The Boomers Are Coming: A Total Cost of Care Model of the Impact of Population Aging on Health Care Costs in the United States by Major Practice Category

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Objective. To project the impact of population aging on total U.S. health care per capita costs from 2000 to 2050 and for the range of clinical areas defined by Major Practice Categories (MPCs).

Data Sources. Secondary data: HealthPartners health plan administrative data; U.S. Census Bureau population projections 2000–2050; and MEPS 2001 health care annual per capita costs.

Study Design. We calculate MPC-specific age and gender per capita cost rates using cross-sectional data for 2002–2003 and project U.S. changes by MPC due to aging from 2000 to 2050.

Data Collection Methods. HealthPartners data were grouped using purchased software. We developed and validated a method to include pharmacy costs for the uncovered.

Principal Findings. While total U.S. per capita costs due to aging from 2000 to 2050 are projected to increase 18 percent (0.3 percent annually), the impact by MPC ranges from a 55 percent increase in kidney disorders to a 12 percent decrease in pregnancy and infertility care. Over 80 percent of the increase in total per capita cost will result from just seven of the 22 total MPCs.

Conclusions. Understanding the differential impact of aging on costs at clinically specific levels is important for resource planning, to effectively address future medical needs of the aging U.S. population.

Key Words. Aging/elderly/geriatrics, administrative data uses, demography, health care costs, access/demand/utilization of services, health planning, health policy, physician training

Our work models the impact of population aging on health care costs in the United States over the next five decades, at an aggregate and clinical level. In the context of many years of increasing health care costs, future cost concerns have centered on the Baby Boom generation: the cohort of 74 million people born in the years 1946–1964 after World War II. The impact of population aging on these costs has become a frequently cited concern in the literature and popular media (Halvorson 2004; Kotlikoff and Burnes 2004; Worldwide Watson Wyatt 1996). While studies have discounted population aging as a factor to explain recent health care cost increases, the baby boom generation ranges from ages 42 to 60 in 2006, well before age-specific costs increase dramatically (Heffler et al. 2003; Meara, White, and Cutler 2004).

Whether the total projected cost increase due to aging applies evenly across body systems, or whether and to what extent aging will have an impact on some body systems more than others, has been unknown. Understanding the differential impact of aging at a disaggregated clinically related level is critical to key stakeholders of the complex U.S. health care “system” such as providers, hospitals, health plans, training organizations, governments, drug companies, device manufacturers, and policy makers, as they plan to meet future age-related health care demands (Cooper 2004).

Several studies of the impact of aging on total health care costs in different populations have similar overall findings. The Australian population’s changing age structure is projected to account for a 0.6 percent annual increase in total health spending from 1995 to 2051 (Richardson and Robertson 1999). In a 1992 study of projected U.S. health care costs to 2030, population aging accounts for a 0.5 percent annual increase in costs (Burner, Waldo, and McKusick 1992). A more recent U.S. study projected per capita health care costs from 2000 to 2030 will increase 20 percent due to aging, or 0.6 percent/year (Alemayehu and Warner 2004). For Americans under age 65, the projected impact of aging is less than 1 percent annual cost growth from 2000 to 2010 (Strunk and Ginsburg 2002). A projection of aggregate personal health spending from 1990 to 2030 shows age-gender factors accounting for 5 percent of total personal health spending in 2030 (Burner et al. 1992; Reinhardt 2002). For the Medicare pop-

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ulation only, the projected annual increase in costs per capita due to aging from 1992 to 2050 is 0.14 percent (Cutler and Sheiner 1998b).

The present study extends the upper range of age- and gender-specific cost rates to ages 100 and above, which is beyond the more commonly reported upper age ranges of 75+ or 85+ (Cutler and Sheiner 1998b; Richardson and Robertson 1999; Alemayehu and Warner 2004; Meara et al. 2004). Our finer disaggregation increases precision to both the overall and detailed cost projections by reflecting variability in per capita cost rates by age and gender. We also extend others' work by examining the impact of aging on medical costs using the entire age range of the population, as opposed to only the working or senior populations used in some studies.

Our model incorporates a commercially available, reputable, and replicable categorization methodology, which we use to decompose the total projected per capita cost increases into clinically related categories. Projected costs reflect a societal view for all health plan services and thus represent a broad view of the total cost of medical care.

