Health Insurance, Medical Care, and Health Outcomes:

A Model of Elderly Health Dynamics

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The Big Picture

- Supplemental Insurance, Rx Coverage
- Rx Use
- Physician Services, Hospitalization

Health: Morbidity, Mortality
The Big Picture

Supplemental Insurance, Rx Coverage

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Health: Morbidity, Mortality
Our Questions

- How might drug coverage among the elderly alter prescription drug expenditures?
- Total medical care expenditures?
- How will health outcomes be affected? Morbidity and mortality?
- How does the change in expenditures compare across individuals? Marginal survivors, the chronically ill?
- Are changes in behavior due to cross-price effects or changes in health over time?
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A preview of our findings

- Drug expenditures over 5 years increase between 7 and 27%.
- Survival rates increase 1-2%.
- The distribution of functional status among survivors shifts toward worse health.
- Marginal survivors spend significantly more than individuals who would have survived anyway.
- There appears to be some contemporaneous reallocation of consumption, but changes in consumption are also driven by changes in health and survival.
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- The Medicare Prescription Drug Improvement and Modernization Act has made drug coverage an option for the elderly (part D).
As economists, what do we know?

Third-party coverage of medical care expenses leads to increased demand for covered services. Prescription drug coverage leads to greater consumption of drugs. Increased prescription drug use reduces mortality (and morbidity). Differences in the cost-sharing characteristics of coverage for different types of medical care can affect consumption behavior. Differences in the effectiveness of different types of medical care can affect consumption behavior.
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Can we predict the *long-run* impact of Rx coverage?

Yes, but what we don’t want to do is:

- ignore the endogeneity of insurance selection
- consider the effect of drug coverage on drug expenditures only
- measure the effect of prescription drug use on mortality only
- fail to model changes in health over time
- evaluate outcomes in a static setting
- ignore unobserved individual heterogeneity likely to influence behavior in several dimensions

– p. 7
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beginning of $t$

$I_t, J_t$

beginning of $t + 1$

$S_t$

$A_t, B_t, D_t$

$E_{t+1}, F_{t+1}$

insurance and drug coverage

health shock

medical care demand

health production
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And model the set of structural equations jointly, allowing unobserved components to be correlated.

- insurance and drug coverage
- health shock
- medical care demand
- health production
Theoretical Motivation

Our empirical model is motivated by Grossman’s theoretical model of health capital (1972). Theoretical models of medical care consumption and health production have been solved and the primitive parameters estimated. Gilleskie (1998, 2008), Blau and Gilleskie (2008), Crawford and Shum (2005), Chan and Hamilton (2006), Davis and Foster (2005), Khwaja (2008). But we can derive (or approximate) the medical care demand functions and estimate the health production function. These dynamic behaviors and processes are functions of endogenous variables.
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Features of our empirical model suggested by theory
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- Supplemental insurance coverage is chosen at the beginning of the period before observing health shocks, but with knowledge of one’s functional status, chronic conditions, and, most importantly, unobserved characteristics entering the period.
Features of our empirical model suggested by theory

- Adverse selection
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- Permanent and time-varying unobserved individual characteristics affect annual demand for all three types of medical care.
Features of our empirical model suggested by theory

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- Jointly estimated demand
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- Health stock transitions are a function of medical care input allocations and health shocks during the year. (Grossman’s health capital formation)
Features of our empirical model suggested by theory

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- Dynamic health production

Previous medical care use may alter the utility of medical care consumption today; hence, lagged use affects current expenditures directly rather than only indirectly through health transitions.
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- Dynamic demand for medical care
Empirical Model: unobserved heterogeneity specification
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- permanent: risk aversion or attitude toward medical care use
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- permanent: risk aversion or attitude toward medical care use
- time-varying: health shocks or natural rate of deterioration
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- permanent: risk aversion or attitude toward medical care use
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\[ u_t^e = \rho^e \mu + \omega^e \nu_t + \varepsilon_t^e \]
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and \( \varepsilon_t^e \sim N(0, \sigma_e^2) \) for continuous outcomes
and Extreme Value for dichotomous or polychotomous outcomes
Identification in the set of dynamic equations
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- Exogeneity of some explanatory variables conditional on the unobserved heterogeneity
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- Theoretically-relevant exogenous identifying variables 
  \((Z_t^I, Z_t^H, Z_t^M)\)
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- Theoretically-relevant exogenous identifying variables \((Z^I_t, Z^H_t, Z^M_t)\)
- Lagged values of exogenous variables
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- Exogenous variables in the reduced-form initial condition equations that are excluded from the dynamic structural equations \((R_0)\)
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- Exogeneity of some explanatory variables conditional on the unobserved heterogeneity
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  - lagged values of exogenous variables ($X_{t-1}$ and $(Z^I_{t-1}, Z^H_{t-1}, Z^M_{t-1})$)
  - lagged values of endogenous variables

- Exogenous variables in the reduced-form initial condition equations that are excluded from the dynamic structural equations ($R_0$)

- Specification and covariance structure of the permanent and time-varying unobserved individual heterogeneity ($\mu$ and $\nu_t$)
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- Exogenous variables in the reduced-form initial condition equations that are excluded from the dynamic structural equations \((R_0)\)
- Specification and covariance structure of the permanent and time-varying unobserved individual heterogeneity \((\mu \text{ and } \nu_t)\)
- Functional form of the equations
Empirical Model: supplemental insurance selection

\[ P(I_t = i) = 0^i + 1^i E_t + 2^i F_t + 3^i A_t + 4^i B_t + 5^i D_t + 6^i X_t + 7^i Z_t I_t + 8^i Z_t M_t + 9^i Z_t H_t + 10^i; i = 0 \text{ Medicare coverage only (parts A and B) (8%)} \\

i = 1 \text{ dually covered by Medicaid (12%)} \\

i = 2 \text{ supplement with private plan (64%)} \\

i = 3 \text{ select the Medicare managed care option (part C) (16%)} \\

\text{Those with a private or part C plan may have Rx coverage (63%)}
\]
Empirical Model: supplemental insurance selection

- Individuals choose whether to supplement Medicare
Empirical Model: supplemental insurance selection

Individuals choose whether to supplement Medicare

\[
\ln \left[ \frac{\Pr(I_t = i)}{\Pr(I_t = 0)} \right] = \eta_0 + \eta_1 E_t + \eta_2 F_t + \eta_3 A_{t-1} + \eta_4 B_{t-1} + \eta_5 D_{t-1}
\]

\[
+ \eta_6 X_t + \eta_7 Z^I_t + \eta_8 Z^M_t + \eta_9 Z^H_t + \eta_{10,I} t + \rho^I \mu + \omega^I \nu_t
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+ \eta_{6i} X_t + \eta_{7i} Z^I_t + \eta_{8i} Z^M_t + \eta_{9i} Z^H_t + \eta_{10,i} t + \rho_i \mu + \omega_i \nu_t
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- Those with a private or part C plan may have Rx coverage (63%)
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- Individuals choose whether to supplement Medicare

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- Those with a private or part C plan may have Rx coverage (63%)

\[ \ln \left[ \frac{\Pr(J_t = 1|I_t = 2 \text{ or } 3)}{\Pr(J_t = 0|I_t = 2 \text{ or } 3)} \right] = \xi_0 + \xi_1 1[I_t = 3] \]
\[ + \xi_2 E_t + \xi_3 F_t + \xi_4 A_{t-1} + \xi_5 B_{t-1} + \xi_6 D_{t-1} \]
\[ + \xi_7 X_t + \xi_8 Z^I_t + \xi_9 Z^M_t + \xi_{10} Z^H_t + \xi_{11} t + \rho^J \mu + \omega^J \nu_t \]
Empirical Model: health shocks

\[ \Pr(\text{S}_{kt} = 1) = k_0 + k_1 E_{kt} + k_2 F_{kt} + k_3 X_t + k_4 Z_H t + \text{Sk}_t + \varepsilon \]

- Heart/stroke (24%)
- Respiratory (5%)
- Cancer (6%)

\( E_k t \) indicates whether one has ever had a chronic condition of type \( k \) and includes if \( E_k t = 1 \) and \( E_k t+1 = 1 \) and if \( E_k t = 0 \) and \( S_k t = 1 \), then \( E_k t+1 = 1 \)
Empirical Model: health shocks

