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

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

\[
WTP = -0.5\sigma_h^2 \frac{u(h)''}{u(h)'}, \quad \text{with } R_A = 0.5\sigma_h^2 R_A,
\]

(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’
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:

\[ LE_{60 it} = \alpha_1 HCE_{it-10} + \alpha_2 HCE_{it-10}^2 + \alpha_3 GDP_{it} + \alpha_4 GDP_{it}^2 \]
\[ + \alpha_5 ALC_{it-10} + \alpha_6 ALC_{it-10}^2 + c_i + \gamma_t + u_{it} \]  \hspace{1cm} (2)

\[ VAD_{it} = \beta_1 HCE_{it-5} + \beta_2 HCE_{it-5}^2 + \beta_3 GDP_{it} + \beta_4 GDP_{it}^2 \]
\[ + \beta_5 ALC_{it-10} + \beta_6 ALC_{it-10}^2 + c_i + \gamma_t + u_{it} \]  \hspace{1cm} (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, \( \gamma_t \): year specific effect,
\( u_{it} \): Random error, N(0, \( \sigma^2 \)), \( i \): 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 ($sd_{mode}$)
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.*
Figure 2: Standard deviation of age at death for 20 OECD countries

- Evidence of decreased variability of health status
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

|                  | Coef. | z    | P > z | Coef. (female)^[a] |
|------------------|-------|------|-------|--------------------|
| $LE_{60}$        |       |      |       |                    |
| $HCE_{-10}$      | 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 $\chi^2$    | 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 roughly 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

| Coef. | z     | P>|z| | Elasticity |
|-------|-------|------|-------------|
| sd    |       |      |             |
| HCE_{-5} | -0.072 | -3.09 | 0.002 | 0.032 |
| HCE_{-5}^{2} | 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_{-10}^{2} | 0.017 | 1.87  | 0.061 |       |
| constant | 3.435 | 11.47 | 0.000 |       |

| Table 2  |
|---------|
| Elasticity |
| LE_{60} |
|         |

| sd    |       |      |             |
|-------|-------|------|-------------|
| rhoar | 0.786 |      |             |
| Wald  | 1,103 |      |             |
| Prob>|χ^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 |
| $HCE_{-5}^2$ | 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 |
| $ALC_{-10}^2$ | -0.046 | -1.97 | 0.049 |
| constant | 1.321 | 1.43 | 0.154 |
| $rho_{ar}$ | 0.237 |      |       |
| Wald $\chi^2$ | 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 \(\chi^2\)     | 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:

  \[
  \frac{1}{2}(((18.01)^2 - (17.93)^2)(4.40 \cdot 10^4)^2 \cdot 10^{-4} = 2.78 \cdot 10^5 \text{ (United States)} \quad (4)
  \]

  \[
  \frac{1}{2}(((16.24)^2 - (16.17)^2)(5.71 \cdot 10^4)^2 \cdot 10^{-4} = 3.25 \cdot 10^5 \text{ (Switzerland)} \quad (5)
  \]
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.
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.