METHODS

The model's building blocks are annualized age- and gender-specific per capita cost rates at an episode of care level. The steps to create the model are:

Compile the Data

The study's primary data sources are from HealthPartners, a Minnesota health plan with approximately 610,000 members, based in the Twin Cities. The 2002–2003 data comprise over 1.2 million person-years of medical care. We include administrative medical claims data for all fully and self-insured members with Commercial, Medicare+Choice (a Medicare HMO plan), and Medicaid products. We exclude data for members of HealthPartners' Medicare supplemental product in order to not understate per capita costs since, as secondary payer, the health plan does not have a complete record of their total health costs. For the few members who have both Medicare primary coverage and Medicaid secondary, we exclude the component of costs Medicaid covers, in order to avoid any possibility of double counting costs. As their Medicaid coverage is usually for modest copays, this approach minimally understates per capita costs for these members. The model does not include long-term facility costs and nursing home costs not covered by the health plan. It represents a societal view of all medical costs as we include the total amount

paid to providers from all sources for services covered by the health plan: health plan payments, member out-of-pocket payments, and coordination of benefits.

We chose to use our health plan data instead of publicly available data for a number of reasons. While the Medicare Current Beneficiary Survey (MCBS) and the Medical Expenditure Panel Survey (MEPS) represent national samples, our population-based geographical data includes all ages of the population (Centers for Medicare and Medicaid Services 2001; Medical Expenditure Panel Survey 2001). Of importance to the reliability of projections by detailed MPC, our model includes 60,000 person-years of medical experience for people over age 65—five times the number of respondents in the MCBS (Centers for Medicare and Medicaid Services 2001). Our population is also substantially larger than the MEPS 2001 sample of 13,500 families (Medical Expenditure Panel Survey 2001). This robust characteristic extends to the oldest age ranges, as the model includes over 500 person-years for ages older than 95 and nearly 100 person-years for ages 100+.

Calculate Age for All Members

Following NCQA's methods for HEDIS reporting, we calculate age separately for 2002 and 2003, as of 12/31 of each year (NCQA 2004).

Select Costs and Adjust 2002–2003 Using Medical Cost Inflation Factor

In order to report all dollars in 2003 terms, we apply the Medical Consumer Price Index of 4.4 percent at the claim level to all 2002 services (U.S. Bureau of Labor Statistics 2002–2003).

Group Claims into Episodes of Care

Using Symmetry's Episodes Treatment Group (ETG) software (Symmetry TM Ingenix 2004) we group medical and pharmacy claims, and demographic information into clinically meaningful units that represent individual episodes of care (episodes). All medical care can be categorized into ETGs, which are aggregated into Major Practice Categories (MPCs). The model includes 4.7 million episodes comprising \$3.2 billion in claims. To create episodes, cost and utilization data from multiple settings, including hospital inpatient, professional, hospital outpatient, hospital-scheduled outpatient, and pharmacy are grouped into episode units. These units include all services related to treatment for a particular episode for an individual. While a given person can have multiple episodes, each claim line is assigned to only one episode. In this

way, services and costs are counted only once and are grouped with all other care for a particular episode. For example, during a given time period, a person may have medical care for coronary disease with AMI, diabetes type II with comorbidities, and receive a flu vaccine. All care related to each of these conditions will be grouped to only the individual episode of care to which it applies. Individual episodes are aggregated to the ETG related to that condition or disorder. To capture total costs, we include both complete (74 percent of total costs) and incomplete (26 percent of total costs) episodes of care. Incomplete episodes are those which started during the study period but were not completed by the study period's end (Symmetry TM Ingenix 2004). This study models per capita costs, not per episode costs, so the incompleteness of some episodes does not compromise the findings.

At the ETG Level, Calculate and Add-In Pharmacy Costs That Need to be Estimated for Members without Pharmacy Coverage

Pharmacy costs make up 20 percent of total U.S. medical costs and are of particular interest because of the 2003 legislation which added a pharmacy benefit to Medicare (Strunk, Ginsburg, and Gabel 2002; Centers for Medicare and Medicaid Services 2003). We developed a method to estimate and include pharmacy costs for members without this benefit (11.2 percent of all members). We first created a validation dataset using a random sample of 20 percent of all episodes for members with pharmacy coverage and then tested several methods for calculating pharmacy costs for the 80 percent of remaining claims. The method with the highest accuracy, as measured against the validation sample, is to remove outliers within each ETG and assign each episode the average pharmacy cost within that ETG, aggregating two averages by the large age groups of under and over 18. This method results in a total predicted pharmacy cost that only varies by 0.5 percent from the actual pharmacy costs in the validation sample. Estimated pharmacy costs are only 1.5 percent of all costs reported in the study.