- Individuals may experience a health shock each period
Empirical Model: health shocks

Individuals may experience a health shock each period

\[
\ln \left[ \frac{\Pr(S_t^k = 1)}{\Pr(S_t^k = 0)} \right] = \phi_0^k + \phi_1^k E_t + \phi_2^k F_t + \phi_3^k X_t + \phi_4^k Z_t^H \\
+ \rho^S_k \mu + \omega^S_k \nu_t
\]
Empirical Model: health shocks

- Individuals may experience a health shock each period

\[
\ln \left[ \frac{\Pr(S_t^k = 1)}{\Pr(S_t^k = 0)} \right] = \phi_0^k + \phi_1^k E_t + \phi_2^k F_t + \phi_3^k X_t + \phi_4^k Z_t^H
\]
\[
+ \rho^{S_k} \mu + \omega^{S_k} \nu_t
\]

\(k = 1\)  Heart/stroke (24%)
Empirical Model: health shocks

- Individuals may experience a health shock each period

\[
\ln \left[ \frac{\Pr(S^k_t = 1)}{\Pr(S^k_t = 0)} \right] = \phi_0^k + \phi_1^k E_t + \phi_2^k F_t + \phi_3^k X_t + \phi_4^k Z^H_t + \rho^{S^k} \mu + \omega^{S^k} \nu_t
\]

\(k = 1\) Heart/stroke (24%)

\(k = 2\) Respiratory (5%)
Empirical Model: health shocks

Individuals may experience a health shock each period

\[
\ln \left[ \frac{\Pr(S_t^k = 1)}{\Pr(S_t^k = 0)} \right] = \phi_0^k + \phi_1^k E_t + \phi_2^k F_t + \phi_3^k X_t + \phi_4^k Z_t^H \\
+ \rho^{S_k} \mu + \omega^{S_k} \nu_t
\]

\( k = 1 \)  Heart/stroke (24%)
\( k = 2 \)  Respiratory (5%)
\( k = 3 \)  Cancer (6%)
Empirical Model: health shocks

- Individuals may experience a health shock each period

\[
\ln \left[ \frac{\Pr(S^k_t = 1)}{\Pr(S^k_t = 0)} \right] = \phi_0^k + \phi_1^k E_t + \phi_2^k F_t + \phi_3^k X_t + \phi_4^k Z^H_t \\
+ \rho^S k \mu + \omega^S k \nu_t
\]

- \( k = 1 \) Heart/stroke (24%)
- \( k = 2 \) Respiratory (5%)
- \( k = 3 \) Cancer (6%)

- \( E_t^k \) indicates whether one has ever had a chronic condition of type \( k \)
Empirical Model: health shocks

- Individuals may experience a health shock each period

\[
\ln \left[ \frac{\Pr(S_t^k = 1)}{\Pr(S_t^k = 0)} \right] = \phi_0^k + \phi_1^k E_t + \phi_2^k F_t + \phi_3^k X_t + \phi_4^k Z_t^H \\
+ \rho^{S_k} \mu + \omega^{S_k} \nu_t
\]

- \( k = 1 \) Heart/stroke (24%)
- \( k = 2 \) Respiratory (5%)
- \( k = 3 \) Cancer (6%)

- \( E_t^k \) indicates whether one has ever had a chronic condition of type \( k \) and includes \( k = 4 \): diabetes
Empirical Model: health shocks

- Individuals may experience a health shock each period

\[
\ln \left[ \frac{\Pr(S^k_t = 1)}{\Pr(S^k_t = 0)} \right] = \phi_0^k + \phi_1^k E_t + \phi_2^k F_t + \phi_3^k X_t + \phi_4^k Z^H_t + \rho^S k \mu_t + \omega^S k \nu_t
\]

- \( k = 1 \) Heart/stroke (24%)
- \( k = 2 \) Respiratory (5%)
- \( k = 3 \) Cancer (6%)

- \( E_t^k \) indicates whether one has ever had a chronic condition of type \( k \) and includes \( k = 4 \): diabetes

and if \( E_t^k = 1 \) and \( E_{t+1}^k = 1 \)
Empirical Model: health shocks

- Individuals may experience a health shock each period

\[
\ln \left[ \frac{\Pr(S^k_t = 1)}{\Pr(S^k_t = 0)} \right] = \phi_0^k + \phi_1^k E_t + \phi_2^k F_t + \phi_3^k X_t + \phi_4^k Z^H_t + \rho^S k \mu + \omega^S k \nu_t
\]

- \( k = 1 \) Heart/stroke (24%)
- \( k = 2 \) Respiratory (5%)
- \( k = 3 \) Cancer (6%)

- \( E_t^k \) indicates whether one has ever had a chronic condition of type \( k \) and includes \( k = 4 \): diabetes

and if \( E_t^k = 1 \) and \( E_{t+1}^k = 1 \)

and if \( E_t^k = 0 \) and \( S_t^k = 1 \), then \( E_{t+1}^k = 1 \)
Empirical Model: medical care demand
Empirical Model: medical care demand

The probability of any expenditures of type $q$
Empirical Model: medical care demand

The probability of any expenditures of type $q$

$$\ln \left[ \frac{\Pr(q_t > 0)}{\Pr(q_t = 0)} \right] = \alpha_0^q + \alpha_1^q I_t J_t + \alpha_2^q S_t + \alpha_3^q E_t + \alpha_4^q F_t$$

$$+ \alpha_5^q [A_{t-1} > 0] + \alpha_6^q [B_{t-1} > 0] + \alpha_7^q [D_{t-1} > 0]$$

$$+ \alpha_8^q X_t + \alpha_9^q Z_t^M + \alpha_{10}^q t + \rho^q \mu + \omega^q \nu_t$$
Empirical Model: medical care demand

The probability of any expenditures of type \( q \)

\[
\ln \left( \frac{\Pr(q_t > 0)}{\Pr(q_t = 0)} \right) = \alpha_0^q + \alpha_1^q I_t J_t + \alpha_2^q S_t + \alpha_3^q E_t + \alpha_4^q F_t \\
+ \alpha_5^q 1[A_{t-1} > 0] + \alpha_6^q 1[B_{t-1} > 0] + \alpha_7^q 1[D_{t-1} > 0] \\
+ \alpha_8^q X_t + \alpha_9^q Z_t^M + \alpha_{10}^q t + \rho^q 1 \mu + \omega^q 1 \nu_t
\]

\( q_t = A_t \) hospital services (part A) (21%)
Empirical Model: medical care demand

The probability of any expenditures of type \( q \)

\[
\ln \left( \frac{\Pr(q_t > 0)}{\Pr(q_t = 0)} \right) = \alpha_0^q + \alpha_1^q I_t J_t + \alpha_2^q S_t + \alpha_3^q E_t + \alpha_4^q F_t \\
+ \alpha_5^q I[A_{t-1} > 0] + \alpha_6^q I[B_{t-1} > 0] + \alpha_7^q I[D_{t-1} > 0] \\
+ \alpha_8^q X_t + \alpha_9^q Z_t^M + \alpha_{10}^q t + \rho^q \mu + \omega^q \nu_t
\]

\( q_t = A_t \)      hospital services (part A) (21%)
\( q_t = B_t \)      physician services (part B) (84%)
Empirical Model: medical care demand

The probability of any expenditures of type $q$

$$\ln \left[ \frac{\Pr(q_t > 0)}{\Pr(q_t = 0)} \right] = \alpha_0^q + \alpha_1^q I_t J_t + \alpha_2^q S_t + \alpha_3^q E_t + \alpha_4^q F_t$$

$$+ \alpha_5^q 1[A_{t-1} > 0] + \alpha_6^q 1[B_{t-1} > 0] + \alpha_7^q 1[D_{t-1} > 0]$$

$$+ \alpha_8^q X_t + \alpha_9^q Z_t^M + \alpha_{10}^q t + \rho^q 1 \mu + \omega^q 1 \nu_t$$

$q_t = A_t$ hospital services (part A) (21%)

$q_t = B_t$ physician services (part B) (84%)

