

# Ascertainment bias in estimating rates of onset of Early-Onset Alzheimer's Disease: A Critical Illness Insurance Application

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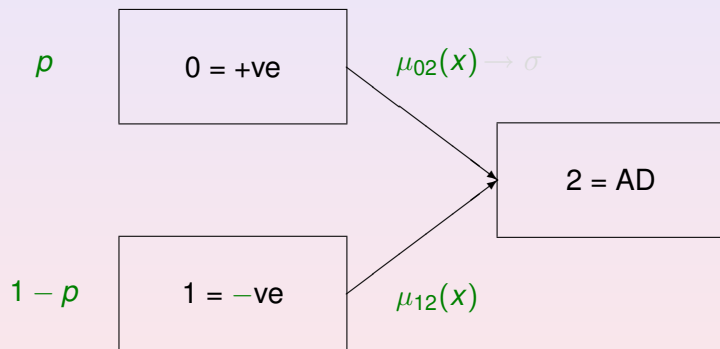
### *Objectives*

- (a) What will be the effect of pricing if insurance can have access to genetic information?
- (b) What will be implications for insurance markets if insurance are denied access to genetic information that is available to others?

### *Remarks*

- (a) EOAD
- (b) Ascertainment Bias
- (c) Incomplete penetrance

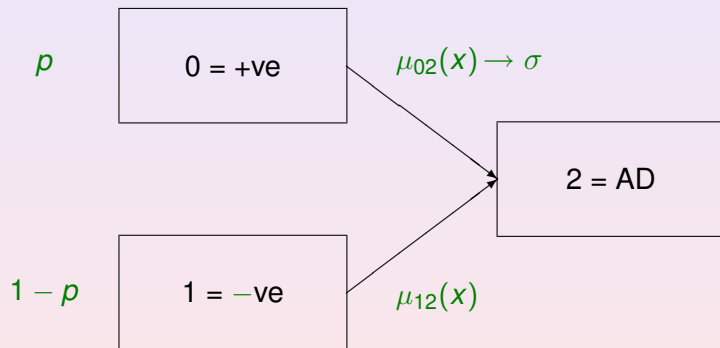
## Multiple State Model



**Figure:** A model of the incidence of Alzheimer's disease where an individual may have an EOAD mutation (State 0, +ve) or may not have an EOAD mutation (State 1, -ve).



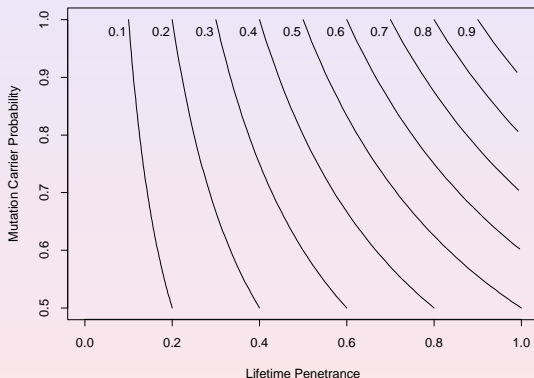
## Multiple State Model



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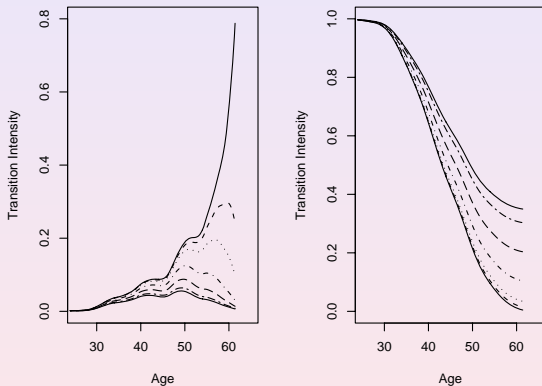
## Model Specification

 $\hat{p}\sigma$ 


**Figure:** Contours of constant  $p\sigma$  (values shown at the left of each contour) in a plot of probability  $p$  against lifetime penetrance  $\sigma$ . The extreme case of full penetrance ( $\sigma = 1$ ) and no ascertainment bias ( $p = 1/2$ ) is at the bottom right.



## Incidence Rates and Survival Probabilities



**Figure:** Estimated intensities  $\hat{\mu}_{02}(x)$  (left) and corresponding survival functions  $\exp(-\int_0^x \hat{\mu}_{02}(t) dt)$  (right).

Assumed values of penetrance  $\bar{\sigma}$  are (a) 1; (b) 0.9; (c) 0.8 and (d) 0.653.





## Markov model for pricing a CI Insurance

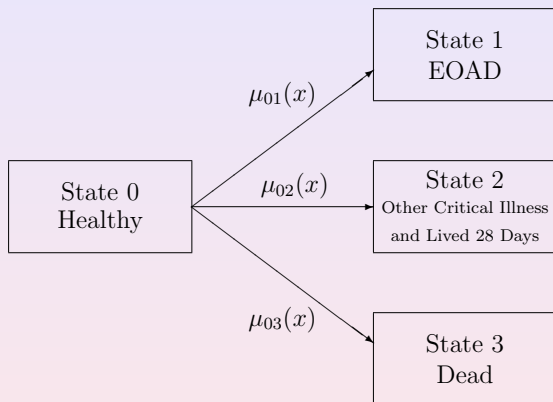


Figure 1: A multiple state model in Critical Illness Insurance.





