The Value of a Statistical Senior's Life: Evidence from Medical Expenditures

Nirman Saha

Arizona State University

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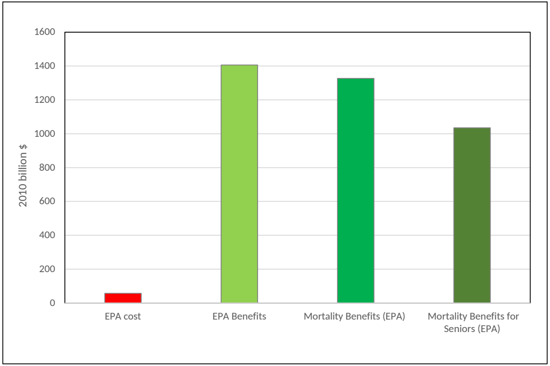
- **Glaring Inconsistency** : mortality from air pollution and climate change mainly concentrated among seniors, while VSL estimates are based on younger, healthier workers

Example: The US Clean Air Act Amendments



- 78 % of lives saved by the CAAA are that of seniors (EPA,1990)
- EPA's $ 8 million based on hedonic wage studies with avg. age of 40
- **Challenge**: Observing senior's consumption-risk trade-off in data

This Paper

- Develop a micro-econometric model of heterogeneous individuals' medical expenditure decisions and use it to:
  - Identify MRS between consumption and mortality risk
  - Develop revealed preference estimates of Value of a Statistical Senior's Life (VSSL)

Key Highlights of the Research

- Derive VSSL using a life-cycle model of consumption and health, extending Hall and Jones (QJE, 2007) to incorporate heterogeneity
- Analyze heterogeneity in VSSL by age, gender, race and health

Outline

1. **Model**
2. Data
3. Identification and Estimation
4. Results
5. Conclusion

A Life Cycle Model starting at age, t=65

- Utility for a retired individual at age, t

$$U_{i,t} = u(c_{i,t}, H_{i,t})$$

$$\begin{aligned} c_{i,t} &= \text{consumption} \\ H_{i,t} &= \text{health stock} \end{aligned}$$

- Intertemporal budget constraint :

$$a_{i,t+1} + \gamma_{i,t} m_{i,t} + c_{i,t} = a_{i,t}(1 + r_t) + I_i$$

$$\begin{aligned} a_{i,t} &= \text{age } t \text{ asset plus return on investment} \\ I_i &= \text{permanent income (e.g: pension, social security)} \\ \gamma_{i,t} m_{i,t} &= \text{out-of-pocket medical expenditure given the Medicare co-payment rate} \end{aligned}$$

Uncertainty: Health and Survival

- Evolution of the health stock

$$H_{i,t+1} = f(H_{i,t}, m_{i,t}, t, \epsilon_{i,t})$$

$$\begin{aligned} \epsilon_{i,t} &= \text{idiosyncratic health shock} \\ m_{i,t} &= \text{total medical expenditure} \end{aligned}$$

- Survival Function:

$$S^*_{it} = \beta_1 + \beta_t + H_t\beta_H + \beta_m m_t + \eta_{i,t}$$

$$\begin{aligned} S^*_{it} &= \text{latent variable: } \{S^*_{it} > 0\} \Rightarrow \text{i surivives to } t+1 \\ \eta_{i,t} &= \textit{iid} \text{ Type 1 EV distributed shock} \end{aligned}$$

$$s_{it} = prob(S^*_{i,t} > 0) = \exp[-\exp(\beta_1 + \beta_t + H_{i,t}\beta_H + \beta_m m_{i.t})]$$

