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TECHNICAL REPORT

Health Status and Medical Treatment of the Future Elderly

Final Report

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SUMMARY

The Centers for Medicare & Medicaid Services (CMS) must generate accurate predictions of future spending for planning purposes. To investigate a better method for understanding how medical breakthroughs and demographic trends will affect future Medicare costs, CMS contracted with RAND to develop models to project how changes in health status, disease, and disability among the next generation of elderly will affect future spending.

BACKGROUND

Predictions of future health care spending necessitate estimating the number and sociodemographic characteristics of future beneficiaries who will be alive in each subsequent year and the likely magnitude of their health care spending. The official projections of the aged beneficiary population by age and sex currently used by CMS are taken from the Trustees' Reports of the Social Security Administration (SSA). These projections already take into account two long-term trends: a decrease in age-specific mortality rates and a significant increase in the over-65 population that will begin in the year 2012, due to the aging of the baby boomers.

However, estimating future health care costs is more difficult. To improve their current projections of health care costs, CMS would like to rely on more accurate estimates of future health care needs and expenditures. Estimates of future health expenditures for an individual of a given age are full of uncertainty. Individual health care spending is a function of many factors: age, sex, health status, diseases and the medical technology used to treat them, the price of care, insurance coverage, living arrangements, and care from family and friends. Per capita estimates of spending are uncertain because they depend on hard-to-predict changes in all these factors. Existing models do not attempt to forecast specific treatment changes that will affect health status and future expenditures or trends in other key factors.

The trend that may be most controversial (with respect to its potential effect on future health expenditures) is the apparent delay in morbidity: many people are staying healthy to older ages. As a consequence of this trend, it has been theorized that the attendant functional limitations and costs of morbidity may be compressed into the last few years of life, which could reduce health care costs. However, the savings expected from compressed morbidity might be offset by the effect of another trend, that is, reduced mortality or extended life expectancy.

Current models account for the added cost of greater longevity that would result from reduced mortality, but such models tend to assume that health (good or bad) is a permanent state. However, studies of particular diseases find that mortality gains follow from lifestyle changes, primary and secondary disease prevention, and dramatic improvements in treatment. These same factors can result in a postponement of disease, disability, and proximity to death, i.e., a compression of morbidity. Thus, the same factors that are expected to raise health care costs by increasing life expectancy might also serve to limit costs by delaying morbidity. As a result,

lower mortality rates might have less effect on expenditures than current models would predict, although, clearly, not all treatment advances postpone the need for medical care.

The primary objective of the present study was to develop a demographic-economic model framework of health care spending projections that will enable CMS actuaries and policymakers to ask and answer what-if questions about the effects of changes in health status and disease treatment on future health care costs. The model answers the following types of questions:

- What are the future health expenditures for Medicare likely to be during the next 25 years if the trends in morbidity and mortality of the last decade are taken as projections into the next decade, and if disability among the elderly declines at a steady rate?
- How will the growth of future health care expenditures for the elderly be affected by advances in the development of new diagnostic tools, medical procedures, and new medications for chronic and fatal illnesses?
- How will the sociodemographic characteristics of the next generation of elderly individuals affect future health care spending?

STUDY DESIGN AND METHODS

The study was conducted in four phases. Phase I consisted of a literature review, Phase II was a technical expert panel (TEP) assessment, Phase III included the development of the model, and in Phase IV, we applied the model to various what-if scenarios.

Literature Review

During Phase I, we reviewed the current literature on trends in the health and functional status of the elderly, the likely effects of new medical advances and treatments on morbidity and mortality among the elderly, and the likely costs of new medical treatments. In what we will refer to as the social science literature review, we also reviewed past efforts to model the effects of changes in health status, risk factors, and treatments on health care expenditures.

Expert Panel Assessments

During Phase II, we convened TEPs to provide guidance on the likely future advances in the medical treatment of specific illnesses and the early detection and prevention of diseases. We used a modification of the technical expert panel method developed at RAND to convene four separate panels targeted at specific clinical domains: cardiovascular disease, the biology of aging and cancer, neurological disease, and changes in health care services. Using our literature reviews, past experience with expert panels, and the advice of local experts, we selected individuals who represented a broad range of clinical and basic science expertise.

The technical experts were surveyed to identify what they considered the leading potential medical breakthroughs in each area, considering factors of potential effect and cost. Based on

these responses and our preliminary literature review, we selected a number of potential breakthroughs in each of the four areas for further, in-depth review using the procedures of evidence-based research. For each breakthrough, we identified the current developmental status and potential barriers to implementation.

As part of Phase II, we also convened a fifth expert panel composed mainly of social scientists from the fields of demography, epidemiology, health economics, actuarial science, and operations research. The role of this panel was to help us determine the appropriate health status measures and methodologies and to identify data sets for estimating model parameters as well as the best modeling techniques.

Development of the Future Elderly Model

During Phase III, with the guidance of our social science technical expert panel, we developed a demographic-economic model, the Future Elderly Model (FEM). The FEM is a microsimulation model that tracks elderly, Medicare-eligible individuals over time to project their health conditions, their functional status, and ultimately their Medicare and total health care expenditures. The FEM was intended to serve two purposes: First, it was to be used to answer the question, If current health status and disability trends continue, what will be the costs to Medicare for treating the elderly? Second, it was to be used to simulate and evaluate a variety of scenarios regarding the future health care environment. The FEM we developed actually combined three individual models: a model of health care costs, a model of health status transitions, and a model to predict characteristics of future, newly-entering Medicare enrollees (the “rejuvenation” model).

