Health, Longevity, and Welfare Inequality of the Elderly

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Introduction
Income Gini coefficient by age of family head, 1979-2012

Source: Bosworth, B., Burtless, G., and Zhang, K. (2016). Data from Census Bureau’s Annual Social and Economic Supplement files from the CPS. An “aged head” is 62 years old or older.
Disparities in well-being

- Consumption and income inequality are incomplete metrics of well-being
  - Leisure, social interactions, political/natural environments, etc. (e.g. Stiglitz, Sen, and Fitoussi, 2008)
  - Health disparities of particular importance among elderly (e.g. Deaton and Paxson, 1998)
Mortality rate ratios of low-earning to high-earning men

Source: Bosworth, B., Burtless, G., and Zhang, K. (2016). “Low-earnings” male is one with at least one-half of years of nonzero earnings between ages 41 and 50 in which earnings are below the 31 percentile of male earnings. Data from Survey of Income and Program Participation (SIPP).
Last age with earnings by thirds of career earnings

We propose a measure of well-being inequality for the elderly

- Include consumption, leisure, mortality, and health

Standard utility theory provides a useful lens to compare well-being inclusive of multiple dimensions

Recently advocated to adjust GDP across countries (Becker et al., 2005; Fleurbaey and Gaulier, 2009; Jones and Klenow, 2016)

Welfare measured in income (consumption) equivalents

Our approach:

- Individual life-cycle simulations \rightarrow entire distribution of welfare
- Expected lifetime utility at age 60 \rightarrow ex-ante welfare
- Birth cohort analysis \rightarrow not cross-sectional extrapolation
- Map health to utility \rightarrow quality-adjusted life year (QALY)
A measure of elderly welfare

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  - Map health to utility $\rightarrow$ quality-adjusted life year (QALY)
Empirical objectives

1. How much better do we expect remaining life to be for the median sixty year old in the U.S., compared to the sixty year old who is the worst off?
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2. How much of the difference in well-being is driven by expected gaps in consumption versus gaps in leisure or health?
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3. How has the distribution of elderly welfare changed over time?
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2. How much of the difference in well-being is driven by expected gaps in consumption versus gaps in leisure or health?

3. How has the distribution of elderly welfare changed over time?

4. How well do other measures (e.g. age 60 income, health) compare to a (more) complete metric of well-being? What measures best identify well-being gaps?
Analysis outline

- Welfare model $\implies$ expected utility framework

- Application using Health and Retirement Study (HRS) data
  1. Forecasting outcomes $\implies$ system of dynamic equations describing the joint evolution of outcomes (panel VAR)
  2. Estimate parameters using full sample
  3. Age 60 data as initial conditions $\implies$ repeatedly simulate outcome paths for each individual
  4. Derive distribution of ex-ante welfare at age 60

- Four birth cohorts $\implies$ EHRS, LHRS, War Babies, Baby Boomers
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Welfare Model
Welfare model

- **Expected lifetime utility:***
  \[ E \left[ \sum_{a=j}^{J} \psi_{ia} \beta^{a-j} u(c_{ia}, l_{ia}, h_{ia}) \right] \]

- **Flow utility:***
  \[ u(c, l, h) = \phi(h) \left[ \bar{u} + \log(c) + \nu(l) \right] \]
Welfare model

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  \[
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  \]

- **Flow utility:**
  \[
  u(c, l, h) = \phi(h) [\bar{u} + \log(c) + \nu(l)]
  \]
  - \(\phi(h) \in [0, 1] \Rightarrow \) quality-adjusted life year (QALY)
Welfare model

- **Expected lifetime utility:**
  \[
  E \left[ \sum_{a=j}^{J} \psi_{ia} \beta^{a-j} u \left( c_{ia}, l_{ia}, h_{ia} \right) \right]
  \]

- **Flow utility:**
  \[u \left( c, l, h \right) = \phi \left( h \right) \left[ \bar{u} + \log \left( c \right) + \nu \left( l \right) \right]\]
  - \(\phi \left( h \right) \in [0, 1] \implies \) quality-adjusted life year (QALY)