Individual's Full Dynamic Problem

$$V_{i,t}(a_{i,t}, I_i, H_{i,t}) = \max_{\{c_{i,t}, m_{i,t}\}} u(c_{i,t}, H_{i,t}) + \beta \; s_{i,t}(H_{i,t}, m_{i,t}, t) \; \mathbb{E}[V_{i,t+1}(a_{i,t+1}, I_i, H_{i,t+1})]$$

$$\textit{subject to}$$

$$c_{i,t} + \gamma_{i,t} \; m_{i,t} + a_{i,t+1} = \; y_{it} + a_{i,t}(1 + r_t)$$

$$s_t = \exp(-\exp(\beta_1 + \beta_t + H_{i,t}\beta_H + \beta_m m_{i,} t))$$

$$H_{it+1} = f(H_{i,t}, m_{i,t}, t, \epsilon_{i,t})$$

Assumption

When people choose medical procedures, they are fully aware of the probabilities of success and failure

Expression for VSL

- From the FOCS:

$$\frac{\beta\,\mathbb{E}[V_{i,t+1}(a_{i,t+1}, I_i, H_{i,t+1})]}{u_c(c_{i,t}, H_{i,t})} + \beta \frac{s_{i,t}}{u_c(c_{i,t}, H_{i,t})}\,\mathbb{E}\left[\frac{\partial V_{t+1}(a_{i,t+1}, I_i, H_{i,t+1}) f_H / s_H}{\partial H_{it+1}}\right]$$

$$= \frac{\gamma_{i,t}}{\partial s_{i,t}/\partial m_{i,t}}$$

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$$= \quad \underbrace{\frac{\gamma_{i,t}}{\partial s_{i,t}/\partial m_{i,t}}}_{marginal\ \ cost\ \ of\ \ saving\ \ a\ \ life} \quad = VSL_{i,t}$$

- In the special case, $\gamma_{i,t} = 1$, it is the marginal social cost of saving a life

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Data

- Confidential Medicare Current Beneficiary Survey (MCBS)
  - Study Period : 2005-2011
  - Age-group : 65 - 100
  - Rotating Panel Survey (people observed for 1-4 years)
  - Sample size: 19,313 individuals (49,380 person-years)
  - Variables: lifestyle habits (smoking) , SRHS , demographics, income, education
- Linked CMS administrative data
  - Variables: total health expenditure, out-of-pocket, chronic disease indicators, residential location, death dates

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Econometric Model

$$1 - s_{i,t} = 1 - \exp[-\exp(\beta_1 + H'_{i,t}\beta_H + \beta_t + \beta_m m_{i,t})]$$

$1 - s_{i,t}$ = 1 if dies in $t + 1$

$m_{i,t}$ = gross medical expenditure

β_t = age dummies

$H_{i,t}$ = *health controls* : ever-smoke, race, gender, education, self-reported health status, ADL and IADL limitations , 30+ chronic conditions

- **Threats to Identification**
  - Simultaneity bias due to correlation between *m* and latent health

IV Estimation: Two - Stage Control Function

$$1 - s_{i,t} = 1 - \exp[-\exp(\beta_1 + H'_{i,t}\beta_H + \beta_t + \beta_m m_{i,t})]$$

- First-stage Regression:

$$m_{i,t} = \pi_1 + \pi_z Z_{i,t} + H'_{i,t}\pi_H + \pi_t + \nu_{i,t}, \ \textit{given} \ \mathbb{E}[\nu_{i,t}|Z_{i,t}] = 0$$

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- Second-Stage Regression:

$$1 - s_{i,t} = 1 - \exp[-\exp(\beta_1 + H'_{i,t}\beta_H + \beta_t + \beta_m m_{i,t} + \hat{\nu}_{i,t})]$$

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- Terza et al. (JHE 2008) find control-function approach outperforms 2SLS in this context

Instrument for medical expenditure

- Medical expenditure vary widely across the US (Fisher et al. 2003a; 2003b)
- Finkelstein (QJE, 2016) concludes half of this is due to supply-side factors (physician's practice styles, institutions, infrastructure)

Intuition for the Instrument

Similar seniors living in different regions face different menus of treatment options, leading to variation in medical spending and survival unrelated to latent health