Data. The FEM started with data from the Medicare Current Beneficiary Survey (MCBS), which includes a nationally representative sample of aged, disabled, and institutionalized Medicare beneficiaries, as the host data set (the data set included individuals who turned 65 and participated in the MCBS from 1992 through 1998). The MCBS is an interview survey designed to ascertain utilization and expenditures for the Medicare population, particularly expenditures borne by the beneficiary or by supplemental insurance. The survey sample is interviewed some 12 times over a three-year period. The data set contains detailed self-reported information on height, weight, the prevalence of various conditions, measures of physical limitations in performing activities of daily living and instrumental activities of daily living, and health service use, as well as Medicare service use records. The sample size for individuals 65 and older in 1998 with complete records was 10,881. Each sample member’s data are weighted to take into account the number of beneficiaries in the Medicare population that member represents.

Because we were studying transitions, our data set included only MCBS respondents who participated in two or more consecutive survey waves. The outcome measure was based on pairs of consecutive interviews. In order to ensure that we were examining the transition from positive health status to a disease state, we included only individuals who did not report a specific condition at the initial interview—i.e., among people without a condition, we modeled the likelihood that they developed the condition in the following year.

Health status transition model. The FEM then predicts the health conditions and functional status of the baseline sample for the next year (reweighting to match the health status trends from the National Health Interview Survey [NHIS] and the Census population projections). To project the health transitions, a discrete piecewise linear hazard model was estimated. The hazard of getting a disease and dying depends on risk factors (gender, education, race, ethnicity, education, obesity, ever having smoked); other conditions if medically warranted; functional status; and age (piecewise linear spline, node at age 77). The model did not control for household income or for current smoking behavior, since doing so would require projection models of future income and smoking behavior, respectively. A similar model was used to predict functional status and nursing home residency. We treated all health states as “absorbing”—i.e., once people got an illness, they had it forever and therefore could not get it again—and modeled transitions into the states. This assumption was consistent with the way the data were obtained (“Has a doctor ever told you....”) and with the course of most of the chronic diseases (diabetes, heart disease, etc.). However, for some conditions or outcomes, such as altered functional status, recovery is possible; therefore, the hazard model would overestimate their prevalence.

Sample rejuvenation. As our initial sample ages, it becomes less representative of the entire over-65 population; thus, we rejuvenated our sample yearly (through 2030) with a newly entering cohort of 65-year-olds.

Cost modeling. Finally, the FEM predicts costs. The cost estimations were based on pooled weighted least squares regressions with total Medicare reimbursement and total health care reimbursement as the dependent variables; and health status measures, self-reported disease categories, and interactions of health measures and disease conditions as the independent variables. The model was calibrated to replicate the total health care and Medicare expenditures for the elderly sample represented by the MCBS.

All FEM costs are in 1998 dollars and are adjusted for inflation, but not for cost of living and changes in the economy. The FEM does not include supply-side factors (e.g., physician supply) or changes in insurance coverage. We dropped Medicare HMO enrollees and assumed that all Medicare beneficiaries were covered under the Medicare Fee-for-Service (FFS) system in our estimation, which may overestimate the total costs if HMOs actually save money compared to FFS. The FEM also does not model the shifts from inpatient to outpatient services. Finally, we assumed that every beneficiary had both Medicare Part A and Part B in predicting future Medicare costs.

We chose health status measures to meet several competing goals. First, we needed measures that could be used to predict costs. Second, our measures had to capture clinically relevant diseases that would be useful for predicting the effects of the breakthrough technologies. Third, the measures had to be readily available in the MCBS and any other data sets we would use to provide estimates for the microsimulation, for example, the NHIS. The health status measures were based on self-reported health conditions and disability. The conditions on which we decided to focus were the ones selected earlier by our expert panels as having the greatest potential for breakthroughs; these conditions are also the ones most prevalent in the elderly population and the most costly to treat. The models were integrated by first estimating costs for

the representative cohort. We then “aged” them one year using the health status model, introduced the new 65-year-olds, and then estimated costs again. This process was repeated for each year until a terminal date was reached.

The What-If Scenarios

Finally, during Phase IV, we considered the implications of a number of potential health care scenarios suggested by the experts—including potential breakthrough technologies as well as changes in lifestyle and the health care system—by exploring changes in the parameters of the model via what-if modeling.

Evaluating the Usefulness of the FEM to the Office of the Actuary

To evaluate the usefulness of the FEM, we focused on five components: the population projection, expenditure projections, econometric methodology, the what-if modeling, and the overall usefulness.

RESULTS

The Potential Breakthroughs

Lists of suggested breakthroughs in future health care were developed based on our literature reviews. Using these lists and the nominal group process, our technical expert panels identified 33 key potential breakthroughs for further review. These breakthroughs spanned the areas of improved disease prevention, more precise risk stratification and earlier detection of subclinical diseases through improved imaging and genetic profiling; better treatment for established diseases through biomedical engineering, cell biology, and genetic engineering; and changes in lifestyle and care management. For each breakthrough, the panels assessed the eligible (target) patient population, likelihood of implementation within 10 and 20 years, effect, and cost. The breakthroughs are listed in Table S.1.