- **Consumption equivalent welfare \(\lambda\):**
  \[U_{ij} \left( \lambda \right) = E \left[ \sum_{a=j}^{J} \psi_{ia} \beta^{a-j} u \left( \lambda c_{ia}, l_{ia}, h_{ia} \right) \right]\]
  welfare defined by:
  \[U_{mj} \left( \lambda_{ij} \right) = U_{ij} \left( 1 \right)\]
Data, Estimation, and Simulation
Data

- Health and Retirement Study (HRS)
  - Biennial longitudinal survey of individuals aged 50+ (1992-2014)
  - Consumption data (CAMs) on off years (2001-2013)

- Estimation sample
  - 35,889 individuals
  - 216,626 person-year observations

- Simulation sample (age 60)
  - 3,091 EHRS cohort (1931-36)
  - 3,607 LHRS cohort (1937-41)
  - 2,572 War Babies (1942-47)
  - 2,735 Baby Boomers (1948-53)

Descriptives
Forecasting model

\[ M_t \]
Hypertension
Diabetes
Lung Disease
Heart Disease
Stroke
Psyche Prob
Arthritis
ADL Difficulty

\[ \text{Self-rated Health } (s_t) \]
\[ \text{Labor Supply } (l_t) \]
\[ \text{Consumption } (c_t) \]
\[ \text{Survival } (\psi_{t+1}) \]

\[ M_{t+1}, s_{t+1}, l_{t+1}, c_{t+1}, \psi_{t+2} \]

**Contemporaneous effects**

**Dynamic effects**
Forecasting model

- Structural panel VAR representation:

\[ AY_{it} = BY_{it-1} + CX_{it} + \epsilon_{it} \]
Forecasting model

- Structural panel VAR representation:

\[ AY_{it} = BY_{it-1} + CX_{it} + \epsilon_{it} \]

- Key assumptions:
  - Block triangulation of the system
  - Consumption fixed effect
  - Differences across cohorts:
    - linear time trend
    - cohort specific intercept
    - initial (age 60) conditions
Impulse response to onset of heart disease at age 62

Notes: Results plot percentage difference in expected outcomes with the exogenous onset of heart disease at age sixty-two relative to remaining without heart disease at sixty-two. Sample includes all individuals in the simulation sample without heart disease at age sixty. Expected outcomes are conditional on survival.
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Life-cycle model fit

Simulated Data

15/25
Calibration of welfare model

- Median 60 year-old in EHRS cohort as reference person
- Health utility function: \( \phi(h) = \gamma h \) \( \Rightarrow \) Health Utilities Mark 3 (HUI3)
- Leisure utility function: \( \nu(l) = -\frac{\theta \epsilon}{1+\epsilon}(1-l)^{\frac{1+\epsilon}{\epsilon}} \) \( \Rightarrow \) constant Frisch elasticity of labor supply
  - \( \epsilon = 1, \theta = 8.37 \) \( \Rightarrow \) FOC of labor supply holds at median
  - Working \( \Rightarrow l = 0.66 \)
- Discount factor \( \beta = 0.98 \)
- Flow utility intercept \( \bar{u} = -0.34 \) \( \Rightarrow \) median value of remaining life equal to $50,000 per QALY
Welfare Results
### Elderly welfare inequality

<table>
<thead>
<tr>
<th>Welfare</th>
<th>Gini</th>
<th>10/50 ratio</th>
<th>90/50 ratio</th>
<th>$\rho$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benchmark</td>
<td>0.544</td>
<td>0.234</td>
<td>3.774</td>
<td>-</td>
</tr>
<tr>
<td>No morbidity</td>
<td>0.453</td>
<td>0.335</td>
<td>2.831</td>
<td>0.972</td>
</tr>
</tbody>
</table>

**Notes:** Estimates use base year sampling weights. No morbidity measure removes health from flow utility. Spearman’s rank correlation between the two welfare measures denoted by $\rho$.  