$q_t = D_t$ prescription drugs (90%)
Empirical Model: medical care demand

The probability of any expenditures of type $q$

$$\ln \left[ \frac{\Pr(q_t > 0)}{\Pr(q_t = 0)} \right] = \alpha_0^q + \alpha_1^q I_t J_t + \alpha_2^q S_t + \alpha_3^q E_t + \alpha_4^q F_t$$

$$+ \alpha_5^q \mathbf{1}[A_{t-1} > 0] + \alpha_6^q \mathbf{1}[B_{t-1} > 0] + \alpha_7^q \mathbf{1}[D_{t-1} > 0]$$

$$+ \alpha_8^q X_t + \alpha_9^q Z_t^M + \alpha_{10}^q t + \rho^q \mu + \omega^q \nu_t$$

$q_t = A_t$ hospital services (part A) (21%)
$q_t = B_t$ physician services (part B) (84%)
$q_t = D_t$ prescription drugs (90%)

The ln(level) of expenditures, conditional on any
Empirical Model: medical care demand

- The probability of any expenditures of type $q$

$$\ln \left[ \frac{\Pr(q_t > 0)}{\Pr(q_t = 0)} \right] = \alpha_0^q + \alpha_1^q I_t J_t + \alpha_2^q S_t + \alpha_3^q E_t + \alpha_4^q F_t$$

$$+ \alpha_5^q 1[A_{t-1} > 0] + \alpha_6^q 1[B_{t-1} > 0] + \alpha_7^q 1[D_{t-1} > 0]$$

$$+ \alpha_8^q X_t + \alpha_9^q Z_t^M + \alpha_{10}^q t + \rho^q \mu + \omega^q \nu_t$$

$q_t = A_t$ hospital services (part A) (21%)

$q_t = B_t$ physician services (part B) (84%)

$q_t = D_t$ prescription drugs (90%)

- The ln(level) of expenditures, conditional on any

$$\ln(q_t|q_t > 0) = \delta_0^q + \delta_1^q I_t J_t + \delta_2^q S_t + \delta_3^q E_t + \delta_4^q F_t$$

$$+ \delta_5^q 1[A_{t-1} > 0] + \delta_6^q 1[B_{t-1} > 0] + \delta_7^q 1[D_{t-1} > 0]$$

$$+ \delta_8^q X_t + \delta_9^q Z_t^M + \delta_{10}^q t + \rho^q \mu + \omega^q \nu_t$$
Empirical Model: health production
Empirical Model: health production

- The probability of a particular functional status

- Pr(\text{F}_{t+1}=0) = 0
- Pr(\text{F}_{t+1}=1) = f_{E_t} + f_{S_t} + f_{A_t} + f_{B_t} + f_{D_t})
- Pr(\text{F}_{t+1}=2) = f_{E_t} + f_{S_t} + f_{A_t} + f_{B_t} + f_{D_t})
- Pr(\text{F}_{t+1}=3) = f_{E_t} + f_{S_t} + f_{A_t} + f_{B_t} + f_{D_t})
- \text{A_t} > 0
- \text{B_t} > 0
- \text{D_t} > 0

- Not disabled; no functional limitation (58%)
- Moderately disabled; at least 1 IADL and up to 2 ADLs (28%)
- Severely disabled; 3 or more ADLs (10%)
- Death (5%)
Empirical Model: health production

The probability of a particular functional status

\[
\ln \left[ \frac{\Pr(F_{t+1} = f)}{\Pr(F_{t+1} = 0)} \right] = \gamma_0 f + \gamma_1 f F_t + \gamma_2 f E_t + \gamma_3 f S_t + \sum_{k=1}^{3} \gamma_{4f} E_t^k S_t^k \\
+ (\gamma_5 f + \gamma_6 f F_t + \gamma_7 f S_t + \gamma_8 f A_t + \gamma_9 f B_t + \gamma_{10, f} D_t) \mathbf{1}[A_t > 0] \\
+ (\gamma_{11, f} + \gamma_{12, f} F_t + \gamma_{13, f} S_t + \gamma_{14, f} A_t + \gamma_{15, f} B_t + \gamma_{16, f} D_t) \mathbf{1}[B_t > 0] \\
+ (\gamma_{17, f} + \gamma_{18, f} F_t + \gamma_{19, f} S_t + \gamma_{20, f} A_t + \gamma_{21, f} B_t + \gamma_{22, f} D_t) \mathbf{1}[D_t > 0] \\
+ \gamma_{23, f} X_t + \rho_f \mu + \omega_f \nu_t
\]
Empirical Model: health production

The probability of a particular functional status

\[ \ln \left[ \frac{\Pr(F_{t+1} = f)}{\Pr(F_{t+1} = 0)} \right] = \gamma_0 f + \gamma_1 f F_t + \gamma_2 f E_t + \gamma_3 f S_t + \sum_{k=1}^{3} \gamma_{4f}^k E_t^k S_t^k \]

\[ + (\gamma_5 f + \gamma_6 f F_t + \gamma_7 f S_t + \gamma_8 f A_t + \gamma_9 f B_t + \gamma_{10,f} D_t) 1[A_t > 0] \]

\[ + (\gamma_{11,f} + \gamma_{12,f} F_t + \gamma_{13,f} S_t + \gamma_{14,f} A_t + \gamma_{15,f} B_t + \gamma_{16,f} D_t) 1[B_t > 0] \]

\[ + (\gamma_{17,f} + \gamma_{18,f} F_t + \gamma_{19,f} S_t + \gamma_{20,f} A_t + \gamma_{21,f} B_t + \gamma_{22,f} D_t) 1[D_t > 0] \]

\[ + \gamma_{23,f} X_t + \rho_f^F \mu + \omega_f^F \nu_t \]

\[ f = 0 \quad \text{not disabled; no functional limitation (58%)} \]
Empirical Model: health production

The probability of a particular functional status

\[
\ln \left[ \frac{\Pr(F_{t+1} = f)}{\Pr(F_{t+1} = 0)} \right] = \gamma_0 f + \gamma_1 f F_t + \gamma_2 f E_t + \gamma_3 f S_t + \sum_{k=1}^{3} \gamma_{4f}^k E_t^k S_t^k \\
+ (\gamma_{5f} + \gamma_{6f} F_t + \gamma_{7f} S_t + \gamma_{8f} A_t + \gamma_{9f} B_t + \gamma_{10f} D_t)1[A_t > 0] \\
+ (\gamma_{11f} + \gamma_{12f} F_t + \gamma_{13f} S_t + \gamma_{14f} A_t + \gamma_{15f} B_t + \gamma_{16f} D_t)1[B_t > 0] \\
+ (\gamma_{17f} + \gamma_{18f} F_t + \gamma_{19f} S_t + \gamma_{20f} A_t + \gamma_{21f} B_t + \gamma_{22f} D_t)1[D_t > 0] \\
+ \gamma_{23f} X_t + \rho_f^F \mu + \omega_F^F \nu_t
\]

\( f = 0 \) not disabled; no functional limitation (58%)

\( f = 1 \) moderately disabled; at least 1 IADL and up to 2 ADLs (28%)
Empirical Model: health production

The probability of a particular functional status

\[
\ln \left[ \frac{\Pr(F_{t+1} = f)}{\Pr(F_{t+1} = 0)} \right] = \gamma_0 f + \gamma_1 f F_t + \gamma_2 f E_t + \gamma_3 f S_t + \sum_{k=1}^{3} \gamma_{4f}^k E_t^k S_t^k \\
+ (\gamma_{5f} + \gamma_{6f} F_t + \gamma_{7f} S_t + \gamma_{8f} A_t + \gamma_{9f} B_t + \gamma_{10f} D_t)1[A_t > 0] \\
+ (\gamma_{11f} + \gamma_{12f} F_t + \gamma_{13f} S_t + \gamma_{14f} A_t + \gamma_{15f} B_t + \gamma_{16f} D_t)1[B_t > 0] \\
+ (\gamma_{17f} + \gamma_{18f} F_t + \gamma_{19f} S_t + \gamma_{20f} A_t + \gamma_{21f} B_t + \gamma_{22f} D_t)1[D_t > 0] \\
+ \gamma_{23f} X_t + \rho^F f \mu + \omega^F f \nu_t
\]

\( f = 0 \) not disabled; no functional limitation (58%)

\( f = 1 \) moderately disabled; at least 1 IADL and up to 2 ADLs (28%)

\( f = 2 \) severely disabled; 3 or more ADLs (10%)
Empirical Model: health production