Table S.1. Potential Medical Breakthroughs Identified by Technical Expert Panels

Disease	Likelihood of Occurrence at 20 years^a (%)	Brief Summary of Effect
Cardiovascular Diseases		
Improved Disease Prevention	40	90% reduction in CVD.
Noninvasive Diagnostic Imaging to Improve Risk Stratification		Better identification of high-risk patients, leading to effective risk reduction strategies.
• General Population >45	15	
• Subclinical Disease	75	
• Clinical Disease	50	
Magnetic Resonance Angiography (as a replacement for coronary catheterization)	100	Replacement for conventional coronary angiography, likely to increase the number of persons undergoing the procedure.
Intraventricular cardioverter defibrillators		Life expectancy for people with congestive heart failure (CHF) is shifted by 6–10 months, 20% now die of some other cause.
• Clinical Disease	30-40	
Left Ventricular Assist Devices (LVAD)	50	General increase in function for persons with functional limitations, 50% decrease in heart failure-related hospitalizations, 20% of patients will have improved 1 year mortality.
Xenotransplants	1–3	Possibly similar to the benefit from human heart transplants, but several experts thought the effect would be lower as the population affected is likely to be different.
Therapeutic Angiogenesis		Little effect on mortality, decreased number of revascularization procedures by 20–30%.
• Clinical disease: augmentation for revascularization	Currently used	
• Clinical disease: replacement for revascularization	10	
Transmyocardial Revascularization	0–5	Little effect on mortality, decreased number of revascularization procedures by 20–30%.
Pacemaker/Defibrillators to Control Atrial Fibrillation	50	Decreased stroke by 50% of the attributable fraction due to atrial fibrillation (AF).

Table S.1. Potential Medical Breakthroughs Identified by Technical Expert Panels

Catheter-based Ablation Techniques to Control Atrial Fibrillation	20	Decreased stroke by 50% of the attributable fraction due to AF.
Disease	Likelihood of Occurrence at 20 years^a (%)	Brief Summary of Effect
Biology of Aging and Cancer		
Telomerase Inhibitors	100	Mortality: 50% will be cured; 50% will have a 25% prolongation of life.
Cancer Vaccines	10–20	Melanoma/renal cell carcinoma could be cured. All other cancers could have a 25% boost in survival.
Selective Estrogen Receptor Modulators (SERMS)	90	Breast cancer decrease of approximately 30%, decreased osteoporosis (increase bone density in spine of osteoporotic women by 2%).
Antiangiogenesis	70–100	Cure for metastatic disease in 10–50%.
Diabetes Prevention via Drugs that Enhance Insulin Sensitivity	65	50% prevention in Type 2 over >10–15 years.
Compounds that Extend Life Span	0–50	10–20 years of extra life of an equivalency between 20 and 50 years of age.
Compounds that Improve Cognition	20	Decrease in traffic accidents due to reflex ability, decrease in pedestrian accidents due to reflex ability, increased period of participation in the workforce.
Neurological Diseases		
Improved Identification of Persons at Risk for Alzheimer's Disease	30	No direct effect on mortality or morbidity, but it will identify people at higher risk for guided treatment.
Primary Prevention of Alzheimer's Disease Using Therapies Based on the Amyloid Hypothesis	40	Delay of onset by median 5 years (range 3–10 years), slow progression by a mild to moderate amount.
Primary Prevention of Alzheimer's Disease Using Existing or Other New Drugs	40	Delay of onset by 2–5 years, minor effect on progression.

Table S.1. Potential Medical Breakthroughs Identified by Technical Expert Panels

Treatment of Established Alzheimer's Disease by Vaccine, Secretase Inhibitor, Antioxidants, Anti-inflammatories, or SERMS	30	Decrease in rate of progression that is mild to moderate.
Treatment of Established Alzheimer's Disease by Cognition Enhancers	40	Shifts back in time by 6 months to 2 years but does not modify the disease.
Prevention and Treatment of Parkinson's Disease by Profiling Genetic Predisposition for Susceptibility to Environmental Toxins	10	Eliminates disease in 15% of existing cases, delays onset in 15–20% of cases.
Treatment of Parkinson's Disease Therapies by Neurotransplantation	25	Shifts back in time by 2 to 5 years but does not modify disease.
Treatment of Acute Stroke by Drugs that Minimize Cell Death	60	Decrease in disability due to stroke of median 30% (range 25–50%).
Treatment of Acute Stroke by Stem Cell Transplant	20	Decrease in disability due to stroke of 25%.
Improved Treatment of Depression Using New or Existing Drugs	70	70% improvement in symptoms (e.g., 35% improvement over placebo).
Health Services		
Increasing the Use of Known Interventions		
• Everybody	80	Very high, approximately equivalent to improving the control of hypertension by 25–50%.
• Chronic Disease Group	90	Very high.
Care Coordination	90	Modest. Approximately equivalent to improving the control of hypertension by 5–10%. Change on function will be slight if at all. Main benefit will be on utilization.
Improved Detection of Under-diagnosed Conditions		Improvement in outcomes for undiagnosed approximately the same as existing evidence for diagnosed patients.
• Depression	30	
• Diabetes	50	
• Dementia	30	
Better Medication Management	100	Moderate sized effect on reduced hospitalization/shortened stay, decreased mortality, and increased function.