![Density of Log Welfare](image)
Elderly welfare and decomposition by decile

Mean log points

Welfare decile

Welfare Consumption QALE Leisure

Mean log points

Welfare
Consumption
QALE
Leisure

18/25
Life-cycle profiles by welfare decile

![Graphs showing consumption, leisure, health utility, and mortality by age for different welfare deciles.](image)
# Welfare over cohorts

<table>
<thead>
<tr>
<th>Cohort</th>
<th>Gini</th>
<th>10/50 ratio</th>
<th>90/50 ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>EHRS</td>
<td>0.544</td>
<td>0.234</td>
<td>3.774</td>
</tr>
<tr>
<td>LHRS</td>
<td>0.606</td>
<td>0.210</td>
<td>4.667</td>
</tr>
<tr>
<td>War Babies</td>
<td>0.643</td>
<td>0.196</td>
<td>5.159</td>
</tr>
<tr>
<td>Baby Boomers</td>
<td>0.674</td>
<td>0.196</td>
<td>5.727</td>
</tr>
</tbody>
</table>

*Notes: Estimates use base year respondent analysis weights.*
Welfare over cohorts

- Log welfare
- Log expected lifetime consumption
- Life expectancy
- QALE

Legend:
- EHRS
- LHRS
- War Babies
- Baby Boomers
## Comparison with other measures of well-being

<table>
<thead>
<tr>
<th>Measure</th>
<th>Gini</th>
<th>ρ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Welfare (λ)</td>
<td>0.544</td>
<td></td>
</tr>
<tr>
<td>Income</td>
<td>0.492</td>
<td>0.508</td>
</tr>
<tr>
<td>Consumption</td>
<td>0.424</td>
<td>0.573</td>
</tr>
<tr>
<td>Health utility</td>
<td>0.109</td>
<td>0.745</td>
</tr>
<tr>
<td>Flow utility</td>
<td>0.235</td>
<td>0.767</td>
</tr>
<tr>
<td>Life expectancy</td>
<td>0.132</td>
<td>0.818</td>
</tr>
<tr>
<td>QALE</td>
<td>0.176</td>
<td>0.872</td>
</tr>
<tr>
<td>Expected lifetime consumption</td>
<td>0.364</td>
<td>0.921</td>
</tr>
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</table>

*Notes:* Estimates for initial HRS cohort using base year respondent analysis weights. Income, consumption, and health utility are cross-sectional measures at age sixty. Flow utility is calculated using cross-sectional consumption, leisure, and health along with our benchmark preferences. Spearman’s rank correlation between λ and each measure denoted by ρ.
Comparison with other measures of over cohorts

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<th>Cons.</th>
<th>QALE</th>
<th>ELC</th>
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<td>0.364</td>
</tr>
<tr>
<td>LHRS</td>
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<td>0.442</td>
<td>0.198</td>
<td>0.390</td>
</tr>
<tr>
<td>War Babies</td>
<td>0.643</td>
<td>0.443</td>
<td>0.203</td>
<td>0.403</td>
</tr>
<tr>
<td>Baby Boomers</td>
<td>0.674</td>
<td>0.449</td>
<td>0.215</td>
<td>0.427</td>
</tr>
</tbody>
</table>

Notes: Estimates use base year respondent analysis weights. Income, consumption, and health utility are cross-sectional measures at age sixty. QALE is quality-adjusted life expectancy at age sixty. ELC is expected lifetime consumption at age sixty.
Conclusions

1. Elderly welfare inequality is substantial
   - Driven foremost by health and mortality gaps, followed by gaps in consumption
   - Ignoring well-being cost of health significantly underestimates inequality
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3. Cross-sectional income and consumption at age 60
   - Underestimate the level and growth of aggregate inequality
   - Are worse predictors of individual welfare rank than cross-sectional health
Limitations and future work