Aggregate ETGs into MPCs

We aggregate data for the 574 ETGs into 22 MPCs. As standard MPC names can make the categories sound specialty-based, and because many MPCs can be treated by providers in more than one specialty, for clarity we use terminology developed at HealthPartners to emphasize the conditions and disorders reflected within each MPC. For example, we use "Lung Conditions"

instead of “pulmonology” and “pregnancy and infertility care” instead of “obstetrics.”

Calculate Annualized Costs by Age, Gender, and MPC

We calculate per capita per month cost rates for each age, gender, and MPC cell and multiply each ratio by 12 to annualize it. The numerator is the adjusted costs during 2002–2003 for each age, gender, and MPC, and the denominator is the sum of member months in the entire population for each age and gender during 2002–2003. Incorporating member months into the equation appropriately apportions costs for members who are enrolled in the health plan for only a fraction of a calendar year. Treating their partial year costs as the total for an entire year would underreport the true cost per member, as it assumes the member was at risk for incurring medical costs for an entire year. As member turnover rates differ across product types, and, thus, age groups, using member months allows us to more precisely calculate and project age-specific annual costs. We aggregate annualized per capita costs by 5-year age group, gender, and MPC. The upper age range is 100–105+.

Adjust Costs to a National Perspective

To extrapolate HealthPartners’ annualized per capita costs to a more meaningful national perspective, we utilize MEPS data. We base an estimate of total national health care costs per capita in 2003 on the reported MEPS rate of \$2,555 and increase it for inflation (Medical Expenditure Panel Survey 2001; U.S. Bureau of Labor Statistics 2002–2003). We exclude dental costs (8.2 percent), as they are not included in the health plan data (Medical Expenditure Panel Survey 2001). The revised total health care costs per capita in the United States in 2003 dollars are $((\$2,555) \times (91.8 \text{ percent})) \times (1.0534) \times (1.0436) = \$2,579$. We calculate the ratio of HealthPartners’ total cost per capita to this national total health care cost per capita and apply it to HealthPartners’ annualized per capita cost rates by 5-year age-, gender-, and MPC-group.

Apply National Cost Rates to the Projected National Age Structure through 2050

We aggregate U.S. population projections by age and gender from the United States Census Bureau for 2000–2050 into 5-year age groups. The projections are based on the cohort-component method in which expected births, deaths, and net migration are applied to the United States Census year 2000 base population and the population is “aged” forward (U.S. Census Bureau 2004). Total fertility is projected to rise slightly from a rate of 2,048 in 1999 to 2,148 in

2050. The mortality assumption is that life expectancy at birth will rise from 74.1 years for males and 79.8 years for females in 1999 to 81.2 years for males and 86.7 years for females in 2050. Net immigration is assumed to stay relatively constant from 996,000 in 1999 to 1,097,000 in 2050.

Holding the United States population size constant at the year 2000 level, we apply our U.S. age group-, gender-, and MPC-specific annualized per capita cost rates to the projected changes in U.S. age structure. Our model's estimates of changes in future health care costs due to aging assume the age group-, gender-, and MPC-specific annualized per capita cost profiles remain the same in future years as in 2003, and holds constant all other factors that could affect medical costs.

RESULTS

HealthPartners' age- and gender-specific annualized per capita cost patterns for total medical costs during 2002–2003 reflect the typical epidemiology of medical care in the United States across the life course, where costs are high for newborns, decrease in childhood for both genders, rise for females in child-bearing years, and crossover at ages 60–64 as costs for men become increasing higher than for women (Figure 1; Worldwide Watson Wyatt 1996). Our upper age range extends beyond the typically reported “ages 85+” and the results show per capita costs go down after age 85 for both males and females. The “Under Age 1” category in our data includes all newborn costs. As well newborn costs are not aggregated with maternity costs, this approach provides a distinct picture of both of those age-specific cost patterns.

Figure 1 also shows the relative ratios of per capita costs within this data set by age and gender, using the reference group of “females ages 40–44” equal to one. For example, comparing costs for the age range 85–89 with the reference group, per capita costs for males are 4.4 times as great, while females are only 2.7 times as great.