Table S.1. Potential Medical Breakthroughs Identified by Technical Expert Panels

Environmental Improvements to Assist with Lifestyle Change and Chronic Disease Self-management	85	For people with chronic disease similar to chronic management programs to decrease utilization.
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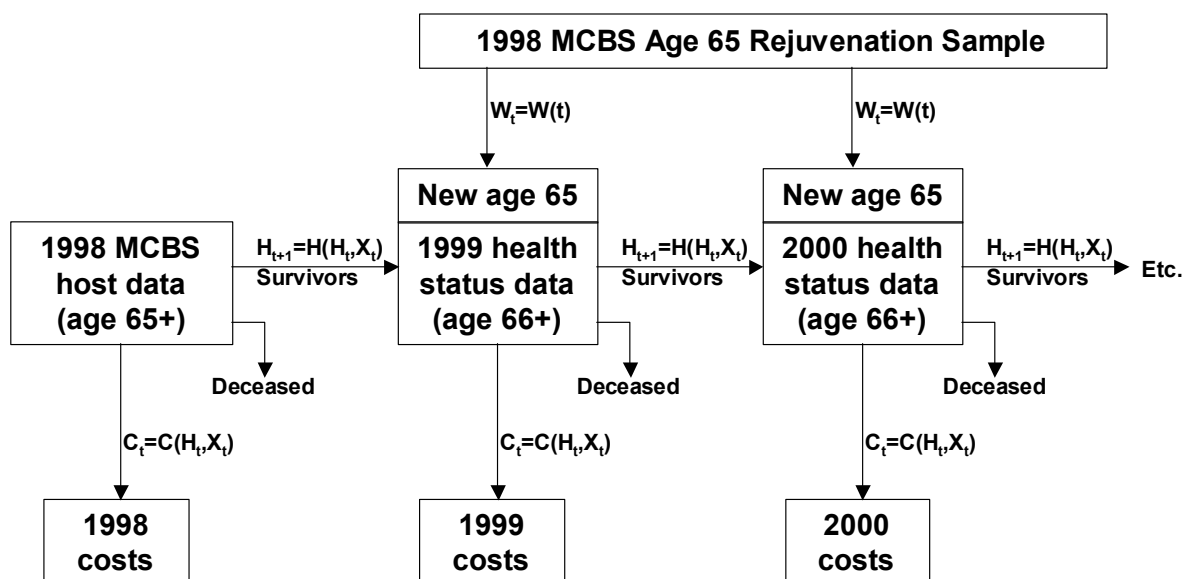
^a Likelihood of occurrence means widespread use in clinical practice.

The Future Elderly Model

The FEM differs from traditional approaches in that it includes a multidimensional characterization of health status and it is not cell-based. This allows us to include a richer set of demographic controls as well as comorbid conditions and functional status.

The first step in creating our microsimulation model was to estimate health transition models for each individual. We then estimated future health transitions. We then brought in a new cohort of 65-year-olds (rejuvenation) and estimate costs for everyone. Figure S.1 depicts how the cost models, transition models, and rejuvenation models are integrated into the microsimulation model.

Figure S.1. Overview of the FEM Model



NOTES: 1. C = costs; C_t = costs in a given calendar year; H = health status; H_t = health status during the year of the interview; W = a relative weight; X_t = demographic controls. 2. Costs are predicted in constant (1998) dollars and assume a level of treatment and technology as it existed in the 1990s.

We assessed the baseline health care characteristics for the cohort of individuals age 65 and older in the 1998 MCBS data set and used these findings to predict per capita expenditures for that year. We then assessed the yearly health and functional status and projected the conditions and health care costs of the survivors for each subsequent year. As people became deceased, they were removed from the cohort. Likewise, each year, the sample was rejuvenated by the addition of a pool of new beneficiaries who turned 65.

Determinants of Health Care Expenditures (the Cost Model)

Using MCBS data, we explored how alternative measures of health and disability affect expenditures. Reporting one or more functional limitations (assessed as activities of daily living

[ADL]), residing in a nursing home, and having one or more chronic diseases were associated with higher expenses. Likewise, self-reported health status was highly correlated with health expenditures; however, the social science TEP cautioned us against considering this measure for a forecasting model, as treatment breakthroughs are difficult to translate into changes in self-reported health status.

Our final cost model also included demographics and measures of physical health. Demographics included such factors as age, gender, ethnicity, education, and geographical area of residence. Measures of physical health included self-reported health status, ADL categories (including nursing home residence), chronic diseases, and interactions of these measures.

Ever having smoked, residing in the Northeast, mortality, obesity, and physical health status (measured by number of ADLs and admission to nursing home) had considerable effects on expenditures. Consistent with the literature, individuals who die during the year have substantially higher medical expenses than survivors. Medical expenditures increase with age, until about age 85. Lower expenditures among the oldest elderly may reflect biological differences among those who have survived to that age as well as less aggressive medical treatment. We also find that costs increase substantially with ADLs, particularly with three or more. The interactions of ADLs and disease vary in magnitude and significance, in both this model and others.