- Limitations
  - Abstract from potentially important inputs \(\Rightarrow\) caregiver time, social interactions, end-of-life care, bequests, etc.
  - Single set of preferences
  - Forecasting model falls short of fully specified structural model

- Opportunities for future work
  - Sub-sample analysis (e.g. education, race, gender, age)
  - Policy experiments / outcome in natural experiments
  - Cross-country comparison of elderly welfare inequality
Thank You!
log \left( \lambda_{ij} \right) =

\tilde{\psi} \sum_{a=j}^{J} \beta^{a-j} \left[ (E \left[ \psi_{ia} \phi (h_{ia}) \right] - E \left[ \psi_{ma} \phi (h_{ma}) \right] ) E \left[ u_{ia} \right] + \Phi \right] \quad QALE

+ \tilde{\psi} \sum_{a=j}^{J} \beta^{a-j} E \left[ \psi_{ma} \phi (h_{ma}) \right] \left( E \left[ \log \left( c_{ia} \right) \right] - E \left[ \log \left( c_{ma} \right) \right] \right) \quad Cons.

+ \tilde{\psi} \sum_{a=j}^{J} \beta^{a-j} E \left[ \psi_{ma} \phi (h_{ma}) \right] \left( E \left[ \nu (l_{ia}) \right] - E \left[ \nu (l_{ma}) \right] \right) \quad Leisure

where

\Phi = (E \left[ \psi_{ia} \phi (h_{ia}) u_{ia} \right] - E \left[ \psi_{ia} \phi (h_{ia}) \right] E \left[ u_{ia} \right])

- (E \left[ \psi_{ma} \phi (h_{ma}) u_{ma} \right] - E \left[ \psi_{ma} \phi (h_{ma}) \right] E \left[ u_{ma} \right])
<table>
<thead>
<tr>
<th>Condition</th>
<th>EHRS</th>
<th>LHRS</th>
<th>WB</th>
<th>BB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (mean)</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>Hypertension (%)</td>
<td>38.10</td>
<td>41.93</td>
<td>47.60</td>
<td>51.23</td>
</tr>
<tr>
<td>Diabetes (%)</td>
<td>11.81</td>
<td>12.77</td>
<td>16.45</td>
<td>20.13</td>
</tr>
<tr>
<td>Cancer (%)</td>
<td>6.84</td>
<td>8.25</td>
<td>10.82</td>
<td>9.48</td>
</tr>
<tr>
<td>Lung disease (%)</td>
<td>7.11</td>
<td>6.78</td>
<td>7.37</td>
<td>8.15</td>
</tr>
<tr>
<td>Heart disease (%)</td>
<td>13.85</td>
<td>14.75</td>
<td>16.11</td>
<td>16.25</td>
</tr>
<tr>
<td>Stroke (%)</td>
<td>2.90</td>
<td>3.88</td>
<td>5.22</td>
<td>4.66</td>
</tr>
<tr>
<td>Psyche problem (%)</td>
<td>7.44</td>
<td>11.85</td>
<td>17.32</td>
<td>21.85</td>
</tr>
<tr>
<td>Arthritis (%)</td>
<td>44.79</td>
<td>48.12</td>
<td>51.62</td>
<td>52.53</td>
</tr>
<tr>
<td>Difficulty with ADLs (%)</td>
<td>11.75</td>
<td>19.35</td>
<td>22.40</td>
<td>22.42</td>
</tr>
<tr>
<td>Self-rated health (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td>7.31</td>
<td>6.68</td>
<td>6.61</td>
<td>7.26</td>
</tr>
<tr>
<td>Fair</td>
<td>15.20</td>
<td>16.71</td>
<td>16.60</td>
<td>17.15</td>
</tr>
<tr>
<td>Good</td>
<td>28.32</td>
<td>30.12</td>
<td>31.08</td>
<td>29.34</td>
</tr>
<tr>
<td>Very good</td>
<td>31.66</td>
<td>30.80</td>
<td>31.72</td>
<td>34.19</td>
</tr>
<tr>
<td>Excellent</td>
<td>17.51</td>
<td>15.70</td>
<td>13.98</td>
<td>12.06</td>
</tr>
<tr>
<td>Retired (%)</td>
<td>48.66</td>
<td>50.46</td>
<td>48.07</td>
<td>47.47</td>
</tr>
<tr>
<td>Annual consumption ($1000s, mean)</td>
<td>27.59</td>
<td>30.29</td>
<td>29.43</td>
<td>26.41</td>
</tr>
</tbody>
</table>

