Flat-of-the-curve Medicine
A New Perspective on the Production of Health

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Prepared for Risk and Choice: A Conference in Honor of Louis Eeckhoudt
Toulouse, 12 & 13 July 2012.

Based on: Schoder, J. and Zweifel, P. (2011), Flat-of-the-curve Medicine : A New Perspective on the Production of Health, in *Health Economics Review 1(2)*

Motivation

- Controversy over returns to health care spending (Auster et. al, 1969; Enthoven 1980; Cutler McClellan 2001; Fuchs 2004)
- Studies using OECD health data find evidence in favor of flat-of-the-curve medicine (see e.g. Zweifel et al. 2005)
- Primary focus of the current literature: Impact of medical and nonmedical inputs on the level of health status
- However, risk-averse individuals should also be interested in reducing the variance of their health status

Motivation cont'd

- The Arrow-Pratt formula for maximum willingness to pay (WTP) for certainty could be applied to health (h):

$$WTP = -0.5\sigma_h^2 \frac{u(h)''}{u(h)'} = 0.5\sigma_h^2 R_A, \tag{1}$$

R_A : Coefficient of absolute risk aversion

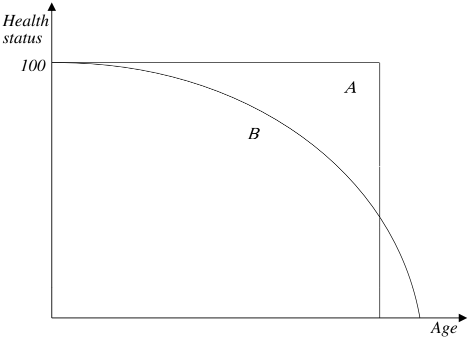
- While estimates of R_A with regard to health exist, their use for health is questionable
- Still, Cameron and DeShazo 2009 find positive WTP values for health risk reductions
- According to their experiment, an individual aged 45 with an income of 42,000 USD is willing to pay 5.82 USD for a reduction of the risk of sudden death by 10^{-6}

Contribution to the Literature

- Only one study assessed the impact of medical and non-medical inputs on the variability of health status (LeGrand 1988), without finding any significant impact of HCE
- LeGrand's study is limited to a cross section and uses the Gini coefficient of age at death (which fails to be translation independent) as a measure of variability
- In contrast, this study uses the standard deviation and a richer dataset that allows to control for country-specific effects

Theoretical Background

Figure 1: Ranking of two health profiles



- Second-order stochastic dominance predicts choice of A
- Quest for 'rectangularization'

Theoretical Background cont'd

- Internationally comparable health profiles are not (yet) available
- However, a necessary condition for being healthy is to be alive
- Therefore, rectangularization of the health profile implies rectangularization of the survival profile
- This justifies the use of life tables as a proxy for health status

Research Questions

There are four research questions to be answered:

- Q1: Are the countries of our sample characterized by flat-of-the-curve medicine?
- Q2: Do medical or non-medical inputs contribute more to reducing variability of age at death (VAD)?
- Q3: Are these effects different for VAD among the elderly?
- Q4: Is flat-of-the-curve medicine wasteful?

Econometric Specification

- Repeated observations for 20 countries between 1960 and 2005 calls for panel econometric estimation methods
- Random effects preferred over fixed effects throughout according to Hausman tests
- In line with previous literature, the specification includes lagged independent and quadratic independent covariates to control for non-linearity
- Specification accounts for heteroskedasticity

Econometric Specification cont'd

Model specification:

$$\begin{aligned} LE_{60it} &= \alpha_1 HCE_{it-10} + \alpha_2 HCE^2_{it-10} + \alpha_3 GDP_{it} + \alpha_4 GDP^2_{it} \\ &\quad + \alpha_5 ALC_{it-10} + \alpha_6 ALC^2_{it-10} + c_i + \gamma_t + u_{it} \end{aligned} \tag{2}$$

$$\begin{aligned} VAD_{it} &= \beta_1 HCE_{it-5} + \beta_2 HCE^2_{it-5} + \beta_3 GDP_{it} + \beta_4 GDP^2_{it} \\ &\quad + \beta_5 ALC_{it-10} + \beta_6 ALC^2_{it-10} + c_i + \gamma_t + u_{it} \end{aligned} \tag{3}$$

All variables in Eq. (3) are in logarithms

LE_{60}: Remaining life expectancy at age 60, VAD: Variability of age at death
HCE: Health care expenditure per capita in 1,000 USD
GDP: GDP per capita in 1,000 USD
ALC: Alcohol consumption in liter per capita.
c_i: Country specific effect, γ_t: year specific effect,
u_{it}: Random error, N(0, σ^2), i: country, t: time