Determinants of Health Status: The Health Status Transition Model

Using the Health Status Transition Model revealed a set of factors that increase the risk for a variety of chronic conditions, decreases in ADLs, and nursing home residence:

- Men tend to have higher risks of cancer and heart disease and lower risks of hypertension, arthritis, and disability than do women.
- Blacks and Hispanics have higher risks of hypertension than do Caucasians.
- Hispanics also have higher risks of diabetes than do Blacks or Caucasians.
- Hispanics are far less likely than non-Hispanics to enter a long-term care facility such as a nursing home.
- Better-educated individuals tend to be in better health.
- Having ever smoked increases the risk of cancer, stroke, lung disease, and disability, but not by very much and only marginally significantly for cancer.
- Co-occurrence of two or more health conditions tended to increase the risk for certain other conditions significantly, for example, diabetes and hypertension significantly increased the risk of developing a heart condition.

We also estimated the effect of a variety of health conditions on the risk for mortality. Cancer, heart disease, stroke, Alzheimer's disease, lung disease, and disability (low ADL score)

were associated with an increased risk of mortality, whereas arthritis was associated with a decreased risk.

The Health Status of Future Medicare Users

Using data from the NHIS, we then created a model to predict the health status of future cohorts of Medicare beneficiaries between the years 2001 and 2030. We considered seven of the chronic conditions most prevalent among the elderly—heart disease, hypertension, cerebrovascular disease, Alzheimer’s disease, cancer, diabetes, and chronic obstructive pulmonary disease—as well as physical disability. Unfortunately, the NHIS provides each age cohort with a unique list of conditions from which to choose; thus, respondents cannot select the conditions they have had from the full list of conditions.

Our prediction strategy consisted of four steps. In the first step, we used the NHIS data to obtain age-specific prevalence rates for the conditions of interest. These prevalence rates were smoothed using the overlap polynomial method to produce noise-free estimates of the incidence of low-prevalence diseases. In the second step, we used a synthetic cohort approach to estimate an age-incidence profile for each disease from the smoothed prevalence estimates. In the third step, we used the prevalence and incidence functions to generate our projections of the health status of future Medicare-entering cohorts. The method is based on the idea that for any given future year, we know the current age of the entering cohort for that year. Finally, in the fourth step, we constructed population-weighted estimates to predict the co-occurrence of several diseases in the same individuals, in order to predict future expenditures more accurately.

Consideration of Future Scenarios

We modified our FEM to simulate the effect on expenditures of a variety of likely scenarios or breakthroughs proposed by our expert panels. We then compared projected expenditures without the scenarios or breakthroughs (the “baseline” situation) with our estimates of expenditures following the breakthroughs over the course of the first 30 years of the 21st century. To assist in this effort, the expert panels identified eligible populations, likelihoods of occurrence, costs, and estimates of effect on morbidity and mortality for most of the technologies.

The use of telomerase inhibitors (TI) to treat cancer. We modeled the potential effects of the use of a class of cell-replication inhibiting chemicals known as telomerase inhibitors (TI) to treat cancer. Our model suggested that TI would reduce the prevalence of cancers considerably: those who received treatment and were cured or whose cancer was controlled would experience an increase in life expectancy. Although TI would increase total expenditures on the elderly, they would not greatly increase Medicare spending. However, we did not consider several factors, such as cancer type: TI works only on solid tumors and less well on metastatic cancer than on localized cancer.

The use of cancer vaccines. We also modeled the possible effects of the introduction of a cancer vaccine that could be used against all types of cancers. Cancer vaccines would have a large effect on cancer prevalence while modestly increasing Medicare costs, largely due to

prolongation of life. However, we did not include the potential effect on melanoma in our simulation: because it is expected that the vaccines could cure melanoma, their effect on prevalence and related expenditures for all cancers would likely be larger than our results suggest.

The use of a drug to prevent diabetes. The third scenario we modeled was the use of an insulin sensitization drug to prevent type 2 diabetes. It is expected that of the 80 million obese people (obesity being defined as a body mass index over 30) in the United States, some 10 percent will develop type 2 diabetes; we assumed that 30 percent of elderly obese people would develop diabetes. The prevalence of diabetes among the elderly is expected to rise by about 12 percent from 2001 to 2030. Over five years, our model showed, the drugs would prevent over 50 percent of new cases of diabetes. Making a number of assumptions, such as a reduction of 65 percent over ten years and a treatment rate of only 30 percent (with random targeting of treatment), we found only modest effects. The drug would reduce prevalence by only about 1 percent, in part due to the large size of the obese diabetic population. The drug had little effect on Medicare expenditures, particularly over the long term where the drug would be expected to increase life expectancy.

The effect of extending lifespan. We modeled the possible effect of a not-yet-identified compound that would extend life span by mimicking the effects of long-term reduction in caloric intake. This scenario is based on findings from the 1970s that chronically reducing rodents' energy intake prolonged their lives. According to our simulation, if begun early enough (around the age of 35), the treatment would extend life expectancy by 10 to 20 years. With no concomitant improvements in health status, disease prevalence and Medicare costs would increase substantially. However, based on the findings from the animal model, the incidence of several diseases, including cardiovascular disease and some types of cancer, is reduced or at least delayed, raising the prospect of compressed morbidity and its attendant costs.