Notes: Mean and percentage estimates use base year sampling weights. Consumption is reported in real 2010 dollars.
Notes: Dependent variables across columns. Average marginal effects on the probability of an outcome reported for probit results—poor health, retirement, mortality, and stroke. Contemporaneous associations reported for poor health, retirement, and consumption as dependent variables. Lagged associations reported for mortality and stroke. Good health coefficients use poor health state as reference group. Spikes indicate 95% confidence intervals.
## Estimated health utility weights

<table>
<thead>
<tr>
<th>Measure</th>
<th>Weight</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-rated health</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fair</td>
<td>0.226</td>
<td>0.026</td>
</tr>
<tr>
<td>Good</td>
<td>0.313</td>
<td>0.026</td>
</tr>
<tr>
<td>Very good</td>
<td>0.403</td>
<td>0.027</td>
</tr>
<tr>
<td>Excellent</td>
<td>0.421</td>
<td>0.031</td>
</tr>
<tr>
<td>Hypertension</td>
<td>0.003</td>
<td>0.012</td>
</tr>
<tr>
<td>Diabetes</td>
<td>-0.001</td>
<td>0.018</td>
</tr>
<tr>
<td>Cancer</td>
<td>0.010</td>
<td>0.017</td>
</tr>
<tr>
<td>Lung disease</td>
<td>-0.020</td>
<td>0.022</td>
</tr>
<tr>
<td>Heart disease</td>
<td>-0.032</td>
<td>0.015</td>
</tr>
<tr>
<td>Stroke</td>
<td>-0.076</td>
<td>0.022</td>
</tr>
<tr>
<td>Psych problem</td>
<td>-0.073</td>
<td>0.020</td>
</tr>
<tr>
<td>Arthritis</td>
<td>-0.062</td>
<td>0.012</td>
</tr>
<tr>
<td>Diff with ADL</td>
<td>-0.161</td>
<td>0.016</td>
</tr>
<tr>
<td>Constant</td>
<td>0.517</td>
<td>0.028</td>
</tr>
</tbody>
</table>

Notes: Results from regression of HUI3 score on self-rated health and morbidities. SE denotes standard error. $R^2 = 0.48$. $N = 1,089$. 

Quality adjusted life expectancy

Ratio of QALE to Life Expectancy vs. Life Expectancy

[Graph showing a scatter plot with data points representing the ratio of quality adjusted life expectancy (QALE) to life expectancy against life expectancy.]
<table>
<thead>
<tr>
<th>Measure</th>
<th>$\lambda$</th>
<th>$\lambda$</th>
<th>Gini by cohort</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10/50</td>
<td>90/50</td>
<td>EHRS</td>
</tr>
<tr>
<td>Benchmark</td>
<td>0.234</td>
<td>3.774</td>
<td>0.544</td>
</tr>
<tr>
<td>Compensating variation</td>
<td>0.059</td>
<td>2.856</td>
<td>0.505</td>
</tr>
<tr>
<td>Reference 90th %tile</td>
<td>0.314</td>
<td>2.842</td>
<td>0.446</td>
</tr>
<tr>
<td>$100k$ per QALY</td>
<td>0.076</td>
<td>6.465</td>
<td>0.670</td>
</tr>
<tr>
<td>$\beta = 0.90$</td>
<td>0.256</td>
<td>3.130</td>
<td>0.491</td>
</tr>
<tr>
<td>$\epsilon = 0.5$</td>
<td>0.231</td>
<td>3.726</td>
<td>0.539</td>
</tr>
<tr>
<td>$\epsilon = 2$</td>
<td>0.239</td>
<td>4.074</td>
<td>0.560</td>
</tr>
<tr>
<td>$\theta = 15.9$</td>
<td>0.258</td>
<td>3.539</td>
<td>0.525</td>
</tr>
<tr>
<td>Survival adjusted</td>
<td>0.177</td>
<td>4.015</td>
<td>0.568</td>
</tr>
<tr>
<td>Non-imputed data</td>
<td>0.242</td>
<td>3.543</td>
<td>0.522</td>
</tr>
</tbody>
</table>