Looking at the MPC level, the age–gender cost pattern for heart and vascular conditions is highly right skewed, indicating that seniors incur much higher costs than younger people (Figure 2). Kidney disorders has a similar right-skewed age–gender cost pattern (Figure 3). For both of these MPCs, per capita costs for males are substantially higher than for females at nearly every age. Orthopedics' cost pattern is also right skewed, with females incurring higher costs than males starting at age 40. In contrast, the chemical dependency cost pattern is left skewed, with a peak at ages 15–19 for both males and

Figure 1: Standardized-Annualized per Capita Costs, 2002–2003, All Services

females, and with lower costs for those older than 65 compared to under 65. Males have higher annualized chemical dependency costs than females for nearly every age, with twice the spike in costs in the teen years compared with females.

Impact of Aging on Costs Overall and by Body System

Overall, we project that per capita costs due to aging will increase from \$2,993 in 2000 to \$3,543 in 2050, an 18 percent increase overall (0.3 percent annually). The rate of change is steepest from 2000 to 2035 as Baby Boomers enter retirement, and then levels off from 2035 to 2050 as the age structure of the population stabilizes (Figure 4).

Per capita cost changes due to aging are unevenly distributed across MPCs (Table 1). Our model projects that 80 percent of the increase in total cost per capita will occur in just seven MPCs: heart and vascular conditions, orthopedic and arthritic conditions, gastric and intestinal conditions, lung conditions, neurologic disorders, endocrine conditions, and urologic conditions. We project kidney disorders costs will be the MPC most affected by

Figure 2: Standardized-Annualized per Capita Costs, 2002–2003, Heart and Vascular Conditions

population aging—increasing by 55 percent, followed by heart and vascular conditions (+44 percent) and urologic conditions (+36 percent). Cost per capita in four MPCs will *decrease* as a result of the changes in the population age structure: psychiatric conditions (− 1 percent), care of newborns (− 2 percent), chemical dependency (− 7 percent), and pregnancy and infertility care (− 12 percent).

Each MPC's relative share of the 18 percent increase in total per capita costs from 2000 to 2050 is a function of the MPC's proportion of total medical per capita costs in 2000 compared with the total in 2000 and its projected percent increase in costs from 2000 to 2050. For example, the heart and vascular MPC contributes the largest relative share of absolute per capita cost change due to aging from 2000 to 2050 (31 percent) as a result of its large percentage increase in cost per capita from 2000 to 2050 (+44 percent) combined with its highest cost per capita relative to all other MPCs in 2000 (\$396). The model projects it will have the highest cost per capita relative to all other MPCs in 2050 (\$568). The orthopedic and arthritic conditions MPC is the second highest contributor to the absolute per capita cost change due to aging,

Figure 3: Standardized-Annualized per Capita Costs, 2002–2003, Kidney Disorders

comprising 12 percent of the total increase, as an expensive per capita MPC whose impact by population aging is moderate (+19 percent). While the kidney disorders MPC has the largest percentage change in cost per capita (+55 percent), it is a much smaller contributor to the relative share of absolute per capita change due to aging from 2000 to 2050 (+4 percent), due to its comparatively low cost per capita in 2000 (\$44).

DISCUSSION

Our overall results mirror those of other studies finding the average annual increase in U.S. health care costs due to aging over the next several decades will be less than 1 percent (Burner et al. 1992; Cutler and Sheiner 1998b; Strunk and Ginsburg 2002; Alemayehu and Warner 2004). Our decomposition of this increase into MPCs reveals that aging will have much more of an impact on some clinical conditions than others, providing a more nuanced view of the impact of aging on future costs than has been previously available.

Figure 4: Cumulative Percent Change in Health Care per Capita Costs Due to Aging, United States 2000–2050

Understanding this differential impact of aging on particular clinical areas is critical as hospitals, medical groups, training institutions, and others make long-term plans for future medical care. Note that four of the seven MPCs we project will be most impacted by aging—heart and vascular conditions, orthopedic and arthritic conditions, gastric and intestinal conditions, and urologic conditions—are related to physician specialties already in short supply (Cooper 2004). Determining whether the impact of aging is large or small, and therefore how to plan for its effect, depends on one's perspective within society and within the health care system. For example, kidney disorders (+55 percent) represents the largest percentage increase due to aging. From the perspective of professional organizations that create policies to regulate physician supply, this finding may support a need to train and retain sufficient nephrologists to meet the projected growth in future demand. It may also support focus on other aspects of delivering care related to this MPC, such as changes to the existing kidney donation system. Alternatively, from the population health perspective of public health departments and health plans, kidney disorders make up only 4 percent of the projected total increase in costs due to aging. Therefore, this may not be as cost-effective a focus for large-scale disease management or prevention programs as would be the heart and vascular conditions and orthopedic conditions MPCs, which make up over