The effect of increasing education level. We also modeled the potential effect of an increase in the average level of education of the future Medicare population. We considered two possible scenarios: 1) after 2002, everyone who became Medicare-eligible had a college degree, or 2) after 2002, the education level of each Medicare-eligible person increased one level (for example, persons with some high school education became high school graduates and high school graduates now had some college education). Whereas neither scenario was realistic, they showed how the FEM incorporated information about education and could be used to project the effect on health status, Medicare expenditures, and total health care costs. Increasing educational attainment resulted in a decrease in death rate and in the prevalence for a number of diseases but higher Medicare and total expenditures; however, the differences in expenditure were small.

The effect of changing ethnicity. We modeled the possible effects of a continued increase in the Hispanic population. Between 2000 and 2030, the proportion of the U.S. population that is made up of Hispanics is expected to grow from 11 percent to 19 percent. This increase is expected to result in an increased mortality rate; an increase in the prevalence of particular diseases, such as heart disease, diabetes, arthritis, and hypertension; and a decrease in the prevalence of cancer, stroke, lung disease, and nursing home use. However, our simulation assumed that the future Hispanic population would have demographic and socioeconomic status similar to the current Hispanic population.

The effect of decreasing smoking rates. We modeled the potential effect of a decrease in the rate of smoking among new Medicare beneficiaries. Our assumption was that no one entering Medicare after 2002 ever smoked. From 2002 to 2030, the overall death rate among Medicare beneficiaries would decrease by 4.3 percent. Whereas the prevalence rates for a number of diseases would change (for example, the lung disease prevalence would fall by 8 percent) with the decrease in smoking, the decrease in mortality rate would also alter the disease prevalence. The reduction in smoking would result in a decrease in Medicare and total health care expenditures, with a savings to Medicare alone of \$434 billion. Whereas this scenario is unrealistic, more modest decreases in the rate of smoking might still alter disease prevalence and Medicare expenditures; the FEM could be used to predict their magnitude.

The effect of decreasing obesity rates. We also modeled the potential effect of a decrease in the rate of obesity among Medicare beneficiaries. We considered two scenarios: no one entering Medicare after 2002 is obese and 2) after 2002, no Medicare beneficiary is obese. Neither scenario resulted in a decrease in the mortality rate. Nevertheless, the prevalence of a number of diseases, including arthritis, diabetes, and heart disease, decreased. Initial differences in the magnitude of the decreases between the two scenarios diminish over time as cohorts who entered prior to 2002 leave the population through death. Our model showed that the unrealistically extreme measure of eliminating obesity reduced Medicare and total expenditures only minimally, suggesting that more modest improvements in weight control would have a smaller effect.

The effects of changes in diagnosis and treatment of cardiovascular diseases. Finally, we modeled the application of eight different emerging technologies to the diagnosis and treatment of cardiovascular diseases. In this simulation, beneficiaries were randomly assigned to a treatment based on the probabilities estimated by the expert panel, and it was assumed that each beneficiary would receive only one such treatment. Our model showed that, with the exception of stroke, the disease prevalence was unaffected by the treatments; the prevalence of stroke decreased relative to the baseline. Nevertheless, the costs of treating cardiovascular diseases are likely to continue to increase over those of the baseline.

Evaluating the Usefulness of the FEM

We considered five aspects of the FEM in assessing its likely utility to the Office of the Actuary (OACT). These aspects included population projection, expenditure projection, econometric methodology, and what-if modeling.

Population projection. Population projections are based on starting population, mortality rates, migration, and fertility patterns (the latter two factors were disregarded for this report).

The FEM used Census data to determine the size of each entering cohort. In contrast, the population projection on which the OACT models are based is generated annually by the Office of the Actuary at the Social Security Administration (SSA). The SSA includes three populations excluded by the Census: those missed by the Census, those residing in territories and outlying areas, and military personnel and dependents residing overseas. Thus, SSA estimates of current population are higher than those of the Census. However, the FEM also assumes all individuals

65 years and older are covered by Medicare Parts A and B, resulting in a small (approximately 3 percent) overstatement of the Medicare population and costs.

The FEM and SSA estimates of mortality also diverge, due to differences in their projections of mortality improvement. The most recent SSA projections assume a decline in the death rate through the year 2030, based on a set of implicitly assumed medical advances and an analysis of historical trends in the causes of death. In contrast, the FEM baseline projections are based on MCBS data from the 1990s and no further improvement in medical technology or mortality rates.

Expenditure projections. We compared our projected expenditures based on the FEM to those of the Medicare Trustees' Report for 2002, making appropriate adjustments.

The FEM is based on four sets of projections with dependent variables for total Medicare expenditures, Medicare Part A payments, Medicare Part B payments, and Medicare Part A and Part B payments. However, the FEM model estimates per capita expenditures only for those with both Part A and Part B. The FEM also includes cases with less than 12 months enrollment (often due to death).

According to the CMS projections, Medicare expenditures will grow at a rate far exceeding that predicted by the FEM, even after adjusting for inflation and population growth. The central concept of the OACT baseline is that it is based on the scenario *most likely* to occur, according to general trends in morbidity and mortality and a number of implicit advances in medical technology that result in increased per capita costs. The FEM baseline assumes no changes in the underlying morbidity and mortality and maintenance of the status quo (no further advances) in medical technology. These conflicting concepts of baseline make any direct comparison between the two difficult. The modeling of a what-if scenario that mimics the assumptions in the OACT baseline would help bridge this gap.

