Modelling Joint Life Functional Disability and Mortality

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Overview

Introduction

Background

- Most retirees in the US are married.[1]
- Even among the healthiest older adults, a 75% chance exists that one partner will require a significant level of long-term care as he or she ages[2]
- Mortality rates of a couple are dependent. One's mortality rates depend on spouse's condition. (Jagger and Sutton, 1991)
- Spouse's disability also affects health states. (Brown et al., 2009)

[1] https://acl.gov/aging-and-disability-in-america/data-and-research/profile-olderamericans

[2] https://www.thriveathome.org/thrive-at-home-can-prepare-and-pay-for-lifes-what-ifs/

Introduction of Joint Health Transition Model

We consider a 3-state health transition model with state H, state LTC and state D. Recovery is not considered in our model.

- The health transition model includes:
  - Time trend
  - Mortality dependence and disability dependence
  - Latent factor
- The objective of our study is:
  - Study whether disability dependence exists
  - Study whether dependence has gender difference
  - Study how the the effect of dependence changes with time

Introduction of Joint Health Transition Model

Our joint health transition model can be used to:

- Assess the disability and mortality risk associated with insuring individuals and populations.
- Develop innovative insurance products, catering to specific needs and differentiating the new products.
- More accurately underwrite policies and price them.

Literature Review

Literature Related to Our Model

- Lawrence et al. (2019) mention the health condition of married population may differ from unmarried population.
- Fu et al. (2022) introduce a single-person health transition model.
- Jagger and Sutton (1991) introduce a joint mortality model.
- Brown et al. (2009) discuss the effect of taking care of a disabled family member.

Model Setting

Model Setting

Define the transition rates of transition Type s for k^{th} individual is

$$\begin{aligned}\ln\{\lambda^j_{k,s}(t)\} =& \beta^j_s + \gamma^{age}_s x_k(t) + \gamma^{female}_s f_k + \gamma_s t \\ &+ \theta^1_k Y_{k,1} g_1(t - T_{k,1}) + \theta^2_k Y_{k,2} g_2(t - T_{k,2}) + \alpha^j_s \cdot \psi(t),\end{aligned} \tag{1}$$

where γ^{age}_s, γ^{female}_s and γ_s represent how sensitive $\ln\{\lambda_{k,s}(t)\}$ is to age, gender and time, $g_1(t - T_{k,1})$ and $g_2(t - T_{k,2})$ measure the impact of mortality and disability dependence, α_s describes the sensitivity of the log transition rates to the common latent factor $\psi(t)$, which is a simple random walk process

$$\psi_n = \psi_{n-1} + \epsilon_n, \quad \epsilon_n \overset{i.i.d.}{\sim} \mathcal{U}(0, t_n - t_{n-1}). \tag{2}$$

Significance

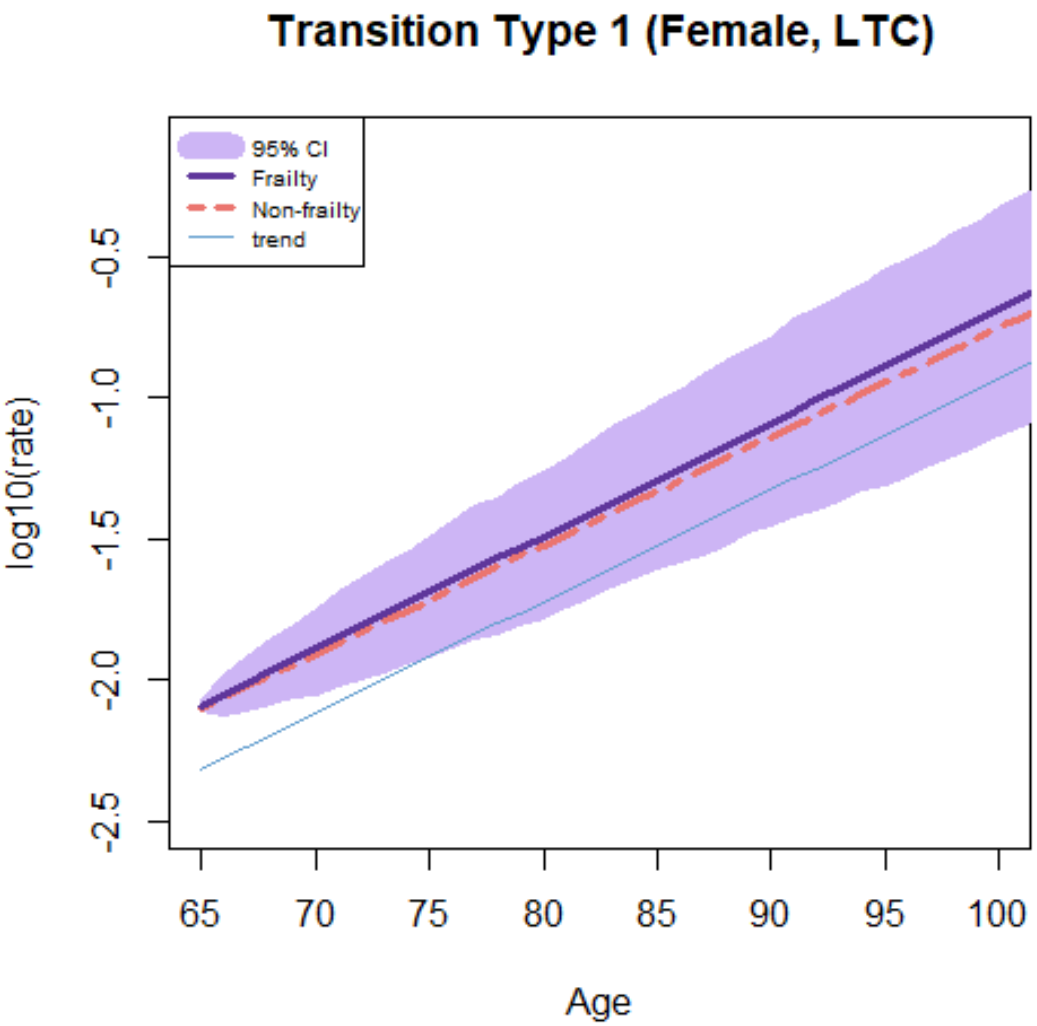
The result of likelihood ratio test of each models:

