Health and the Factors Driving Medical Spending

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With the rising cost of health care already a major concern for government, employers and individuals, one might reasonably ask what the future holds. Is the future burden of health care greater, lower, or just different? This paper reports on a multi-faceted research agenda on the factors that influence health and health care costs over time, and what they suggest for the future (see Cutler 2006 and Cutler, Glaeser, and Rosen 2008). Projecting the future is substantially more complicated than looking at age-specific health care spending today, and adding to that the component costs that might be associated with an older population demographic. It is at least as importantly about the evolution over time in health behaviors, chronic illness, medical innovation, education, disability, health care financing systems, the state of the economy and many other influences. Thus I have been engaged in research across a multitude of these inter-related influences.

I start by considering theoretically how to forecast medical spending. Traditional models of spending consider population demographics only. I highlight those models and their results in Section I. Section 2 then focuses on the evolution of health behaviors and risk factors, such as smoking, obesity, and control of hypertension and high cholesterol. These risk factor changes have had a mixed influence on health trends to date and, depending on how health behaviors continue to evolve in the future, could be fundamental to population health in the future. Section 3 considers the major advances in medical innovation in recent years, most of which have improved health, some of which have done so with expensive technological care, but some of which have contained costs with more effective disease and risk management. While I make no attempt to quantitatively integrate these various influences to project future health care costs, I conclude with some observations about a model that would do so.

I. Alternative Forecasts of Medical Care Spending

The need to forecast medical spending is obvious. Medical care is 16 percent of GDP and is growing rapidly. Half of medical care is paid for by the public sector (over 80 percent in most countries). Thus, public concern about rising costs is particularly high. But medical costs are a concern in the private sector as well. Increased medical spending involves painful adjustments as families shift their spending allocations among different goods and businesses pass on the costs of medical care to workers. None of this implies that medical spending increases are bad, but it indicates why we need to know what the medical burden will be.

Forecasting medical spending is simple in some ways and horribly complex in others. To understand the issues, I start with a truism: per capita medical spending is the product of the number of people at each age times spending at that age, divided by the number of people in the country as a whole. Denoting age groups with the subscript *a*, this can be expressed as:

$$(1) \qquad \text{Per capita medical spending} = \sum_a \text{Pop}_a * \text{Spend}_a \; / \; \text{Total Pop}$$

To forecast medical spending, therefore, we need projections of the population and spending at each age. The Social Security Administration publishes projections of population by age (Bell, 1997). While they are subject to some uncertainty, I use them in the analysis.

Figure 1 shows these forecasts through 2030. The most obvious change is the forecast increase in the share of the population that is elderly. That share increases from 12 percent in 2000 to 20 percent in 2030. There is a corresponding decline in the share of population that is young, or at young working ages.

Forecasting spending in each age group is more difficult. Most models start with relative medical spending at a point in time, and then increase spending in each age group over time. Aging is more of a problem in countries where medical spending is more highly tilted to the aged and in countries where overall cost growth is more rapid.

In the United States, medical spending is heavily tilted towards the aged – more so than in other countries (See Cutler, 2006). Figure 2 shows medical spending by age in 2000, taken from Meara, White, and Cutler (2004). Average spending increases from $1,500 per person at young ages to over $15,000 per person for people over aged 65. A lot of spending in the advanced ages is for care outside of the acute medical care system – long-term care, for example.

By itself, aging would have a significant impact on overall population medical spending. Average spending in 2000 was about $4,000 per person. Relative to that amount, spending would increase by 2 percent by 2005, 4 percent by 2010, 7 percent by 2015, 11 percent by 2020, 15 percent by 2025, and 20 percent by 2030. These are significant, but manageable.

On top of these demographic changes, however, are increases in the level of medical spending at each age – the $spend_a$ term in equation (1). Over time, the increase in medical spending has been largely independent of age – that is, it has affected all ages approximately equally. The increase is largely because medicine can do more things to more people, and that improves population health. Even modest increases in spending condition on age can have enormous impacts on average medical costs. For example, if medical care increased at 1 percent per year for all ages, even in the absence of demographic change medical costs would rise by 35 percent by 2030.[1] If it increased by 2 percent per year, the increase would be 81 percent. Together, aging and intrinsic increases in medical spending are forecast to increase medical spending by over 60 percent by 2030.

The intrinsic increase in medical costs is really proxying for several factors. Broadly speaking, there are two parts to the intrinsic increase. The first is the health status of the population. As the

[1] The most natural way to think about this is as spending increases relative to GDP. The model with no increase in spending is close to a simulation where health care increases at the rate of GDP. Current forecasts suggest an average increase of 1 percent above GDP. The historical norm is over 2 percent.

population becomes healthier, the demand for medical care falls. The second factor is the supply of medical care. The technology that is available, and the sense of physicians about which patients would benefit from it, both affect how patients with the same condition are treated over time. A complete model of medical care needs to consider both factors.

II. Health Status Changes

I start with the demand-side of care – what health status will people be in, and how will that affect their need for care. A simple example helps understand how changes in health status affect the spending estimates above. Suppose we differentiate people not just by what their age is but also by whether they are in the last year of life or not. If we do this, equation (1) becomes:

$$(2) \qquad \text{Per capita medical spending} = \sum_{a,d} \text{Pop}_{a,d} * \text{Spend}_{a,d} \;/\; \text{Total Pop}$$

where the subscript *d* denotes whether the person is a decedent or not.

People in the last year of life spend more than people who are not in the last year of life. On average, spending in the last year of life is about 10 times spending outside of the last year of life. In addition, as the population lives longer, there are naturally fewer people in the last year of life. For example, the Social Security estimates that 5.5 percent of the elderly were in the last year of life in 2000, and that 5.1 percent will be in 2030. Thus, the longer life will not be nearly as bad as the population forecasts alone suggest.