Table 1: Impact of Population Aging on Total Health Care Costs and by Major Practice Category, U.S., 2000–2050

Major Practice Category	Per Capita Cost, 2000	% of Total per Capita Cost, 2000 (%)	Projected Change in per Capita Cost Due to Aging, 2000– 2050 (%)	Projected per Capita Cost, 2050	% of Total per Capita Cost, 2050 (%)	Absolute per Capita Cost Change from 2000 to 2050	Relative Share of Absolute Projected per Capita Cost Change (%)
Kidney disorders	\$44	1	55	\$69	2	\$25	4
Heart and vascular conditions	\$396	13	44	\$568	16	\$172	31
Urologic conditions	\$100	3	36	\$136	4	\$36	7
Eye conditions	\$98	3	33	\$130	4	\$32	6
Lung conditions	\$150	5	31	\$197	6	\$47	9
Blood-related diseases	\$70	2	29	\$91	3	\$21	4
Neurologic disorders	\$174	6	25	\$218	6	\$44	8
Gastric and intestinal conditions	\$224	7	21	\$272	8	\$48	9
Endocrine conditions	\$192	6	20	\$231	7	\$39	7
Orthopedic and arthritic conditions	\$364	12	19	\$433	12	\$69	12
Late effects/complications	\$19	1	15	\$22	1	\$3	0
Dermatologic conditions	\$116	4	15	\$133	4	\$17	3
Infectious diseases	\$26	1	13	\$29	1	\$3	1
Liver-related conditions	\$52	2	11	\$57	2	\$5	1
Isolated signs/symptoms	\$40	1	7	\$42	1	\$2	0
Gynecologic conditions	\$143	5	1	\$144	4	\$1	0
Ear, nose, and throat conditions	\$163	5	1	\$164	5	\$1	0
Preventive and administrative care	\$137	5	0	\$138	4	\$1	0
Psychiatric conditions	\$170	6	–1	\$169	5	–\$1	0
Care of newborns	\$96	3	–2	\$95	3	–\$1	0
Chemical dependency	\$27	1	–7	\$25	1	–\$2	0
Pregnancy and infertility care	\$125	4	–12	\$110	3	–\$15	–3
Ungroupable	\$67	2	10	\$73	2	\$6	1
Total	\$2,993	100	18	\$3,546	100	\$553	100

Sorted by Projected Change in per Capita Cost Due to Aging, 2000–2050.

one-third of the total projected increase in per capita costs due to aging. We also project the impact of aging will mean a reduced demand for some services, such as those related to pregnancy and infertility care and chemical dependency.

Policy makers increasingly recognize the need for approaches that leverage the large effect of environmental, social, and individual influences on sustaining and improving health (Hubert et al. 2002; Gostin, Boufford, and Martinez 2004). Our work supports that approach, as overall costs and those related to several of the MPCs we project will have the greatest impact on future costs have been shown to be related to health status (Martinson et al. 2003; Anderson et al. 2005).

Representativeness

Our model assumes that age, gender, and MPC per capita cost rates from HealthPartners can be generalized to the United States population as a whole. This is supported on an overall basis by the close similarity in the ratios of relative per capita health care costs for nearly all age groups for the specific and general population (Table 2; Meara et al. 2004; Meara 2005). Because the ratio of costs for the oldest age group compared with ages 35–44 is lower in our data than in national figures, our projections of the impact of aging may be slightly understated. This lower HealthPartners' ratio for the oldest old is consistent with the findings that show Minnesota is one of the lowest cost areas of the country for Medicare services (Dartmouth Atlas of Health Care 1999).

Table 2: Medical Costs per Capita by Age Group, Relative to Ages 35–44

<i>Age group (years)</i>	<i>HealthPartners</i>	<i>National</i>
0–4	1.13	0.53
5–14	0.41	0.51
15–24	0.73	0.58
25–34	0.95	0.83
35–44	1.00	1.00
45–54	1.38	1.42
55–64	2.10	2.02
65–74	3.20	3.14
75+	3.99	5.45

National = 2000, Meara et al. (2004), Meara (2005).