pair of models	LR test statistics
trend model vs. mortality model	291.68***
$g_1(t) = a * \exp(-38t) + b$	
mortality model vs. disability model	76.3***
$g_2(t) = c * t^2 + d * t + g$	
disability model vs. frailty model	124.58***

Note: $***p < 0.01$, $p > 0.1$ otherwise.

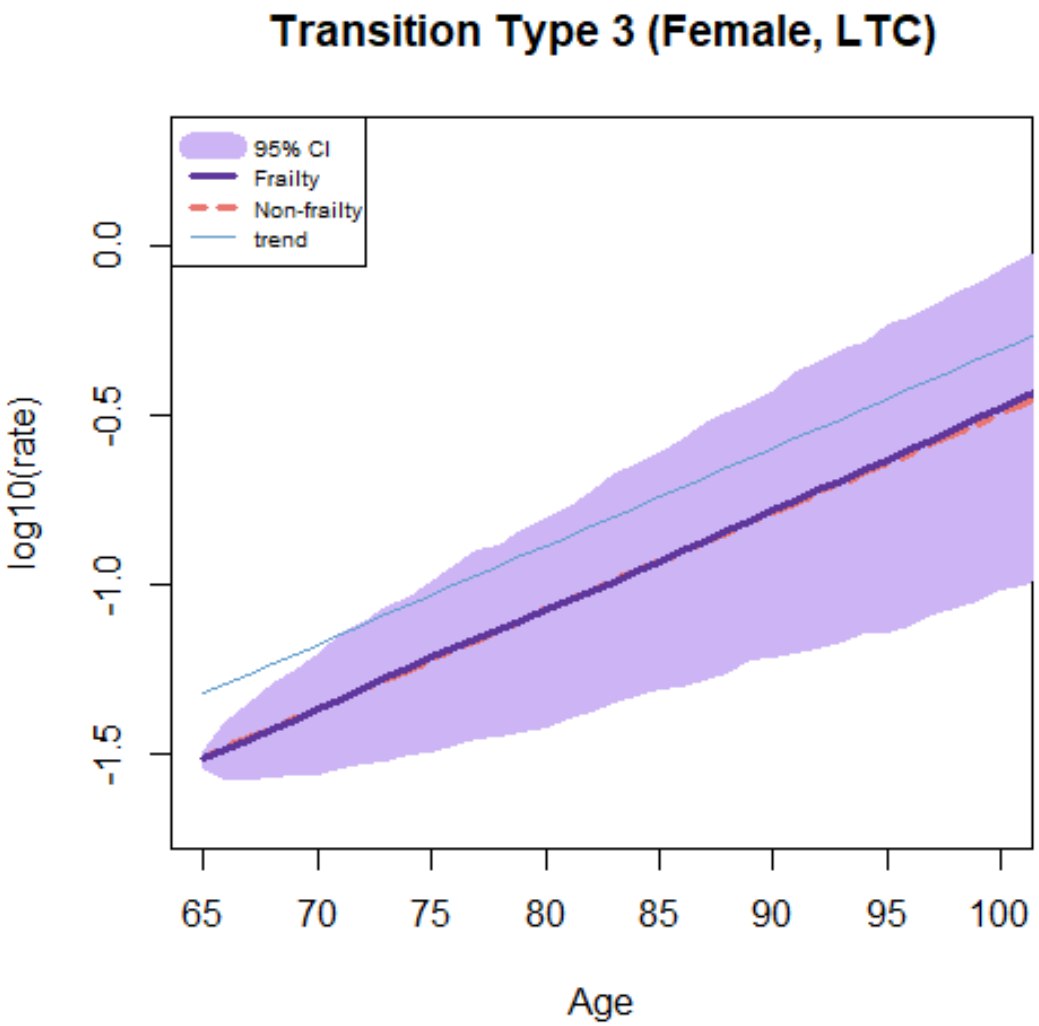
Simulation Results

Transition Rates



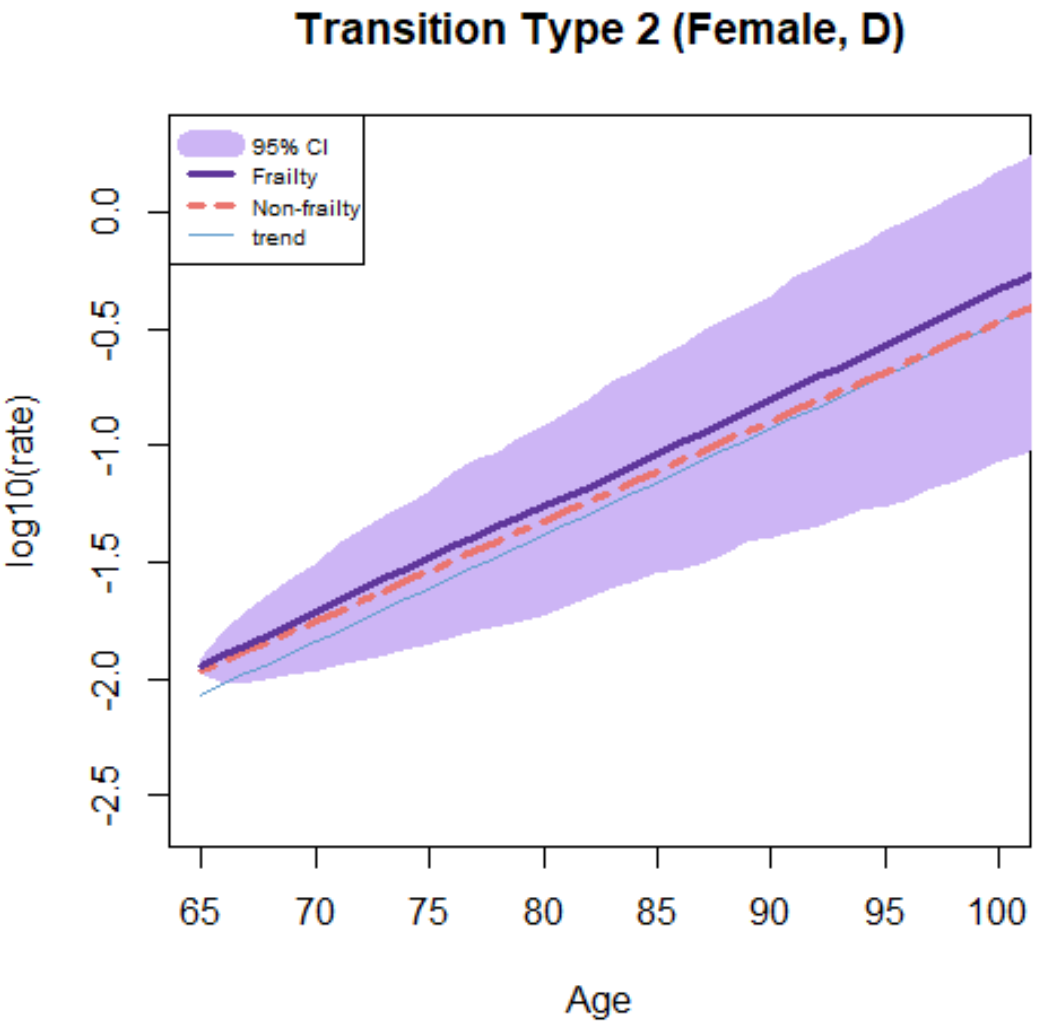
- The figure shows the difference of transition rates from state H to state LTC for females between three models assuming $t - T2 = 0.2$.
- Spouse's disability has negative effect on health.