Econometric methodology. The FEM modeled transitions into a variety of health states, using proportional hazards modeling. The transition probabilities are based on a variety of independent variables including age, sex, race, education, and other medical conditions. The results are consistent with epidemiological findings and clinical intuition.

What-if scenarios. The what-if scenarios summarized above illustrate one of the most useful features of the FEM to the Office of the Actuary, namely the ability to model the potential effects on future costs of a variety of hypothetical or likely trends in medical technology, health care services, and demographics. However, we realize that the current utility of the model is limited because of the differences in baselines and expenditure projections enumerated above.

Conceptually, these differences could be bridged by adopting specific scenarios in which the FEM-projected death rate decreases similarly to that projected by the SSA, using it as a baseline, and analyzing what-if scenarios relative to such a baseline. However, the work required to produce a suitable baseline would be substantial and the analytical problems to be overcome would be non-trivial.

Several other changes to the FEM would also make it more suitable to the OACT. These include modifying the calculations of Medicare costs (using the same categories of services as does CMS) and the choice of dependent variables.

CONCLUSIONS

This project served several purposes. First, it identified possible breakthroughs that could greatly affect the future health of and expenditures on behalf of the elderly. Second, we developed a microsimulation model that can be used to quantify the effect of these breakthroughs and other scenarios of interest to CMS and other policymakers. The model is flexible enough to consider life extensions and the interaction of treatment with disease, and it incorporates what is known about the health of future cohorts. Several key policy issues and recommendations arise as a result of this work.

Modeling Future Health and Spending

For our baseline scenario, we predicted the prevalence and Medicare costs for a particular disease in the next 30 years under the status quo (health status and disability trends defined by technology and risk factors of the elderly population in the 1990s). In this scenario, we held the health transitions and risk factors in the elderly population constant, so the variations in disease prevalence and costs came from only two sources: the health status of entering 65-year-olds and the population growth. Under the baseline scenario, Medicare expenditures will reach \$360 billion in 2030.

We simulated the effects of medical breakthroughs and changes in risk factors on health status transitions (disease prevalence) and cost projections by altering the health status transition parameters or risk factors among the elderly according to the assessments from the expert panel. Thus, the difference in disease prevalence and costs between the base scenario and the breakthroughs scenario was solely attributable to the breakthroughs (e.g., eliminating heart disease among the entering 65-year-olds would result in a decrease in the prevalence of heart disease and total Medicare costs). But the mechanism is more complicated because of the interactions among all diseases, disability, and death in the health status transitions. In this case, eliminating heart disease among the young directly reduces costs, the risk of death, stroke, disability and nursing home residence; but the lower death rate results in an increase in the risk for other conditions and in life expectancy, both of which result in higher costs. The FEM explicitly models these interactions and provides estimates of the net effects. Thus, eliminating heart disease among the young would reduce heart disease prevalence by about 20 percentage points in 2030 and save Medicare \$328 billion over the next 28 years. However, it also would increase the prevalence of cancer, stroke, diabetes, hypertension, lung disease, and arthritis; increase the prevalence of disability (ADL1+ and ADL3+); and have no significant effects on the prevalence of Alzheimer's disease and the use of nursing home care. The model can be used to quantify the future ramifications of changes in demographic trends and in patient behaviors and certain types of changes in medical technologies.

Implications of the Panel Findings

In Phase I, our TEPs identified the most important potential breakthroughs in four areas: cardiovascular disease, biology of aging and cancer, neurological disease, and health services. They provided estimates about the likelihood that a breakthrough could occur, the potential effect of the breakthrough, and the potential cost implications. Their work provides important insight into the future of medicine as it affects the elderly. Themes that emerged from the deliberations of the disease group panels included the following:

Improved disease prevention. Breakthroughs that improved prevention of disease were identified for all three disease categories. Nearly all the breakthroughs identified have relatively low per-person costs. However, because the interventions would need to be applied to very large populations, their cumulative costs are high. Counterbalancing these increased costs is the improvement in the direct cost of the care related to the prevented condition and improvements in morbidity and mortality.

Better detection or risk stratification of people with early disease. The health and expenditures of the future elderly could be dramatically affected by better detection of subclinical disease or early clinical disease, which will allow earlier and better targeting of effective therapies, to try to ameliorate the progression of morbidity and mortality associated with the diseases. Breakthroughs in this area were identified for cardiovascular diseases and by the health services panel. In both cases, the breakthroughs involve better detection of people at higher risk than the general population for worse outcomes from a variety of chronic conditions. The Human Genome Project is expected to vastly increase our ability to genotype people and determine their susceptibility to disease. Improved imaging should also increase our ability to detect subclinical disease.

Better treatment for patients with established disease. Breakthroughs in many different disciplines are likely to influence the treatment of established diseases:

- Advances in biomedical engineering were identified by the cardiovascular panel as being especially critical.
- Medical breakthroughs targeting genes or specific cells are also likely to have important consequences. All these breakthroughs tended to be of moderate cost, consistent with existing new drug therapies.
- Breakthroughs in cell or organ transplantation tend to be very expensive on a per-person basis and also face a host of ethical and technological challenges to successful implementation.