Data

- Sample consists of 20 OECD countries and covers 46 years (1960 to 2005)
- Data obtained from: Human Mortality data base 2008 (dependent variable) and OECD health data 2007 (independent variables)
- Dependent variables (LE_{60} and VAD_{it}) are calculated from period life tables
- Two measures of variability of age at death (VAD) are used: Standard deviation of age at death (sd) and standard deviation above the modal year (sd_{mode})

Data cont'd

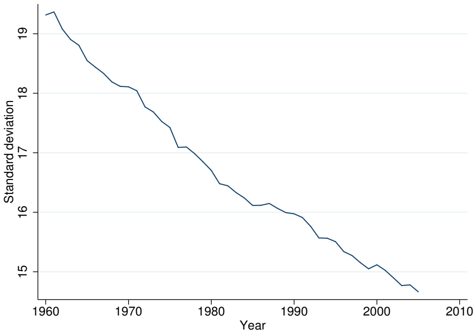
Table 1: Descriptive statistics, selected years

Variable	Mean	1960	1983	2005	sd_o	sd_b	sd_w	N
LE_{60}	19.67	17.63	19.51	22.85	1.99	1.06	1.69	997
SD	16.81	19.34	16.44	14.74	1.76	0.97	1.49	1,102
SD_{mode}	4.17	4.34	4.33	3.81	0.39	0.19	0.35	1,102
HCE	1,283	60.25	792.28	3,436	1,187	636.22	1068	838
GDP	13,866	1,341	10,287	35,782	11,903	7,787	10,780	965
ALC	10.62	7.87	11.81	9.41	3.66	3.27	1.78	1,003

Note: sd_o: overall standard deviation, sd_b: between standard deviation, sd_w: within standard deviation. The countries included are Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, Germany, Hungary, Iceland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Slovak Republic, Spain, Sweden, Switzerland, United Kingdom, United States.

Data cont'd

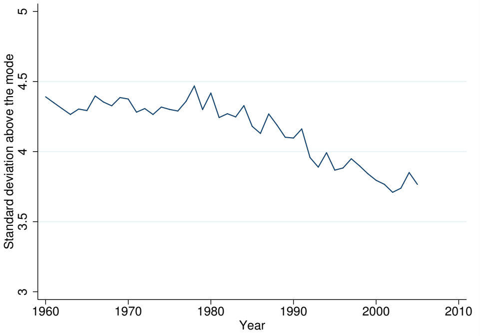
Figure 2: Standard deviation of age at death for 20 OECD countries



- Evidence of decreased variability of health status

Data cont'd

Figure 3: Standard deviation of age at death above the modal year for 20 OECD countries



- Evidence of decreased variability of health status among the elderly

Q1: Estimation results, life expectancy itself

Table 2: Determinants of remaining life expectancy at age 60 (total population), 1960-2005

LE_{60}	Coef.	z	P>z	Coef. $(female)^a$
HCE_{-10}	0.842	2.49	0.013	2.045**
HCE^2_{-10}	-0.199	-1.99	0.046	-0.565**
GDP	0.041	2.06	0.040	0.122**
GDP^2	-0.001	-2.11	0.036	-0.004**
ALC_{-10}	-0.039	-0.60	0.546	-0.043
ALC^2_{-10}	-0.002	-1.09	0.276	0.002
constant	17.230	51.14	0.000	18.57
rho_{ar}	0.911			
Wald χ^2	719.24			
Prob$>\chi^2$	0.814			
R-squared	0.477			
Observations	631			

Note: **p$<$0.01.[a]Estimates for females from Zweifel et al. 2005.

Q1: Findings

- Estimated coefficients rougly correspond with previous estimates (see e.g. Zweifel et al. 2005)
- HCE exhibits decreasing marginal returns
- The critical value of HCE beyond which its marginal effect ceases to be positive can be put at USD 2,116
- With a mean value of USD 3,436 as of 2005, OECD countries on average are within flat-of-the-curve medicine

Q2: Estimation results, Variability of age at death

Table 3: Determinants of variability of age at death, 1960-2005

sd	Coef.	z	P>z	Table 2 Elasticity LE_{60}
HCE_{-5}	-0.072	-3.09	0.002	0.032
HCE^2_{-5}	0.005	2.65	0.008	
GDP	-0.066	-1.99	0.046	0.041
GDP^2	0.004	0.94	0.345	
ALC_{-10}	0.049	1.29	0.198	-0.029
ALC^2_{-10}	0.017	1.87	0.061	
constant	3.435	11.47	0.000	
rho_{ar}	0.786			
Wald χ^2	1,103			
Prob$>\chi^2$	0.000			
R-squared	0.6390			
Observations	631			