HealthPartners = 2002–2003 services.

Boldface identifies the reference age group of 35–44 that is set to the value of 1.

Our youngest age ratio is higher than national, which may be due to it including all newborn costs instead of grouping well newborn inpatient costs in the mother's claim.

The model assumes the individuals in HealthPartners' Medicare managed care products are representative of individuals in both Medicare managed care and fee-for-service programs. While Medicare managed care products have attracted healthier individuals on a national basis, this effect toward lower costs may be offset because Medicare managed care products have cost more per enrollee than fee-for-service Medicare (U.S. General Accounting Office 2000; Biles, Nicholas, and Cooper 2004; Dartmouth Atlas of Health Care 1999).

Limitations and Strengths

Several considerations are relevant to interpreting our findings. First, we rely on the underlying assumptions made by the United States Census Bureau for U.S. population projections. While the continued aging of the Baby Boom generation is a certainty, changes in immigration and fertility rates could change the overall age structure of the future population.

The model also assumes that cost ratios between age groups in the cross-sectional age-specific cost curves from 2002 to 2003 will remain static as each cohort ages. Recent evidence suggests the Baby Boom generation is increasing its use of medical services at higher rates than older generations (Shactman et al. 2003). If that continues, the impact of aging will be higher than projected here. In addition, increases in the average age at death and changes in disability rates among the elderly would change the shape of the age-specific cost curves at older ages (Manton and Gu 2001).

Another factor we hold constant that will certainly affect health care per capita costs is changes in technology (Cutler and Sheiner 1998a; Goldman et al. 2005). Additionally, the pharmacy costs for the elderly that we estimated are likely understated, because we base them in part on data from the working-age population.

The societal view of health care and living expenses for the elderly are only partially covered in this work, as, by definition, we include only costs covered by the health plan. As a result, the projections do not include long-term nursing home care, a major component of health care and *living* expenses for many elderly individuals.

The usefulness of the projections by clinical conditions for those planning the future supply of medical professionals may be limited by the fact that

some MPCs correspond to a combination of body systems, conditions, and physician specialties (Symmetry TM Ingenix 2004). As the categories include all services, not just professional services, the projections are not directly equivalent to provider specialties or job types.

Despite these limitations, our findings both provide further support of other recent studies and provide a related new level of detail. The model reflects current medical use patterns and, by using 2 years of data instead of 1, provides better stability to the projections, particularly for low-incidence conditions and disorders. Including pharmacy costs for all members, particularly seniors, allows for a more complete picture of the impact of aging (Centers for Medicare and Medicaid Services 2003; Meara et al. 2004).

And finally, our model's highest age range is 100–105+, which is beyond what has been reported in the literature and available in MCBS (Burner et al. 1992; Cutler and Sheiner 1998b; Centers for Medicare and Medicaid Services 2001; Alemayehu and Warner 2004). This feature is important because we show a decline in costs for the oldest old, and as a result, model with better specificity the oldest ages.

CONCLUSIONS

Future work to increase reliability of the projections by MPC could use aggregated data across several health plans. Our analysis also raises questions about gender differences in health care costs as areas for further investigation. For example, controlling for age, male costs related to heart and vascular conditions are up to 60 percent higher than female costs. While this difference may be explained by the natural history of heart and vascular conditions (Mendelsohn and Karas 2005), part of the gap may represent undertreatment of women and/or overtreatment of men (Dong et al. 1998; Saha, Stettin, and Redberg 1999; Giardina 2000; Wenger 2003).

In addition, the model's ETGs age and gender cost rates could be aggregated, in some cases across MPCs, to the level of selected chronic diseases of significant interest, such as diabetes, asthma, coronary artery disease, and congestive heart failure to provide insight into the impact of aging on chronic diseases.

Our model also provides a solid base from which to build more complex models of the multivariate drivers of future health care costs. It sets the stage for modeling impacts of population and environmental changes such as obesity rates, disability rates, disease incidence, treatment costs due to medical and

technology advancements, practice pattern changes, and demands for services by age and gender cohort. Other areas for research include incorporating nursing home costs in the projections and the financing of health care costs in light of the increased costs due to aging.

