t` x 1	numeric
$p_{[S1,S2,t]}$	Time-dependent transition probabilities from sick to sicker	`v_p_S1S2_tunnels`	vector	`n_t` x 1	numeric
$r_{[S1,S2,t]}$	State-residence-dependent transition rate of becoming Sicker when Sick	`v_r_S1S2_tunnels`	vector	`n_t` x 1	numeric
	Annual costs				
	Healthy individuals	`c_H`	scalar		numeric
	Sick individuals in Sick	`c_S1`	scalar		numeric
	Sick individuals in Sicker	`c_S2`	scalar		numeric
	Dead individuals	`c_D`	scalar		numeric
	Additional costs treatment A	`c_trtA`	scalar		numeric
	Additional costs treatment B	`c_trtB`	scalar		numeric
	Vector of state costs for a strategy	`v_c_str`	vector	1 x `n_states`	numeric
	List that stores the vectors of state costs for each strategy	`l_c`	List		numeric
	Utility weights				
	Healthy individuals	`u_H`	scalar		numeric
	Sick individuals in Sick	`u_S1`	scalar		numeric
	Sick individuals in Sicker	`u_S2`	scalar		numeric
	Dead individuals	`u_D`	scalar		numeric
	Treated with treatment A	`u_trtA`	scalar		numeric
	Vector of state utilities for a strategy	`v_u_str`	vector	1 x `n_states`	numeric

Element	Description	R name	Data structure	Dimensions	Data type
	Vector of S1 utilities when including state-residency for a strategy SoC for	`v_u_S1_SoC`	vector	1 x `n_tunnel_size`	numeric
	List that stores the vectors of state utilities for each strategy	`l_u`	List		numeric
	Transition weights				
	Utility decrement of healthy individuals when transitioning to S1	`du_HS1`	scalar		numeric
	Cost of healthy individuals when transitioning to S1	`ic_HS1`	scalar		numeric
	Cost of dying	`ic_D`	scalar		numeric
	Tunnel state structures				
	number of tunnel states	`n_tunnel_size`	scalar		numeric
	vector with cycles for tunnels states	`v_cycles_tunnel`	vector	1 x `n_tunnel_size`	numeric
	tunnel names of the Sick state	`v_Sick_tunnel`	vector	1 x `n_states`	numeric
	state names including tunnel states	`v_names_states_tunnels`	vector	1 x `n_states_tunnels`	character
	number of states including tunnel states	`n_states_tunnels`	scalar		numeric
	Initial state vector for the model with tunnels	`v_m_init_tunnels`	vector	1 x `n_states_tunnels`	numeric
$\mathbf{P}$	Time-dependent transition probability array	`a_P`	array	`n_states` x `n_states` x `n_t`	numeric
$\mathbf{P}_{tunnels}$	Transition probability array for the model with tunnels	`a_P_tunnels`	array	`n_states_tunnels` x `n_states_tunnels` x `n_t`	numeric
$\mathbf{A}$	Transition dynamics array	`a_A`	array	`n_states` x `n_states` x (`n_t` + 1)	numeric
	List of the transition dynamics arrays for all strategies	`l_m_A`	list		numeric
$\mathbf{R_u}$	Transition rewards for effects	`a_R_u`	array	`n_states` x `n_states` x (`n_t` + 1)	numeric
$\mathbf{R_c}$	Transition rewards for costs	`a_R_c`	array	`n_states` x `n_states` x (`n_t` + 1)	numeric
$\mathbf{Y_u}$	Expected effects per states per cycle	`a_Y_u`	array	`n_states` x `n_states` x (`n_t` + 1)	numeric
$\mathbf{Y_c}$	Expected costs per state per cycle	`a_Y_c`	array	`n_states` x `n_states` x (`n_t` + 1)	numeric

Element	Description	R name	Data structure	Dimensions	Data type
	Expected QALYs per cycle under a strategy	v_qaly_str	vector	1 x (n_t + 1)	numeric
	Expected costs per cycle under a strategy	v_cost_str	vector	1 x (n_t + 1)	numeric
	Vector of expected discounted QALYs for each strategy	v_tot_qaly	vector	1 x n_states	numeric
	Vector of expected discounted costs for each strategy	v_tot_cost	vector	1 x n_states	numeric
	Summary matrix with costs and QALYS per strategy	m_outcomes	table	n_states x 2	
	Summary of the model outcomes	df_cea	data frame		
	Summary of the model outcomes	table_cea	table		
	Input parameters values of the model for the cost-effectiveness analysis	df_psa	data frame		
	*NOTE: these structures can have _strX to indicate the strategy of interest				
	Probabilistic analysis structures				
	Number of PSA iterations	n_sim	scalar		numeric
	List that stores all the values of the input parameters	l_params_all	list		numeric
	Data frame with the parameter values for each PSA iteration	df_psa_input	data frame		numeric
	Vector with the names of all the input parameters	v_names_params	vector		character
	List with the model outcomes of the PSA for all strategies	l_psa	list		numeric
	Vector with a sequence of relevant willingness-to-pay values	v_wtp	vector		numeric
	Data frame to store expected costs and effects for each strategy from the PSA	df_out_ce_psa	data frame		numeric
	Data frame to store incremental cost-effectiveness ratios (ICERs) from the PSA	df_cea_psa	data frame		numeric
	For more details about the PSA structures read dampack's vignettes				