The probability of a particular functional status

\[
\ln \left[ \frac{\Pr(F_{t+1} = f)}{\Pr(F_{t+1} = 0)} \right] = \gamma_0 f + \gamma_1 f F_t + \gamma_2 f E_t + \gamma_3 f S_t + \sum_{k=1}^{3} \gamma_4^k f E_t^k S_t^k \\
+ (\gamma_5 f + \gamma_6 f F_t + \gamma_7 f S_t + \gamma_8 f A_t + \gamma_9 f B_t + \gamma_{10} f D_t) \mathbf{1}[A_t > 0] \\
+ (\gamma_{11} f + \gamma_{12} f F_t + \gamma_{13} f S_t + \gamma_{14} f A_t + \gamma_{15} f B_t + \gamma_{16} f D_t) \mathbf{1}[B_t > 0] \\
+ (\gamma_{17} f + \gamma_{18} f F_t + \gamma_{19} f S_t + \gamma_{20} f A_t + \gamma_{21} f B_t + \gamma_{22} f D_t) \mathbf{1}[D_t > 0] \\
+ \gamma_{23} f X_t + \rho f \mu + \omega f \nu_t
\]

\( f = 0 \) not disabled; no functional limitation (58%)
\( f = 1 \) moderately disabled; at least 1 IADL and up to 2 ADLs (28%)
\( f = 2 \) severely disabled; 3 or more ADLs (10%)
\( f = 3 \) death (5%)
Empirical Model: initial conditions

\[
\ln \left[ \frac{\Pr(E_0^k = 1)}{\Pr(E_0^k = 0)} \right] = \lambda_0^k + \lambda_1^k X_t + \lambda_2^k Z_0^H + \lambda_3^k R_0 + \lambda_4^k t + \rho^k \mu \ \forall k
\]

\[
\ln \left[ \frac{\Pr(I_0 = i)}{\Pr(I_0 = 0)} \right] = \lambda_0^i + \lambda_1^i E_0 + \lambda_2^i X_0 + \lambda_3^i Z_0^I + \lambda_4^i R_0 + \lambda_5^i t + \rho_i^i \mu \ \forall i
\]

\[
\ln \left[ \frac{\Pr(J_0 = 1|I_0 = 2 \text{ or } 3)}{\Pr(J_0 = 0|I_0 = 2 \text{ or } 3)} \right] = \lambda_0^3 + \lambda_1^3 1[I_0 = 3] + \lambda_2^3 E_0 + \lambda_3^3 X_0 + \lambda_4^3 Z_0^I + \lambda_5^3 R_0 + \lambda_6^3 t + \rho^3 \mu
\]

\[
\ln \left[ \frac{\Pr(q_0 > 0)}{\Pr(q_0 = 0)} \right] = \lambda_0^q + \lambda_1^q I_0 J_0 + \lambda_2^q E_0 + \lambda_3^q X_0 + \lambda_4^q Z_0^M + \lambda_5^q R_0 + \lambda_6^q t + \rho^q \mu \ \forall q
\]

\[
\ln \left[ \frac{\Pr(F_1 = f)}{\Pr(F_1 = 0)} \right] = \lambda_0^f + \lambda_1^f E_0 + \lambda_2^f X_0 + \lambda_3^f R_0 + \lambda_4^f t + \rho_f^f \mu \ \forall f
\]
Description of Data

Medicare Current Beneficiary Survey (MCBS) Survey and Event files from 1992-2001
Overlapping samples followed from 2 to 5 years
Exclude individuals ever in a nursing home
Attrition due to death and sample design
Sample: 25,935 men and women or 76,321 person-year obs
Exogenous Individual and Identifying variables
Functional Status, Chronic Condition, and Health Shock statistics
Supplemental Insurance and Drug Coverage statistics
Medical Care Demand (part A, part B, Rx) statistics
Description of Data

- Medicare Current Beneficiary Survey (MCBS)
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- Supplemental Insurance and Drug Coverage statistics
- Medical Care Demand (part A, part B, Rx) statistics
Results

Parameter estimates: See Tables 7a-7c, 8a-8c, 9, 10, 11 and A2-A6 in paper
Unobserved heterogeneity distributions
Fit of the model: mortality, part A, part B, Rx, exps in death year, Table A7
Simulations – p. 23
Results

Parameter estimates:

See Tables 7a-7c, 8a-8c, 9, 10, 11 and A2-A6 in paper
Results

- Parameter estimates:
  See Tables 7a-7c, 8a-8c, 9, 10, 11 and A2-A6 in paper

- Unobserved heterogeneity *distributions*
Results

- Parameter estimates:
  See Tables 7a-7c, 8a-8c, 9, 10, 11 and A2-A6 in paper

- Unobserved heterogeneity *distributions*

- Fit of the model:
  mortality, part A, part B, Rx, exps in death year, Table A7
Results

- Parameter estimates:
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- Unobserved heterogeneity *distributions*
- Fit of the model:
  mortality, part A, part B, Rx, exps in death year, Table A7
- Simulations
Simulations

Start everyone off with a particular type of health insurance:
- Medicare only
- Dual coverage with Medicaid
- Private supplement without Rx coverage
- Private supplement with Rx coverage
- Medicare managed care (part C) without Rx coverage
- Medicare managed care (part C) with Rx coverage

Simulate behavior for 5 years

Average expenditures and outcomes over 5 years

Average expenditures of 5-year survivors

– p. 24
Start everyone off with a particular type of health insurance.
Simulations

- Start everyone off with a particular type of health insurance
  - Medicare only
Simulations

- Start everyone off with a particular type of health insurance
  - Medicare only
  - Dual coverage with Medicaid
Simulations

- Start everyone off with a particular type of health insurance
  - Medicare only
  - Dual coverage with Medicaid
  - Private supplement without Rx coverage
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Simulations

- Start everyone off with a particular type of health insurance
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Simulations

- Start everyone off with a particular type of health insurance
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Simulations

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- Simulate behavior for 5 years
- Average *expenditures* and outcomes over 5 years
Simulations

- Start everyone off with a particular type of health insurance
  - Medicare only
  - Dual coverage with Medicaid
  - Private supplement without Rx coverage
  - Private supplement with Rx coverage
  - Medicare managed care (part C) without Rx coverage
  - Medicare managed care (part C) with Rx coverage

- Simulate behavior for 5 years

- Average *expenditures* and outcomes over 5 years

- Average *expenditures* of 5-year survivors
Conclusions

A change from Medicare with no drug coverage to a plan that covers prescription drugs reveals that:

- Drug expenditures over 5 years increase between 7 and 27%.
- Survival rates increase 1-2%.
- The distribution of functional status among survivors shifts toward worse health.
- Marginal survivors spend significantly more than individuals who would have survived anyway.
- There appears to be some contemporaneous reallocation of consumption, but changes in consumption are also driven by changes in health and survival.
- The differences in behavior and outcomes across plan simulations highlight some unexplored questions.
Conclusions

A change from Medicare with no drug coverage to a plan that covers prescription drugs reveals that:

- Drug expenditures over 5 years increase between 7 and 27%.
- Survival rates increase 1-2%.
- The distribution of functional status among survivors shifts toward worse health.
- Marginal survivors spend significantly more than individuals who would have survived anyway.
- There appears to be some contemporaneous reallocation of consumption, but changes in consumption are also driven by changes in health and survival.
- The differences in behavior and outcomes across plan simulations highlight some unexplored questions.
A change from Medicare with no drug coverage to a plan that covers prescription drugs reveals that:

- Drug expenditures over 5 years increase between 7 and 27%. 