ACKNOWLEDGMENTS

This work was supported in part by HealthPartners Research Foundation grant #03-091. The authors thank Louise Anderson F.S.A., M.S., Ph.D., and Jen Creer for their contributions to the paper, Elaine Moses and Thanh Huong Tran for their technical assistance, and Ellen Meara, Ph.D., for unpublished data.

Disclosures: None.

Disclaimers: None.

REFERENCES

- Alemayehu, B., and K. E. Warner. 2004. "The Lifetime Distribution of Health Care Costs." *Health Services Research* 39 (3): 627-42.
- Anderson, L. H., B. C. Martinson, A. L. Crain, N. P. Pronk, R. R. Whitebird, P. J. O'Connor, and L. J. Fine. 2005. "Health Care Charges Associated with Physical Inactivity, Overweight, and Obesity" [accessed on October 4, 2005]. Available at http://www.cdc.gov/pcd/issues/2005/oct/04_0118.htm
- Biles, B., L. H. Nicholas, and B. Cooper. 2004. "The Cost of Privatization: Extra Payments to Medicare Advantage Plans—2005 Update." *Issue Brief (Commonwealth Fund)* (750): 1-12.
- Burner, S. T., D. R. Waldo, and D. R. McKusick. 1992. "National Health Expenditures Projections Through 2030." *Health Care Financing Review* 14 (1): 1-29.
- Centers for Medicare and Medicaid Services. 2001. "Medicare Current Beneficiary Survey" [accessed on October 4, 2005]. Available at <http://www.cms.hhs.gov/MCBS/PubCNP01.asp>
- . 2003. "Medicare Prescription Drug, Improvement, and Modernization Act of 2003, Section 1013: Priority Topics for Research." Available at <http://www.cms.hhs.gov/MMAupdate/>
- Cooper, R. A. 2004. "Weighing the Evidence for Expanding Physician Supply." *Annals Internal Medicine* 141 (9): 705-14.
- Cutler, D. M., and L. Sheiner. 1998a. "Managed Care and the Growth of Medical Expenditures." In *Frontiers in Health Policy Research* (Volume 1), pp. 77-115. Cambridge, MA: MIT Press, 1998.
- . 1998b. "Demographics and Medical Care Spending: Standard and Non-Standard Effects." *NBER Work Paper Series* (6866): 1-33.

- Dartmouth Atlas of Health Care. 1999. "A Report on the Medicare Program." Available at <http://www.dartmouthatlas.org/atlases>
- Dong, W., Y. Ben-Shlomo, H. Colhoun, and N. Chaturvedi. 1998. "Gender Differences in Accessing Cardiac Surgery across England: A Cross-Sectional Analysis of the Health Survey for England." *Social Science Medicine* 47 (11): 1773-80.
- Giardina, E. G. 2000. "Heart Disease in Women." *International Journal of Fertility in Womens Medicine* 45 (6): 350-7.
- Goldman, D. P., B. Shang, J. Bhattacharya, A. M. Garber, M. Hurd, G. F. Joyce, D. N. Lakdawalla, C. Panis, and P. G. Shekelle. 2005. "Consequences of Health Trends and Medical Innovation for the Future Elderly" [accessed on October 11, 2005]. Available at http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=16186147 *Health Affairs Web Exclusive* W5-R5-17.
- Gostin, L. O., J. I. Boufford, and R. M. Martinez. 2004. "The Future of the Public's Health: Vision, Values, and Strategies." *Health Affairs* 23 (4): 96-107.
- Halvorson, G. C. 2004. "Credibility and Creativity: A Conversation with Kaiser Permanente's George C. Halvorson." *Health Affairs* 23 (4): 133-42.
- Heffler, S., S. Smith, S. Keehan, M. K. Clemens, G. Won, and M. Zezza. 2003. "Health Spending Projections for 2002-2012." *Health Affairs-Web Exclusive* W3-54-65.
- Hubert, H. B., D. A. Bloch, J. W. Oehlert, and J. F. Fries. 2002. "Lifestyle Habits and Compression of Morbidity." *Journals of Gerontology. Series A, Biological Sciences and Medical Sciences* 57 (6): M347-51.
- Kotlikoff, L. J., and S. Burnes. 2004. *The Coming Generational Storm*. Cambridge, MA: MIT Press.
- Manton, K. G., and X. Gu. 2001. "Changes in the Prevalence of Chronic Disability in the United States Black and Nonblack Population above Age 65 from 1982 to 1999." *Proceedings of the National Academy of Sciences USA* 98 (11): 6354-9.
- Martinson, B. C., A. L. Crain, N. P. Pronk, P. J. O'Connor, and M. V. Maciosek. 2003. "Changes in Physical Activity and Short-Term Changes in Health Care Charges: A Prospective Cohort Study of Older Adults." *Preventive Medicine* 37 (4): 319-26.
- Meara, E. C. 2005. "Year 2000 Unpublished Data for Graph of Relative Spending in Exhibit 2 of *Health Affairs* Trends in Medical Spending By Age."
- Meara, E., C. White, and D. M. Cutler. 2004. "Trends in Medical Spending by Age, 1963-2000." *Health Affairs* 23 (4): 176-83.
- Medical Expenditure Panel Survey. 2001. "2001 Compendium of Tables-Household Medical Expenditures" [accessed on October 4, 2005]. Available at http://www.meps.ahrq.gov/MEPSNet/TC/TC13.asp?File=HCFY2001&Table=HCFY2001_PLEXP
- Mendelsohn, M. E., and R. H. Karas. 2005. "Molecular and Cellular Basis of Cardiovascular Gender Differences." *Science* 308 (5728): 1583-7.
- National Committee for Quality Assurance. 2004. "HEDIS 2004 Volume 2: Technical Specifications: National Committee for Quality Assurance." Available at <http://www.ncga.org/communications/publications/archives2.htm>