Q2: Findings

- A 10 percent increase of HCE 5 years earlier is estimated to reduce the current sd by 0.42 percent
- Effect of non-medical inputs in a similar range (0.66 percent)
- Alcohol seems to weaken control over health status
- Therefore, both medical and non-medical inputs contribute to the observed reduction of VAD, and to a comparable extent

Q3: Determinants of variability of age at death above the modal year

Table 4: Determinants of variability of age at death, 1960-2005

	Coef.	z	P>z
sd_{mode}			
HCE_{-5}	-0.019	-0.27	0.788
HCE^2_{-5}	0.002	0.28	0.783
GDP	-0.006	-0.03	0.980
GDP^2	0.001	0.06	0.955
ALC_{-10}	0.210	2.17	0.030
ALC^2_{-10}	-0.046	-1.97	0.049
constant	1.321	1.43	0.154
rho_{ar}	0.237		
Wald χ^2	280.46		
Prob$>\chi^2$	0.000		
R-squared	0.3407		
Observations	631		

Q3: Findings

- Only alcohol consumption significant at the 5 percent level
- Especially at older ages, unhealthy lifestyle seems to induce lack of control over health status
- Insignificant HCE possibly due to the fact that HCE influenced variability of age at death among the elderly only in recent years
- Figure 3 calls for reestimation of the model for the time period between 1983 to 2005

Q3: Determinants of variability of age at death above the modal year cont'd

Table 5: Determinants of variability of age at death above the modal year (sd_{mode}), 1983-2005

Explanatory variable	Coef.	z	P>z
HCE_{-5}	-0.056	-2.49	0.013
HCE^2_{-5}	0.005	0.47	0.639
GDP	-0.058	-2.97	0.001
GDP^2	0.002	0.15	0.881
ALC_{-10}	0.061	0.28	0.776
ALC^2_{-10}	-0.017	-0.36	0.719
constant	1.774	5.52	0.000
rho_{ar}	0.217		
Wald χ^2	2,284		
Prob$>\chi^2$	0.000		
R-squared	0.2921		
Observations	430		

Q4: Do HCE have the property of 'real insurance'?

- Is flat-of-the-curve medicine wasteful? A rough calculation for the US and Switzerland:
- 10 percent more HCE amounts to USD 470 and USD 353, respectively (at 2000 prices)
- Put the statistical value of life at USD 6.5 mn. for the United States and USD 8.7 for Switzerland (the U.S. Environmental Protection Agency has been using a value of USD 6.3 mn. per statistical life in its cost-benefit analyses since 1999).
- With an average life expectancy of 73.8 (US) and 76.2 (Switzerland) years, a standard deviation of 1 year is worth some USD 87,927 (US) and USD 114,102 (Switzerland)

Q4: Do HCE have the property of 'real insurance'?

cont'd

- Edwards (2008) predicts that one standard deviation less is worth one-half of an extra year of life, i.e. USD 44,000 (US) and 57,100 (Switzerland)
- The 10 percent additional HCE is estimated to reduce the sd by 0.42 percent, i.e. from 18.01 to 17.93 years in the US and from 16.24 to 16.17 in Switzerland
- Put R_A at 10^{-4} (conservative; Friedman 1974 obtains $3 \cdot 10^{-3}$ for health insurance)
- According to the Arrow-Pratt formula, WTP for this reduction would be:

$$\frac{1}{2}((18.01)^2-(17.93)^2)(4.40\cdot10^4)^2\cdot10^{-4} = 2.78\cdot10^5 \text{ (United States)} \quad (4)$$

$$\frac{1}{2}((16.24)^2-(16.17)^2)(5.71\cdot10^4)^2\cdot10^{-4} = 3.25\cdot10^5 \text{ (Switzerland)} \quad (5)$$

Q4: Findings

- Distributed over 73.8 and 76.2 years, respectively this becomes a WTP value for the of USD 3,771 (United States) and USD 4,261 (Switzerland) per capita $>$ USD 470 p.a.
- Even if HCE should not prolong life anymore, it may be worth its cost as 'real insurance' reducing the variability of health status

Concluding remarks

- The research questions can be answered as follows:
- Q1: According to our estimates, the critical value of HCE beyond which its marginal effect ceases to be positive can be put at USD 2,116. With a mean value of USD 3,436 as of 2005, the OECD countries of our sample are on average well within the flat-of-the-curve range.
- Q2: The reduction of VAD (indicating better control over health status) is importantly due to both HCE and GDP.

Concluding remarks cont'd

- Q3: Significant effects of HCE and GDP on VAD among the elderly are found for the time period between 1983 to 2005 only, of a magnitude comparable to Q2.
- Q4: Comparing the marginal cost in terms of HCE with the WTP values for the US and Switzerland, we find that the benefits in terms of reduced VAD exceed the extra cost. Therefore, flat-of-the-curve medicine may be worthwhile as real insurance serving to reduce uncertainty of health status.