Conclusions
A change from Medicare with no drug coverage to a plan that covers prescription drugs reveals that:

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- There appears to be some contemporaneous reallocation of consumption, but changes in consumption are also driven by changes in health and survival.
- And the differences in behavior and outcomes across plan simulations highlight some unexplored questions.
Empirical Distribution of Sample Participation in MCBS, 1992-2001

<table>
<thead>
<tr>
<th>Years Followed</th>
<th>#</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>At least 2 years</td>
<td>25,935</td>
<td>100</td>
</tr>
<tr>
<td>At least 3 years</td>
<td>19,913</td>
<td>77</td>
</tr>
<tr>
<td>At least 4 years</td>
<td>3,574</td>
<td>13</td>
</tr>
<tr>
<td>More than 4 years</td>
<td>1,031</td>
<td>4</td>
</tr>
<tr>
<td>Exactly 2 years</td>
<td>6,022</td>
<td>23</td>
</tr>
<tr>
<td>Exactly 3 years</td>
<td>16,366</td>
<td>63</td>
</tr>
<tr>
<td>Exactly 4 years</td>
<td>2,516</td>
<td>10</td>
</tr>
<tr>
<td>More than 4 years</td>
<td>1,031</td>
<td>4</td>
</tr>
<tr>
<td>1992</td>
<td>6,470</td>
<td>8.5</td>
</tr>
<tr>
<td>1993</td>
<td>7,860</td>
<td>10.3</td>
</tr>
<tr>
<td>1994</td>
<td>8,675</td>
<td>11.4</td>
</tr>
<tr>
<td>1995</td>
<td>7,850</td>
<td>10.3</td>
</tr>
<tr>
<td>1996</td>
<td>7,480</td>
<td>9.8</td>
</tr>
<tr>
<td>1997</td>
<td>7,484</td>
<td>9.8</td>
</tr>
<tr>
<td>1998</td>
<td>7,227</td>
<td>9.4</td>
</tr>
<tr>
<td>1999</td>
<td>8,470</td>
<td>11.1</td>
</tr>
<tr>
<td>2000</td>
<td>8,954</td>
<td>11.7</td>
</tr>
<tr>
<td>2001</td>
<td>5,891</td>
<td>7.7</td>
</tr>
</tbody>
</table>
## Functional Status Transitions

<table>
<thead>
<tr>
<th>Observed one-year functional status transitions</th>
<th>Not disabled</th>
<th>Moderately disabled</th>
<th>Severely disabled</th>
<th>Die</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functional status in year $t$ ($F_t$)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not disabled (no ADL or IADL)</td>
<td>0.81</td>
<td>0.15</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Moderately disabled (IADL or &lt; 3 ADLs)</td>
<td>0.26</td>
<td>0.57</td>
<td>0.11</td>
<td>0.06</td>
</tr>
<tr>
<td>Severely disabled (3 or more ADLs)</td>
<td>0.06</td>
<td>0.24</td>
<td>0.56</td>
<td>0.14</td>
</tr>
<tr>
<td>Dead</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Note: Die means the status is dead.
## Health Shocks and Chronic Conditions

<table>
<thead>
<tr>
<th>Chronic condition entering year $t$ ($E^k_t$)</th>
<th>Heart/stroke</th>
<th>Respiratory</th>
<th>Cancer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart/stroke (ICD-9 390-439)</td>
<td>0.38</td>
<td>0.06</td>
<td>0.06</td>
</tr>
<tr>
<td>Respiratory (ICD-9 480-496)</td>
<td>0.32</td>
<td>0.20</td>
<td>0.07</td>
</tr>
<tr>
<td>Cancer (ICD-9 140-209)</td>
<td>0.27</td>
<td>0.18</td>
<td>0.06</td>
</tr>
<tr>
<td>Diabetes (ICD-9 250)</td>
<td>0.33</td>
<td>0.05</td>
<td>0.06</td>
</tr>
<tr>
<td>None</td>
<td>0.01</td>
<td>0.05</td>
<td>0.08</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Probability of health shock (conditional on existing chronic conditions) $^a$</th>
<th>Health shock during year $t$ ($S^k_t$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart/stroke</td>
<td>0.38</td>
</tr>
<tr>
<td>Respiratory</td>
<td>0.32</td>
</tr>
<tr>
<td>Cancer</td>
<td>0.27</td>
</tr>
<tr>
<td>Diabetes</td>
<td>0.33</td>
</tr>
<tr>
<td>None</td>
<td>0.01</td>
</tr>
</tbody>
</table>
## Exogenous Individual Variables

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Mean</th>
<th>Std Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Non time-varying individual characteristics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education (range: 0-18 years)</td>
<td>6.72</td>
<td>2.67</td>
</tr>
<tr>
<td>Male (omitted: female)</td>
<td>0.42</td>
<td>0.49</td>
</tr>
<tr>
<td>Race (omitted: white)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>0.09</td>
<td>0.29</td>
</tr>
<tr>
<td>Hispanic</td>
<td>0.02</td>
<td>0.13</td>
</tr>
<tr>
<td>Other non-white</td>
<td>0.01</td>
<td>0.10</td>
</tr>
<tr>
<td>Veteran</td>
<td>0.23</td>
<td>0.42</td>
</tr>
<tr>
<td>Birth decade (0  \equiv  1900)</td>
<td>1.63</td>
<td>0.81</td>
</tr>
<tr>
<td><strong>Time-varying individual characteristics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (range: 65-106 years)</td>
<td>75.67</td>
<td>7.11</td>
</tr>
<tr>
<td>Rural resident (omitted: urban)</td>
<td>0.27</td>
<td>0.45</td>
</tr>
<tr>
<td>Marital status (omitted: married)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Widowed</td>
<td>0.38</td>
<td>0.49</td>
</tr>
<tr>
<td>Divorced, separated, or single</td>
<td>0.06</td>
<td>0.24</td>
</tr>
<tr>
<td>Annual income (000's of year 2001 $)</td>
<td>26.58</td>
<td>57.49</td>
</tr>
</tbody>
</table>
Exogenous Variables used for Identification

<table>
<thead>
<tr>
<th>Role</th>
<th>Variable Name</th>
<th>Variation</th>
<th>Mean</th>
<th>Std Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>Availability/Price of Insurance</td>
<td>% of county HMO enrolled</td>
<td>County, Year</td>
<td>18.91</td>
<td>14.14</td>
</tr>
<tr>
<td>Price of hospitalization</td>
<td>Medicare AAPCC part A rate</td>
<td>County, Year</td>
<td>350.07</td>
<td>230.75</td>
</tr>
<tr>
<td>Price of physician services</td>
<td>Medicare AAPCC part B rate</td>
<td>County, Year</td>
<td>226.56</td>
<td>140.53</td>
</tr>
<tr>
<td>Price of prescription drugs</td>
<td>Average pres. drug retail price</td>
<td>State, Year</td>
<td>41.01</td>
<td>5.49</td>
</tr>
<tr>
<td>Price of prescription drugs</td>
<td>Live &lt;100 miles from border</td>
<td>Zip code, Year</td>
<td>0.17</td>
<td>0.37</td>
</tr>
<tr>
<td>Supply of physicians</td>
<td># of physicians/1000 elderly</td>
<td>County, Year</td>
<td>18.01</td>
<td>14.26</td>
</tr>
<tr>
<td>Supply of hospitals</td>
<td># of hospitals/1000 elderly</td>
<td>County, Year</td>
<td>0.18</td>
<td>0.18</td>
</tr>
<tr>
<td>Supply of hospital beds</td>
<td># of hospitals beds/1000 elderly</td>
<td>County, Year</td>
<td>30.52</td>
<td>22.12</td>
</tr>
<tr>
<td>Exogenous shift in health</td>
<td>Median air quality index</td>
<td>County, Year</td>
<td>34.79</td>
<td>11.04</td>
</tr>
<tr>
<td>Exogenous variable in initial conditions</td>
<td>Initial height (range: 36-88 in)</td>
<td>Individual</td>
<td>65.67</td>
<td>3.99</td>
</tr>
</tbody>
</table>
## Endogenous Variables