Notes: Estimates use base year respondent analysis weights. War Babies denoted by WB and Baby Boomers by BB. Spearman’s rank correlation between welfare and cross-sectional consumption at age sixty denoted by $\rho$. 

25/25
• More general preferences:

\[ u(c, l, h) = \phi(h) \left[ \bar{u} + \frac{c^{1-\gamma}}{1-\gamma} \left( 1 - (1 - \gamma) \frac{\theta \epsilon}{1 + \epsilon} (1 - l)^{\frac{1+\epsilon}{\epsilon}} \right)^\gamma - \frac{1}{1-\gamma} \right] \]

<table>
<thead>
<tr>
<th>( \gamma )</th>
<th>EV 10/50 ratio by cohort</th>
<th>CV 90/50 ratio by cohort</th>
<th>( \rho )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>EHRS</td>
<td>LHRS</td>
<td>WB</td>
</tr>
<tr>
<td>0.234</td>
<td>0.210</td>
<td>0.196</td>
<td>0.196</td>
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<tr>
<td>1.5</td>
<td>0.207</td>
<td>0.180</td>
<td>0.163</td>
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<tr>
<td>2</td>
<td>0.231</td>
<td>0.197</td>
<td>0.163</td>
</tr>
</tbody>
</table>

Notes: Estimates use base year respondent analysis weights. War Babies denoted by WB and Baby Boomers by BB. Spearman’s rank correlation between EV measure of welfare and cross-sectional consumption at age sixty denoted by \( \rho \).
## Welfare decomposition in EHRS cohort

<table>
<thead>
<tr>
<th></th>
<th>Median $\lambda$</th>
<th>Mean log $\lambda$</th>
<th>Decomposition</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Education</td>
<td>Cons.</td>
<td>Leisure</td>
<td>QALY</td>
<td></td>
</tr>
<tr>
<td>&lt;HS</td>
<td>-0.393</td>
<td>0.031</td>
<td>-0.440</td>
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</tr>
<tr>
<td>HS grad</td>
<td>-0.015</td>
<td>0.019</td>
<td>-0.025</td>
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</tr>
<tr>
<td>Some college</td>
<td>0.196</td>
<td>0.006</td>
<td>0.069</td>
<td></td>
</tr>
<tr>
<td>College grad</td>
<td>0.476</td>
<td>-0.012</td>
<td>0.429</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>Cons.</td>
<td>Leisure</td>
<td>QALY</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>0.045</td>
<td>-0.005</td>
<td>-0.190</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>-0.030</td>
<td>0.031</td>
<td>0.081</td>
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</tr>
<tr>
<td>Race</td>
<td>Cons.</td>
<td>Leisure</td>
<td>QALY</td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>0.063</td>
<td>0.013</td>
<td>-0.005</td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>-0.404</td>
<td>0.028</td>
<td>-0.366</td>
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</tr>
<tr>
<td>Other</td>
<td>-0.245</td>
<td>0.011</td>
<td>-0.070</td>
<td></td>
</tr>
</tbody>
</table>
Consumption by Welfare Decile

- **Age 60 Consumption**
- **Age 60 Equivalent Consumption**

$1000s$ range: 0 to 250

Deciles: 1 to 10