Breakthroughs identified by the health services panel included changes in the organization and delivery of health care that could improve the receipt of effective services; better care management; and changes in lifestyle, which could have the most dramatic consequences for the health and medical expenditures of the future elderly.

Implications of the Results of Our “What-If” Scenarios

As shown in the simulations of what-if scenarios, the existing FEM can be directly used to assess the future ramifications of changes in demographic trends (e.g., better-educated future elderly and rise in Hispanic population) and in patient behaviors (trends in risk factors, such as smoking and obesity) because these factors are explicitly built into the FEM as covariates in the hazard models.

For changes in medical technologies in the areas of primary prevention (e.g., technologies for disease immunization) and secondary prevention (e.g., screening tests), FEM can also be applied with only minor modifications. Examples include technologies that can eliminate heart disease among the young, a compound that extends life span, and diabetes prevention via insulin sensitization drugs.

For certain types of changes in medical technologies, moderate modifications need to be made to the FEM with detailed information on eligibility and the effect of these technologies on health status and costs. Examples include the development of telomerase inhibitors, cancer vaccines, and treatments for cardiovascular disease in the simulation scenarios.

For other types of changes in medical technologies and changes in the health care system, the existing FEM would need to be modified substantially. Examples include better care coordination, better medication management, and environmental improvements.

Our approach was broadly supported by our social science expert committee. The policy community generally has been interested in this approach as well, especially technical advisors to Medicare trustees, because of its great policy relevance: These potential breakthroughs could have important effects on future health conditions and health care expenditures, and the FEM could help CMS and other government agencies evaluate these effects as well as the effectiveness of corresponding policies. But FEM cannot replace the existing baseline forecasts developed by the CMS OACT and can only serve as a tool for evaluating specific trends or breakthroughs.

One limitation to our what-if scenarios that needs to be considered is that the panels did not adopt uniform definitions for likelihood of occurrence or adoption. The first panel had a difficult time assessing the likelihood of adoption, with estimates ranging in some cases from 0 to 100 percent. The reason for this range is that some interpreted “likelihood of adoption” as the likelihood that even one person would receive a treatment, whereas others interpreted the term to mean the likelihood that any eligible person would receive it (which would be close to the prevalence rate). After clarification of the term to refer to the likelihood of this procedure being an important part of clinical practice, subsequent panels estimated much less variable rates of adoption. Variation also existed in the definition of likelihood of occurrence (for a breakthrough). Technologies with a low probability of occurrence clearly would have been of less importance than those with higher probabilities. Thus, we did not consider the estimated likelihood of occurrence but rather the effect conditional on occurrence in our simulations.

Recommendations

Expand the expert panel process. Our expert panel process seems to have merit, but more assessment is needed. Ideally, this process would be made more formal and would be repeated at regular intervals. The choices made by this panel (and perhaps the alternatives they deem best) would be reviewed regularly. One alternative might include organizing panels by research areas, e.g., bioengineering or stem cells, rather than by disease type, so that experts can provide more detailed and reliable information about the breakthroughs in their areas of specialization. Key themes should be reviewed regularly. Scenarios would incorporate updated information and then make changes accordingly because of the rapidity of technological development.

Integrate the FEM into the OACT. The FEM is an innovative tool and produces interesting results that will be useful in several policy venues. The FEM is especially useful as a tool for conducting what-if simulations that explain what might happen with explicit changes in demographics and medical technology. It could be used by the OACT to answer questions about specific medical technologies. However, for it to be useful, the model needs to be kept up-to-date with recent MCBS and NHIS data.

Model complex scenarios. Some of the technologies identified in this report may have spillover effects, that is, therapeutic benefits in more than one area. For example, the use of a “longevity pill” that mimics caloric restriction might lower the risk of a number of diseases, in addition to extending life span. More information from the expert panels about joint probabilities and treatment scenarios would be useful. We relied on the literature review and the panel assessments to quantify these effects precisely; such quantification needs to be done on a case-by-case basis. Past assessment of novel technologies could also assist in this effort.

Model technology diffusion. The ultimate effect of a technology depends on its timing and its price, both of which are difficult to forecast, are interrelated, and influence its diffusion. But it is unclear how to forecast future prices in the context of our model. The panels recognized, but could not predict, that costs of a procedure will fall over time with higher rates of adoption. Costs are affected by both supply and demand factors.

Model recovery. Some of the health states in the MCBS, e.g. disability, nursing home entry, and possibly even some types of cancer, might allow for recovery. Recovery could be modeled in several ways. Since it is hard to predict who will recover, the easiest method is to examine the raw probabilities of leaving a health state in subsequent years, i.e., to assess the fraction of people who do not report a particular disease or functional state but who reported it in the previous year. This method is simply the reverse of the FEM health transitions model.

Collect additional information in the Medicare Current Beneficiary Survey. Our modeling exercise showed some of the unique benefits of the MCBS. The link between self-reported information and claims and enrollment information in Medicare is particularly useful. However, the MCBS has the disadvantage of containing poor economic data: in particular, employment, income, and wealth. Information on these economic factors would greatly improve the range of useful scenarios, since one could consider key economic trends. Furthermore, some self-reported information about disease and its treatment, e.g., whether people had angioplasty or

were taking oral hypoglycemics, would also allow much better links between claims data and self-reported information.