<table>
<thead>
<tr>
<th>Notation</th>
<th>Variable Name</th>
<th>Specification</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>$I_t$</td>
<td>Supplemental insurance plan in $t$</td>
<td>multinomial</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Medicare only (no supplement)</td>
<td>logit</td>
<td>8.05</td>
</tr>
<tr>
<td></td>
<td>Medicaid</td>
<td></td>
<td>11.96</td>
</tr>
<tr>
<td></td>
<td>Private plan</td>
<td></td>
<td>64.43</td>
</tr>
<tr>
<td></td>
<td>Part C plan</td>
<td></td>
<td>15.56</td>
</tr>
<tr>
<td>$J_t$</td>
<td>Prescription drug coverage in $t$</td>
<td>logit</td>
<td>62.99</td>
</tr>
<tr>
<td></td>
<td>conditional on private or Part C plan</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$S_t$</td>
<td>Health shock in $t$</td>
<td>logit</td>
<td>24.47</td>
</tr>
<tr>
<td></td>
<td>Heart/stroke (ICD-9 390-439)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Respiratory (ICD-9 480-496)</td>
<td></td>
<td>4.79</td>
</tr>
<tr>
<td></td>
<td>Cancer (ICD-9 140-209)</td>
<td></td>
<td>5.70</td>
</tr>
<tr>
<td>$A_t &gt; 0$</td>
<td>Any hospitalization in $t$</td>
<td>logit</td>
<td>20.82</td>
</tr>
<tr>
<td>$B_t &gt; 0$</td>
<td>Any physician service use in $t$</td>
<td>logit</td>
<td>83.79</td>
</tr>
<tr>
<td>$D_t &gt; 0$</td>
<td>Any prescription drug use in $t$</td>
<td>logit</td>
<td>89.58</td>
</tr>
<tr>
<td>$A_t</td>
<td>A_t &gt; 0$</td>
<td>Hospital expenditures in $t$</td>
<td>OLS</td>
</tr>
<tr>
<td>$B_t</td>
<td>B_t &gt; 0$</td>
<td>Physician service expenditures in $t$</td>
<td>OLS</td>
</tr>
<tr>
<td>$D_t</td>
<td>D_t &gt; 0$</td>
<td>Prescription drug expenditures in $t$</td>
<td>OLS</td>
</tr>
</tbody>
</table>

**Identification**  | **Description of Data**  | **Functional Status or Chronic Condition/Health Shock Equations**
## Endogenous Variables - continued

<table>
<thead>
<tr>
<th>Notation</th>
<th>Variable Name</th>
<th>Specification</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>$F_{t+1}$</td>
<td>Functional status entering $t + 1$ (at end of $t$)</td>
<td>multinomial</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Not disabled (no ADL or IADLs)</td>
<td>logit</td>
<td>57.74</td>
</tr>
<tr>
<td></td>
<td>Moderately disabled (IADL or $&lt; 3$ ADLs)</td>
<td></td>
<td>28.05</td>
</tr>
<tr>
<td></td>
<td>Severely disabled (3 or more ADLs)</td>
<td></td>
<td>9.62</td>
</tr>
<tr>
<td></td>
<td>Dead</td>
<td></td>
<td>4.59</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>$E_{t+1}$</th>
<th>Chronic conditions entering $t + 1$ (at end of $t$)</th>
<th>(E_{t+1} = E_t + S_t, t = 1, \ldots, T)</th>
<th>(E_1 = E_0) where (E_0) includes shocks at period $t = 0^c$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$E_0$</td>
<td>Heart/stroke</td>
<td>logit</td>
<td>46.68</td>
</tr>
<tr>
<td></td>
<td>Respiratory</td>
<td>logit</td>
<td>15.02</td>
</tr>
<tr>
<td></td>
<td>Cancer</td>
<td>logit</td>
<td>19.26</td>
</tr>
<tr>
<td></td>
<td>Diabetes</td>
<td>logit</td>
<td>19.73</td>
</tr>
</tbody>
</table>
# Initial Condition Equations

<table>
<thead>
<tr>
<th>Notation</th>
<th>Variable Name</th>
<th>Specification</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>$E_0$</td>
<td>Existing chronic conditions up to and including $t = 0$</td>
<td>logit</td>
<td>46.68</td>
</tr>
<tr>
<td></td>
<td>Heart/stroke</td>
<td>logit</td>
<td>46.68</td>
</tr>
<tr>
<td></td>
<td>Respiratory</td>
<td>logit</td>
<td>15.02</td>
</tr>
<tr>
<td></td>
<td>Cancer</td>
<td>logit</td>
<td>19.26</td>
</tr>
<tr>
<td></td>
<td>Diabetes</td>
<td>logit</td>
<td>19.73</td>
</tr>
<tr>
<td>$I_0$</td>
<td>Supplemental insurance in $t = 0$</td>
<td>multinomial</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Medicare only (no supplement)</td>
<td>logit</td>
<td>8.63</td>
</tr>
<tr>
<td></td>
<td>Medicaid</td>
<td></td>
<td>11.53</td>
</tr>
<tr>
<td></td>
<td>Private plan</td>
<td></td>
<td>64.90</td>
</tr>
<tr>
<td></td>
<td>Part C plan</td>
<td></td>
<td>14.94</td>
</tr>
<tr>
<td>$J_0$</td>
<td>Prescription drug coverage in $t = 0$</td>
<td>logit</td>
<td>61.83</td>
</tr>
<tr>
<td></td>
<td>conditional on private or Part C plan</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$A_0 &gt; 0$</td>
<td>Any hospitalization in $t = 0$</td>
<td>logit</td>
<td>17.33</td>
</tr>
<tr>
<td>$B_0 &gt; 0$</td>
<td>Any physician service use in $t = 0$</td>
<td>logit</td>
<td>84.91</td>
</tr>
<tr>
<td>$D_0 &gt; 0$</td>
<td>Any prescription drug use in $t = 0$</td>
<td>logit</td>
<td>89.22</td>
</tr>
<tr>
<td>$F_1$</td>
<td>Functional status entering $t = 1$ (at end of $t = 0$)</td>
<td>multinomial</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No disability (no ADL or IADLs)</td>
<td>logit</td>
<td>62.46</td>
</tr>
<tr>
<td></td>
<td>Moderately disabled (IADL or up to 2 ADLs)</td>
<td></td>
<td>28.31</td>
</tr>
<tr>
<td></td>
<td>Severely disabled (3 or more ADLs)</td>
<td></td>
<td>9.23</td>
</tr>
</tbody>
</table>

Description of Data Identification Initial Condition Equations
# Five-year Simulations — With Unobserved Heterogeneity

<table>
<thead>
<tr>
<th></th>
<th>Medicare only</th>
<th>Medicaid</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Health Outcomes in the 5th year</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Survival</td>
<td>73.54</td>
<td>76.28</td>
<td>2.75</td>
</tr>
<tr>
<td>Not disabled</td>
<td>64.82</td>
<td>62.77</td>
<td>-2.05</td>
</tr>
<tr>
<td>Moderately disabled</td>
<td>26.22</td>
<td>27.33</td>
<td>1.11</td>
</tr>
<tr>
<td>Severely disabled</td>
<td>8.96</td>
<td>9.90</td>
<td>0.93</td>
</tr>
</tbody>
</table>

| **Medical Care Expenditures over 5 years** |               |          |    |
| Rx expenditures        | 4,176         | 5,283    | 26.51|
| Hospital expenditures   | 11,306        | 10,628   | -6.00|
| Physician expenditures  | 6,026         | 8,024    | 33.16|
| Total expenditures      | 21,508        | 23,935   | 11.28|

Without unobserved heterogeneity

Simulation
### Health Outcomes in the 5th year

<table>
<thead>
<tr>
<th></th>
<th>Medicare only</th>
<th>Private no Rx</th>
<th>% △*</th>
<th>Private with Rx</th>
<th>% △*</th>
<th>Part C no Rx</th>
<th>% △*</th>
<th>Part C with Rx</th>
<th>% △*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Survival</strong></td>
<td>73.54</td>
<td>74.56</td>
<td>1.02</td>
<td>75.10</td>
<td>1.57</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Not disabled</strong></td>
<td>64.82</td>
<td>63.38</td>
<td>-1.44</td>
<td>61.90</td>
<td>-2.92</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Moderately disabled</strong></td>
<td>26.22</td>
<td>26.90</td>
<td>0.69</td>
<td>27.63</td>
<td>1.41</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Severely disabled</strong></td>
<td>8.96</td>
<td>9.72</td>
<td>0.75</td>
<td>10.47</td>
<td>1.51</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Medical Care Expenditures over 5 years

<table>
<thead>
<tr>
<th></th>
<th>Rx expenditures</th>
<th>4,176</th>
<th>4,434</th>
<th>6.18</th>
<th>5,439</th>
<th>30.24</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hospital expenditures</td>
<td>11,306</td>
<td>11,689</td>
<td>3.39</td>
<td>12,931</td>
<td>14.37</td>
</tr>
<tr>
<td></td>
<td>Physician expenditures</td>
<td>6,026</td>
<td>8,407</td>
<td>39.51</td>
<td>8,808</td>
<td>46.17</td>
</tr>
<tr>
<td></td>
<td>Total expenditures</td>
<td>21,508</td>
<td>24,530</td>
<td>14.05</td>
<td>27,178</td>
<td>26.36</td>
</tr>
</tbody>
</table>