- Reinhardt, U. E. 2002. "Health Care for the Aging Baby Boomers: How Serious a Problem?" In *Economic Policy for Aging Societies*, edited by H. Siebert, pp. 235–62. New York: Springer.
- Richardson, J., and I. Robertson. 1999. "Ageing and the Cost of Health Services." *Ageing and Health Expenditure*. Working paper no. 90, Centre for Health Program Evaluation, Sydney.
- Saha, S., G. D. Stettin, and R. F. Redberg. 1999. "Gender and Willingness to Undergo Invasive Cardiac Procedures." *Journal of General Internal Medicine* 14 (2): 122–5.
- Shactman, D., S. H. Altman, E. Eilat, K. E. Thorpe, and M. Doonan. 2003. "The Outlook for Hospital Spending." *Health Affairs* 22 (6): 12–26.
- Strunk, B. C., and P. B. Ginsburg. 2002. "Aging Plays Limited Role in Health Care Cost Trends." *Data Bulletin by the Center for Study of Health System Change* (23): 1–2.
- Strunk, B. C., P. B. Ginsburg, and J. R. Gabel. 2002. "Tracking Health Care Costs: Hospital Spending Spurs Double-Digit Increases in 2001" [accessed on October 4, 2005]. Available at <http://www.hschange.org/CONTENT/472/?words=tracking+health+care+costs>. Center for Studying Health System Change, *Data Bulletin No. 22*
- Symmetry TM Ingenix I. 2004. *Episodes of Care* (release software). Available at http://www.symmetry-health.com/ETGTut_Desc1.htm
- U.S. Bureau of Labor Statistics. 2002–2003. "Consumer Price Index- Minneapolis-St. Paul MN-WI Area, Medical Care Item, Series ID: CUURA211SAM, Area: Minneapolis-St. Paul MN-WI, Item: Medical Care from 2002–2003" [accessed on January 31, 2006]. Available at www.bls.gov/cpi
- U.S. Census Bureau. 2004. "Interim Projections of the U.S. Population by Age, Sex, Race, and Hispanic Origin" [accessed on October 4, 2005]. Available at <http://www.census.gov/ipc/www/usinterimproj/>
- U.S. General Accounting Office. 2000. "Medicare+Choice: Payments Exceed Cost of Fee-for-Service Benefits, Adding Billions to Spending." Washington, DC: General Accounting Office.
- Wenger, N. K. 2003. "Coronary Heart Disease: The Female Heart Is Vulnerable." *Progress in Cardiovascular Diseases* 46 (3): 199–229.
- Worldwide Watson Wyatt. 1996. "From Baby Boom to Elder Boom: Providing Health Care for an Aging Population" [accessed on October 6, 2005]. Available at <http://www.watsonwyatt.com/news/press.asp?ID=6958>

SUPPLEMENTARY MATERIAL

The following supplementary material for this article is available online:

APPENDIX A. HSR-05-0370: The Boomers Are Coming: A Total Cost of Care Model of the Impact of Population Aging on Health Care Costs in the United States by Major Practice Category.