## Premiums

		Males							
Entry Age	Term (Years)	Known PSEN-1 Mutations				Family History of EOAD			
		Penetrance ( $\sigma$ )				Penetrance ( $\sigma$ )			
		100%	90%	80%	70%	100%	90%	80%	70%
20	10	823.46	750.58	677.82	605.18	460.92	424.64	388.40	352.20
	20	2,366.22	2,126.0	1,889.08	1,655.19	1,198.49	1,085.27	972.82	861.13
	30	1,857.43	1,653.94	1,457.47	1,267.66	908.20	821.32	735.88	651.84
	40	1,184.88	1,049.66	921.66	800.30	576.47	523.50	471.84	421.42
30	10	3,399.71	3,016.64	2,647.03	2,290.18	1,615.08	1,452.01	1,291.69	1,134.04
	20	2,426.17	2,106.39	1,812.17	1,540.56	1,057.44	946.39	839.22	735.72
	30	1,567.05	1,336.25	1,133.11	952.91	648.58	581.37	517.44	456.57
40	10	2,537.14	2,048.75	1,658.38	1,339.22	850.32	750.02	656.95	570.36
	20	1,772.87	1,341.66	1,039.11	815.08	506.57	447.84	394.66	346.25
50	10	2,124.35	1,043.02	665.49	473.33	279.43	249.11	223.11	200.57

**Figure:** Level net premiums for level Critical Illness cover with known PSEN-1 mutations (left) and family history of EOAD known to be associated with PSEN-1 mutations (right), as a percentage of the standard level premiums.





## Adverse Selection

- (a) *Moratoria on the use of all genetic test results.*
- (b) *Moratoria on the use of adverse genetic test results.*
- (c) *Moratoria on all genetic test results and family history.*

The potential cost of adverse selection will depend on:

- (a) Market size (tendency to buy insurance)
- (b) Genetic testing
- (c) Increased tendency to buy insurance



# Model Specification

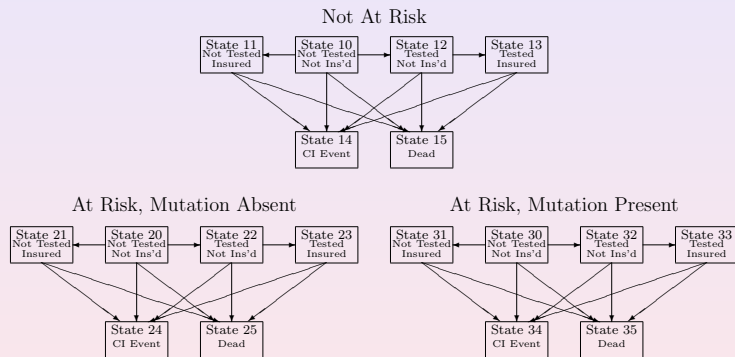


Figure 1: A Markov model allowing for family history of a Mendelian disorder.



## Application

		Moratoria Genetic Test										Moratoria Family History and Genetic Test					
Adverse Selection	Market Size	Rate of Purchase by Person Rated-up	All				Adverse				Adverse Selection	Market Size	Penetrance $\bar{\sigma}$				
			Penetrance $\bar{\sigma}$				Penetrance $\bar{\sigma}$						Penetrance $\bar{\sigma}$				
			100%	90%	80%	70%	100%	90%	80%	70%			100%	90%	80%	70%	
				%	%	%	%	%	%	%	%	%	%	%	%		
Moderate	Large	Same as normal	0.003	0.003	0.002	0.002	0.003	0.002	0.002	0.002	Moderate	Large	0.041	0.037	0.033	0.029	
		Half of normal	0.007	0.006	0.005	0.004	0.006	0.006	0.005	0.004							
		Uninsured	0.014	0.012	0.011	0.009	0.014	0.012	0.010	0.008							
Severe	Small	Uninsured	0.015	0.013	0.011	0.009	0.014	0.012	0.010	0.009	Small	0.082	0.074	0.066	0.058		
		Same as normal	0.006	0.005	0.004	0.004	0.006	0.005	0.004	0.003							
	Large	Half of normal	0.010	0.009	0.008	0.006	0.010	0.009	0.007	0.006	Severe	Large	0.069	0.062	0.055	0.048	
		Uninsured	0.019	0.017	0.014	0.012	0.019	0.016	0.014	0.011							
		Uninsured	0.058	0.050	0.043	0.036	0.056	0.048	0.041	0.034							Small



## Conclusions

- (a) Premiums are high.
- (b) The costs of adverse selection are very small
- (c) Unidentifiability of  $p\sigma \rightarrow$  range of premium increments and cost of adverse selection
- (d) Premium rates and cost of adverse selection depend strongly on the severity of ascertainment bias

<http://www.ma.hw.ac.uk/ams/girc/publications.php>