Without unobserved heterogeneity

Simulation
### Five-year Simulations — With Unobserved Heterogeneity

<table>
<thead>
<tr>
<th></th>
<th>Medicare only</th>
<th>Private no Rx</th>
<th>% △ *</th>
<th>Private with Rx</th>
<th>% △ *</th>
<th>Part C no Rx</th>
<th>% △ *</th>
<th>Part C with Rx</th>
<th>% △ *</th>
</tr>
</thead>
</table>

#### Health Outcomes in the 5th year

<table>
<thead>
<tr>
<th>Outcome</th>
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<th>Private no Rx</th>
<th>% △ *</th>
<th>Medicare only</th>
<th>Private no Rx</th>
<th>% △ *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Survival</td>
<td>73.54</td>
<td>74.56</td>
<td>1.02</td>
<td>75.10</td>
<td>1.57</td>
<td>72.71</td>
</tr>
<tr>
<td>Not disabled</td>
<td>64.82</td>
<td>63.38</td>
<td>-1.44</td>
<td>61.90</td>
<td>-2.92</td>
<td>64.09</td>
</tr>
<tr>
<td>Moderately disabled</td>
<td>26.22</td>
<td>26.90</td>
<td>0.69</td>
<td>27.63</td>
<td>1.41</td>
<td>26.79</td>
</tr>
<tr>
<td>Severely disabled</td>
<td>8.96</td>
<td>9.72</td>
<td>0.75</td>
<td>10.47</td>
<td>1.51</td>
<td>9.47</td>
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</tbody>
</table>

#### Medical Care Expenditures over 5 years

<table>
<thead>
<tr>
<th>Expenditure</th>
<th>Medicare only</th>
<th>Private no Rx</th>
<th>% △ *</th>
<th>Medicare only</th>
<th>Private no Rx</th>
<th>% △ *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rx expenditures</td>
<td>4,176</td>
<td>4,434</td>
<td>6.18</td>
<td>5,439</td>
<td>30.24</td>
<td>4,627</td>
</tr>
<tr>
<td>Hospital expenditures</td>
<td>11,306</td>
<td>11,689</td>
<td>3.39</td>
<td>12,931</td>
<td>14.37</td>
<td>11,343</td>
</tr>
<tr>
<td>Physician expenditures</td>
<td>6,026</td>
<td>8,407</td>
<td>39.51</td>
<td>8,808</td>
<td>46.17</td>
<td>3,951</td>
</tr>
<tr>
<td>Total expenditures</td>
<td>21,508</td>
<td>24,530</td>
<td>14.05</td>
<td>27,178</td>
<td>26.36</td>
<td>19,921</td>
</tr>
</tbody>
</table>

Without unobserved heterogeneity

Simulation
### Five-year Simulations — Without Unobserved Heterogeneity

<table>
<thead>
<tr>
<th></th>
<th>Medicare only</th>
<th>Medicaid</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health Outcomes in the 5th year</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Survival</td>
<td>71.10</td>
<td>74.28</td>
<td>3.18</td>
</tr>
<tr>
<td>Not disabled</td>
<td>66.07</td>
<td>63.16</td>
<td>−2.91</td>
</tr>
<tr>
<td>Moderately disabled</td>
<td>25.47</td>
<td>27.02</td>
<td>1.54</td>
</tr>
<tr>
<td>Severely disabled</td>
<td>8.46</td>
<td>9.82</td>
<td>1.36</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Medical Care Expenditures over 5 years</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Rx expenditures</td>
<td>3,217</td>
<td>4,381</td>
<td>36.18</td>
</tr>
<tr>
<td>Hospital expenditures</td>
<td>12,557</td>
<td>13,663</td>
<td>8.81</td>
</tr>
<tr>
<td>Physician expenditures</td>
<td>4,607</td>
<td>7,143</td>
<td>55.05</td>
</tr>
<tr>
<td>Total expenditures</td>
<td>20,381</td>
<td>25,187</td>
<td>23.58</td>
</tr>
</tbody>
</table>

*With unobserved heterogeneity: Simulation*
# Five-year Simulations — Without Unobserved Heterogeneity

<table>
<thead>
<tr>
<th></th>
<th>Medicare only</th>
<th>Private no Rx</th>
<th>%</th>
<th>Private with Rx</th>
<th>%</th>
<th>Part C no Rx</th>
<th>%</th>
<th>Part C with Rx</th>
<th>%</th>
</tr>
</thead>
</table>

## Health Outcomes in the 5th year

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Medicare only</th>
<th>Private no Rx</th>
<th>%</th>
<th>Private with Rx</th>
<th>%</th>
<th>Part C no Rx</th>
<th>%</th>
<th>Part C with Rx</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Survival</td>
<td>71.10</td>
<td>73.53</td>
<td>2.43</td>
<td>75.57</td>
<td>4.47</td>
<td>71.07</td>
<td>-0.03</td>
<td>70.44</td>
<td>-0.66</td>
</tr>
<tr>
<td>Not disabled</td>
<td>66.07</td>
<td>64.07</td>
<td>-2.00</td>
<td>62.43</td>
<td>-3.63</td>
<td>65.50</td>
<td>-0.57</td>
<td>64.60</td>
<td>-1.47</td>
</tr>
<tr>
<td>Moderately disabled</td>
<td>25.47</td>
<td>26.50</td>
<td>1.03</td>
<td>27.47</td>
<td>2.00</td>
<td>26.01</td>
<td>0.53</td>
<td>26.58</td>
<td>1.11</td>
</tr>
<tr>
<td>Severely disabled</td>
<td>8.46</td>
<td>9.43</td>
<td>0.97</td>
<td>10.10</td>
<td>1.64</td>
<td>8.50</td>
<td>0.04</td>
<td>8.82</td>
<td>0.36</td>
</tr>
</tbody>
</table>

## Medical Care Expenditures over 5 years

<table>
<thead>
<tr>
<th>Expenditure</th>
<th>Medicare only</th>
<th>Private no Rx</th>
<th>%</th>
<th>Private with Rx</th>
<th>%</th>
<th>Part C no Rx</th>
<th>%</th>
<th>Part C with Rx</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospital expenditures</td>
<td>12,557</td>
<td>13,649</td>
<td>8.70</td>
<td>13,708</td>
<td>9.17</td>
<td>10,746</td>
<td>-14.42</td>
<td>11,939</td>
<td>-4.92</td>
</tr>
<tr>
<td>Physician expenditures</td>
<td>4,607</td>
<td>6,827</td>
<td>48.19</td>
<td>6,927</td>
<td>50.36</td>
<td>2,893</td>
<td>-37.20</td>
<td>2,322</td>
<td>-49.60</td>
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<tr>
<td>Total expenditures</td>
<td>20,381</td>
<td>24,336</td>
<td>19.41</td>
<td>25,757</td>
<td>26.38</td>
<td>17,164</td>
<td>-15.78</td>
<td>18,104</td>
<td>-11.17</td>
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</table>

With unobserved heterogeneity Simulation
## Sole Survivors vs. Marginal Survivors — 5-year Expenditures