- Calculating the instrument for the 306 Hopsital Referral Regions (HRR):

$$m_{i,j,s} = \alpha_i + \gamma_j + \tau_s + X'_{i,s}\beta + \epsilon_{i,s}$$

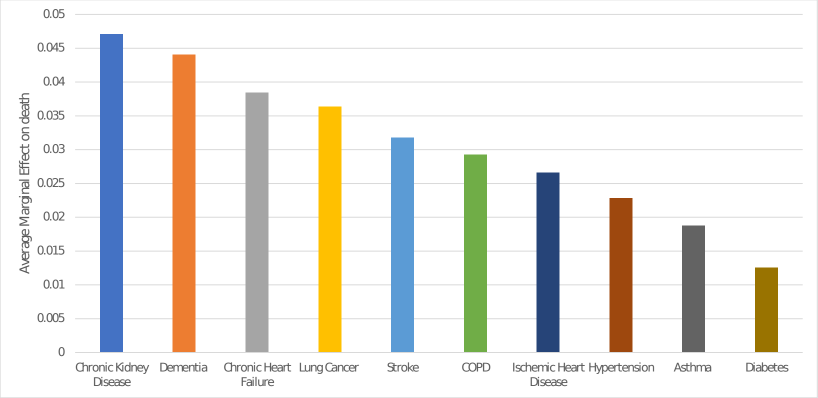
  - $X_{i,s}$ includes age bin dummies and years since move
  - Model estimated for movers with constant observed health

Estimation Results

	One-stage	Instrumental Variable			
	(1)	(2)	(3)	(4)	(5)
Coefficient on Medical Spending	**0.023***** (0.001)	**-0.105**** (0.045)	**-0.093**** (0.045)	**-0.092**** (0.047)	**-0.124**** (0.058)
Average Marginal Effect ($1,000)		**-0.004**** (0.001)	**-0.004**** (0.002)	**-0.004**** (0.002)	**-0.005**** (0.002)
F-Stat Excl. Instrument		81	77	76	45
Demographics			X	X	X
Hospital Quality				X	X
Hospital Characteristics					X
No. of individuals	19,313	19,313	19,313	19,313	19,313

- First-stage results suggest a dollar-for-dollar increase in medical expenditure due to supply-side factors

Ranking of disease in terms of effect on death



- This is compared to the 0.004** reduction in death probability from a $1,000 increase in medical expenditure

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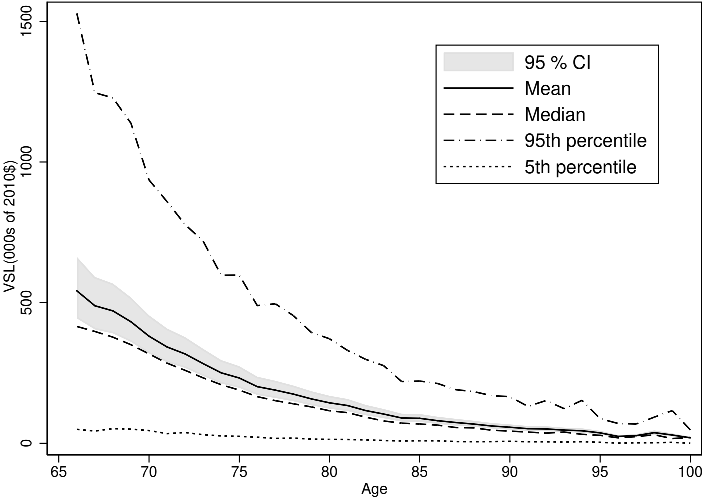
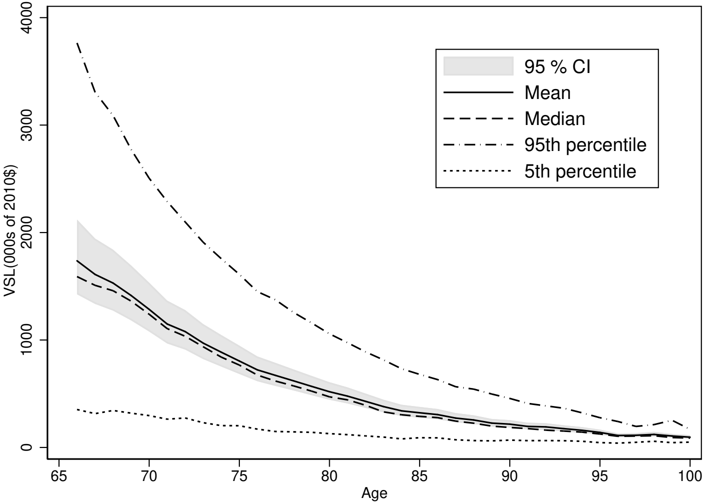
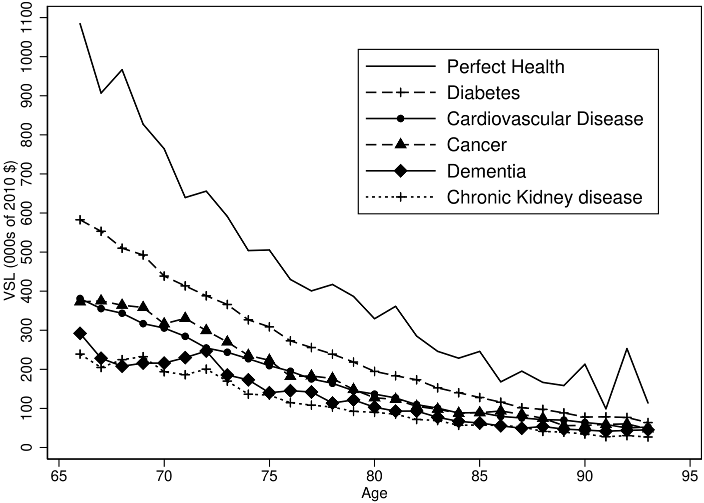
Private Value of a Statistical Senior's Life