Transition Rates



- The figure shows the difference of transition rates from state LTC to state D for females between three models assuming $t - T2 = 0.2$.
- Disability dependence exists on both transition Type 1 and transition Type 2.

Transition Rates



- The figure shows the difference of transition rates from state LTC to state D for females between three models assuming $t - T1 = 0.1$.
- Spouse's death increases the mortality rate.

Ratio

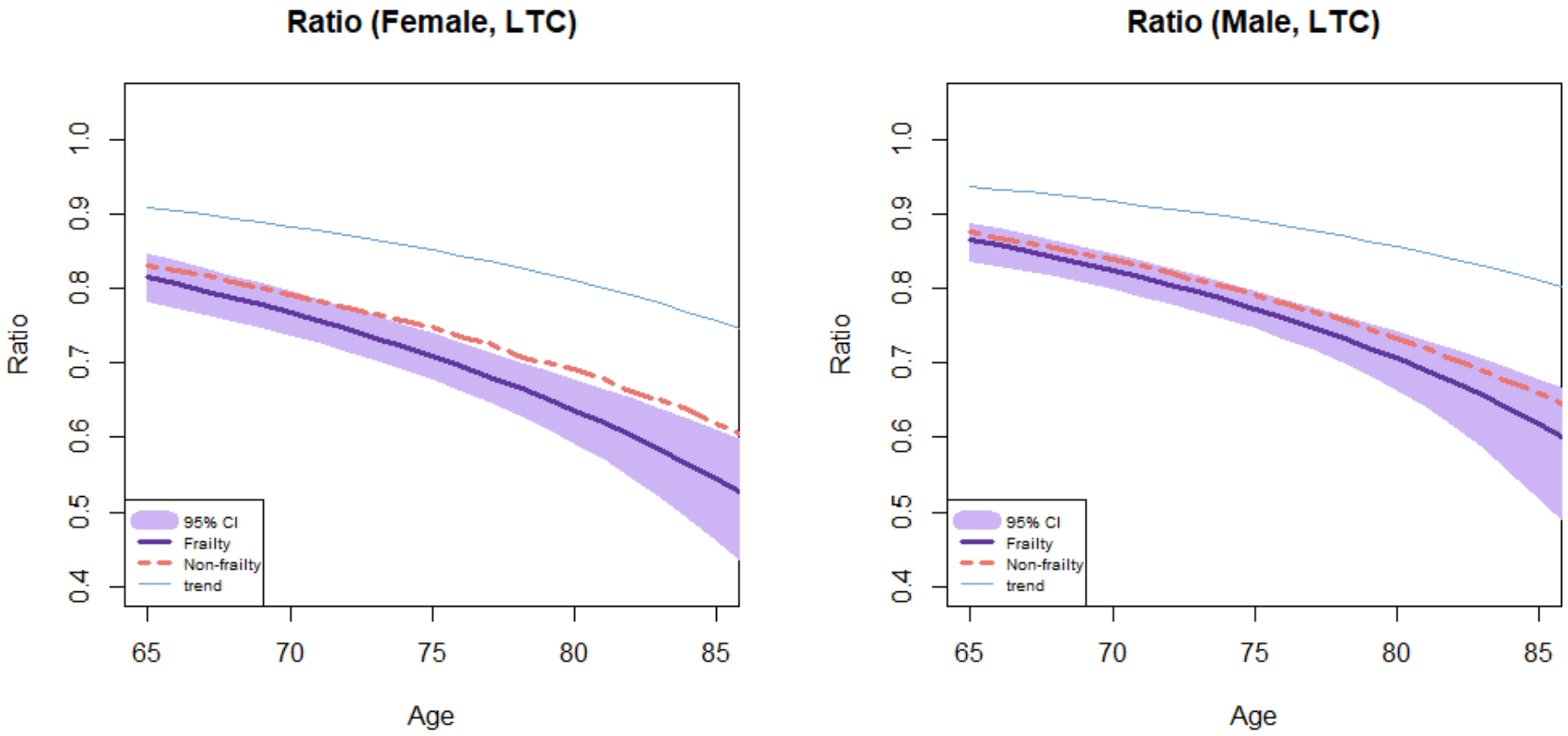


Figure: Comparison of Ratio

Conclusion

Conclusion

- Our joint health transition model takes into account the spouse's disability state and death state.
- The effects of spouse's mortality and disability on health transition are significant, and their effects varied with the duration of the spouse's stay in the state.
- A model that takes into account disability dependence has important implications for predicting the health evolution of a population and for assessing the disability risk in this population.
- Our joint health transition model can be used to develop LTC-related insurance products.

References I

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