<table>
<thead>
<tr>
<th></th>
<th>Medicaid Marginal</th>
<th>Medicaid Sole</th>
<th>Private, with Rx Marginal</th>
<th>Private, with Rx Sole</th>
<th>Part C, with Rx Marginal</th>
<th>Part C, with Rx Sole</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Prescription drug expenditures</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medicare only</td>
<td>2,031</td>
<td>4,934</td>
<td>1,656</td>
<td>4,938</td>
<td>1,774</td>
<td>4,962</td>
</tr>
<tr>
<td>Plan with Rx coverage</td>
<td>6,359</td>
<td>6,093</td>
<td>6,557</td>
<td>6,313</td>
<td>6,424</td>
<td>5,823</td>
</tr>
<tr>
<td>%Δ</td>
<td><strong>213.10</strong></td>
<td><strong>23.49</strong></td>
<td><strong>295.95</strong></td>
<td><strong>27.85</strong></td>
<td><strong>262.12</strong></td>
<td><strong>17.35</strong></td>
</tr>
<tr>
<td><strong>Hospital expenditures</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medicare only</td>
<td>14,008</td>
<td>10,121</td>
<td>11,699</td>
<td>10,122</td>
<td>15,106</td>
<td>10,142</td>
</tr>
<tr>
<td>Plan with Rx coverage</td>
<td>16,057</td>
<td>9,264</td>
<td>18,952</td>
<td>11,482</td>
<td>21,184</td>
<td>11,692</td>
</tr>
<tr>
<td>%Δ</td>
<td><strong>14.63</strong></td>
<td><strong>–8.47</strong></td>
<td><strong>62.00</strong></td>
<td><strong>13.44</strong></td>
<td><strong>40.24</strong></td>
<td><strong>15.28</strong></td>
</tr>
<tr>
<td><strong>Physician service expenditures</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medicare only</td>
<td>4,566</td>
<td>6,443</td>
<td>3,686</td>
<td>6,417</td>
<td>5,003</td>
<td>6,394</td>
</tr>
<tr>
<td>Plan with Rx coverage</td>
<td>11,297</td>
<td>8,488</td>
<td>11,651</td>
<td>9,393</td>
<td>5,365</td>
<td>3,376</td>
</tr>
<tr>
<td>%Δ</td>
<td><strong>147.42</strong></td>
<td><strong>31.74</strong></td>
<td><strong>216.09</strong></td>
<td><strong>46.38</strong></td>
<td><strong>7.24</strong></td>
<td><strong>–47.20</strong></td>
</tr>
<tr>
<td><strong>Total medical care expenditures</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medicare only</td>
<td>20,605</td>
<td>21,498</td>
<td>17,041</td>
<td>21,477</td>
<td>21,883</td>
<td>21,498</td>
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<tr>
<td>Plan with Rx coverage</td>
<td>33,713</td>
<td>23,845</td>
<td>37,160</td>
<td>27,188</td>
<td>32,973</td>
<td>20,891</td>
</tr>
<tr>
<td>%Δ</td>
<td><strong>63.62</strong></td>
<td><strong>10.92</strong></td>
<td><strong>118.06</strong></td>
<td><strong>26.59</strong></td>
<td><strong>50.68</strong></td>
<td><strong>–2.82</strong></td>
</tr>
</tbody>
</table>

5th year outcomes

Initial condition

Simulation

- p. 39
## Sole Survivors vs. Marginal Survivors — Initial Condition

<table>
<thead>
<tr>
<th></th>
<th>Medicaid</th>
<th>Private, with Rx</th>
<th>Part C, with Rx</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Marginal</td>
<td>Sole</td>
<td>Marginal</td>
</tr>
<tr>
<td>Age</td>
<td>76.71</td>
<td>73.37</td>
<td>76.71</td>
</tr>
<tr>
<td>Male</td>
<td>0.44</td>
<td>0.40</td>
<td>0.43</td>
</tr>
<tr>
<td>Height</td>
<td>65.73</td>
<td>65.69</td>
<td>65.68</td>
</tr>
<tr>
<td>Moderately disabled</td>
<td>0.34</td>
<td>0.26</td>
<td>0.33</td>
</tr>
<tr>
<td>Severely disabled</td>
<td>0.12</td>
<td>0.06</td>
<td>0.12</td>
</tr>
<tr>
<td>Chronic condition: heart/stroke</td>
<td>0.53</td>
<td>0.42</td>
<td>0.52</td>
</tr>
<tr>
<td>Chronic condition: respiratory</td>
<td>0.17</td>
<td>0.13</td>
<td>0.16</td>
</tr>
<tr>
<td>Chronic condition: cancer</td>
<td>0.24</td>
<td>0.16</td>
<td>0.23</td>
</tr>
<tr>
<td>Chronic condition: diabetes</td>
<td>0.22</td>
<td>0.19</td>
<td>0.2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>5-year expenditures</th>
<th>5th year outcomes</th>
<th>Simulation</th>
</tr>
</thead>
</table>
Actual and Simulated Annual Mortality Rate, by Age

Description of Data

Equation Specification or Results
Actual and Simulated Hospital Use and Expenditures, by Age

Description of Data

Equation Specification or Results
Actual and Simulated Physician Services Use and Expenditures, by Age

Description of Data

Equation Specification or Results

Data Description

Graphs showing the probability of physician service use and prescription service expenditures, with actual and simulated data for different age groups. The graphs compare these metrics across age from 65 to 100, with simulated data indicated by blue circles (MCBS) and actual data indicated by red squares (Simulated).
Actual and Simulated Prescription Drug Use and Expenditures, by Age

Description of Data

Equation Specification or Results
Physician Services Use and Expenditures, by Age and Death

Description of Data

Equation Specification or Results
Prescription Drug Use and Expenditures, by Age and Death
Unobserved Heterogeneity Distribution

Permanent Individual Heterogeneity

<table>
<thead>
<tr>
<th>Probability</th>
<th>( \theta_1 )</th>
<th>( \theta_2 )</th>
<th>( \theta_3 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \mu_1 )</td>
<td>0.00</td>
<td>0.24</td>
<td></td>
</tr>
<tr>
<td>( \mu_2 )</td>
<td>0.42</td>
<td>0.40</td>
<td></td>
</tr>
<tr>
<td>( \mu_3 )</td>
<td>1.00</td>
<td>0.36</td>
<td></td>
</tr>
</tbody>
</table>

Time-Varying Individual Heterogeneity

<table>
<thead>
<tr>
<th>Probability</th>
<th>( \psi_1 )</th>
<th>( \psi_2 )</th>
<th>( \psi_3 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \nu_{1t} )</td>
<td>0.12</td>
<td>0.64</td>
<td>0.26</td>
</tr>
<tr>
<td>( \nu_{2t} )</td>
<td>0.62</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \nu_{3t} )</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Identification | Equation Specification | Results
So, this is what we propose . . .

- Model the behavior of individuals age 65+ over time (1992-2001)
- Model the presence of chronic conditions when first observed
- Model the supplemental insurance choices of the elderly
- Model the demand for hospital services (part A), physician services (part B), and prescription drugs
- Model health shocks each year: either onset of chronic conditions or complications of existing chronic conditions
- Model the end-of-year health stock transitions (i.e., the health production function)
- And model the set of equations jointly, allowing unobserved components to be correlated
So, this is what we propose . . .

- Model the behavior of individuals age 65+ over time (1992-2001)
So, this is what we propose . . .

- Model the behavior of individuals age 65+ over time (1992-2001)
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So, this is what we propose . . .

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- Model the behavior of individuals age 65+ over time (1992-2001)
- Model the presence of chronic conditions when first observed
- Model the supplemental insurance choices of the elderly
- Model the demand for hospital services (part A), physician services (part B), and prescription drugs
- Model health shocks each year: either onset of chronic conditions or complications of existing chronic conditions
- Model the end-of-year health stock transitions (i.e., the health production function)
- And model the set of equations jointly, allowing unobserved components to be correlated
But we have a few caveats!

Believe it or not, "finding" a positive effect of medical care on health is difficult. Observed health is multidimensional and unobserved health is even more multi-faceted. Our demand models are approximations. The many dynamic relationships complicate interpretation, but better mimic reality.
But we have a few caveats!

Believe it or not, "finding" a positive effect of medical care on health is difficult.
But we have a few caveats!

- Believe it or not, "finding" a positive effect of medical care on health is difficult.
- Observed health is multidimensional . . . and unobserved health is even more multi-faceted.
But we have a few caveats!

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- Our demand models are approximations.
But we have a few caveats!

• Believe it or not, "finding" a positive effect of medical care on health is difficult.

• Observed health is multidimensional . . . and unobserved health is even more multi-faceted.

• Our demand models are approximations.

• The many dynamic relationships complicate interpretation, but better mimic reality.
A few numbers . . .

- National health expenditures around 16% of GDP
- The elderly (65+) make up 13% of the population
- but consume 36% of the personal health care expenditures
- Medicare pays for about 17% of our nation’s health expenditures

Introduction
Source of Health Insurance Among Elderly

Medicare (part A & B) only 8 %
Dual coverage with Medicaid 12 %
Medicare managed care (part C) 16 %
Private supplemental coverage 64 %
Source of Health Insurance Among Elderly

Medicare (part A & B) only 8 %
Dual coverage with Medicaid 12 %
Medicare managed care (part C) 16 %
Private supplemental coverage 64 %

Medicare managed care with Rx coverage 85 %
Private supplemental with Rx coverage 58 %

Introduction