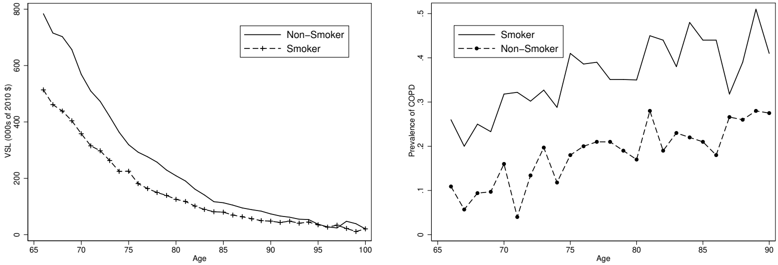
The 'Social Value' of a Statistical Senior's Life



Heterogeneity by Medical Conditions

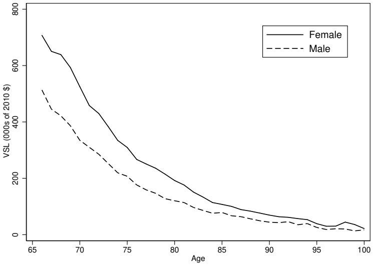


Heterogeneity by Smoking History



- Lower VSSL for smokers driven by higher prevalence of Chronic Obstructive Pulmonary Disease

Heterogeneity by Gender



- Lower VSSL for men driven by higher rates of smoking, chronic kidney disease and cancer

Policy Application: Evaluating CAAA (1990)

Type of Benefit	Billions of 2010 $		
	Estimates with private valuation	Estimates with social valuation	EPA (2011)
Total Mortality Benefit	284	340	1,328
All Other Benefit	130	130	130
Total Benefit	414	470	1,458

- The above estimates yields a benefit-cost ratio of 7:1 rather than 25:1 as envisaged by EPA

Conclusion

- New microeconometric framework for estimating private VSSL
- Standard hedonic wage estimate for VSL ($8-10$ mill) overstates the average senior's WTP to reduce mortality risk by an order of magnitude
- Replacing VSL with VSSL will substantially change benefit-cost ratios for policies targeting air pollution, climate change and energy
- Heterogeneity in VSSL is intuitive and economically important, especially for chronic medical conditions
- This framework provides a new way to measure benefits of policies targeting morbidity; e.g. a dementia diagnosis at age 75 for an otherwise healthy individual reduces VSSL by about $ 350,000