Of course, health status involves more than whether the person is near death. People not near death spend more when they are sick than when they are healthy. Thus, one needs a measure of health status that captures the full range of health states. There are many ways to measure health status: the number and type of diseases people have (for example, cancer or cardiovascular disease); the average level of physical functioning (for example, can the person cook and clean), and their propensity of people to get sick in the future (for example, are people smokers or overweight)

These measures of health are all related. At the basic level, one might classify them linearly: risk factors such as smoking and obesity influence the onset of disease (along with other factors), which in turn affects physical and mental well being. For short-term measures of demand for care, one typically wants to focus on of physical and mental functioning. If one wants to know what the change in hip replacements will be from this year to next year, a good way to estimate this is to look at change in the share of relevant population that is in arthritic pain. Over the longer-term, measures of risk factors are more important: sound risk factors lead to lower disease burden, and thus less need for care. Since I am primarily interested in long-term forecasts of medical spending, I consider forecasts of risk factor changes.

I think of risk factors in several dimensions. The first is behaviors that individuals have control over (to a great extent, at least). Smoking, obesity, and alcohol intake are the primary risk factors that affect the elderly and near elderly population. Smoking is the most important behavioral risk factor in terms of mortality rates. Mokdad et al. (2004) estimate that smoking accounts for about 435,000 deaths annually. Obesity is second in importance, though the impact is controversial (Flegal et al., 2005; Willett et al., 2005). Studies assessing the impact of obesity on mortality range from about 100,000 deaths per year to about 400,000 deaths per year. Excessive alcohol use is the third important risk factor, accounting for 85,000 deaths. Remaining risk factors include exposure to microbial agents (75,000 deaths) or toxic agents (55,000 deaths), motor vehicle accidents (43,000 deaths), guns (29,000 deaths), sexual behaviors (20,000 deaths), and illicit drug use (17,000 deaths). Many of these latter risk factors disproportionately affect the young. For purposes of forecasting medical costs, especially in an aging population, my focus is primarily on the elderly. Thus, I limit the analysis of behavioral risks to smoking, obesity, and alcohol use.

A second set of risk factors are clinical measures that predict future risk. Blood pressure and cholesterol levels are the leading example here. People with high blood pressure or high cholesterol are at greater risk for a variety of diseases: heart attacks, strokes, kidney failure, blindness, dementia, and so on. Both hypertension and high cholesterol are a result of behavioral factors – especially obesity – but it is important to consider them separately because they may be modified separate from the underlying behavioral factor. For example, hypertension and high cholesterol can both be treated medically, even for people who have difficulty losing weight.

Developing risk factor forecasts requires data on physical measures of the population, not just self-reports. Not everyone with high blood pressure knows they are hypertensive, for example, and the share of people with this knowledge changes over time. In the US, the leading survey with both physical examination and laboratory measurements is the National Health and Nutrition Examination Survey, or NHANES. More detail on the survey design and operation is reported elsewhere (Miller, 1973; NCHS, 2006).

There have been many changes in these risk factors over time. Figure 3 shows the trend in age-adjusted smoking rates. Smoking rates have fallen markedly, from over 40 percent of the population in the mid-1960s to about 20 percent today. The reduction is partly a result of price increases for cigarettes, and partly a result of changing attitudes about the harms of smoking, communicated widely by the Surgeon General in 1964 and reinforced countless times since then.

In contrast, obesity rates have increased markedly, as figure 4 shows. The share of the population that is obese nearly tripled from the early 1960s until early in the 2000s, with most of the change coming in the late 1970s and early 1980s. The share of the population that is overweight stayed roughly the same; to a first approximation, the entire weight distribution in the United States has shifted to the right.

Figures 5 and 6 show data on hypertension and cholesterol control over time. In the case of high blood pressure, there have been good medications for several decades. As figure 5 shows, most people with hypertension are aware they are hypertensive. But only half the hypertensive population is treated, and even among those treated, blood pressure does not meet guideline levels. Only 31 percent of people with hypertension – fewer than 1 in 3 such people – have their blood pressure at guideline levels. That number is up from a decade earlier, but it is not high in absolute terms.

The same is true about high cholesterol. Effective medications without significant side effects were developed for high cholesterol in the 1980s and 1990s. They were marketed heavily, to physicians and patients. Generally, people got the message. One third of people with high cholesterol know their cholesterol was high. But treatment is not as complete; as a result, fewer than 5 percent of people with high cholesterol had their cholesterol under control.

Changes in Health

One way to gauge the likely impact of risk factor changes is to use a model to see how these various trends have affected and will affect population health. I do this using micro data on risk factors and their relation to disease (see Cutler, Glaeser, and Rosen, 2008).

I use two NHANES surveys, the first from 1971-75 (NHANES I), and the second from 1999-2002 (NHANES IV). In each case, the initial sample is the population aged 25-74. The upper age restriction matches the sampling frame of NHANES I. To focus on the elderly and non-elderly population in specific, I also consider the population aged 55 and older.

Table 1 shows the characteristics of the sample in the two time periods. The first set of columns is for the entire population, and the second set of columns restricts the sample to people aged 55 and older. After eliminating people with missing risk factor information, the full age sample includes 6,764 respondents to NHANES I and 6,255 respondents to NHANES IV. The subset of older respondents is about one-third the size.

Age is categorized into 10 year age groups beginning at age 25. Race is defined as white, black, or other. Education is divided into three groups: less than a high school degree; a high school degree; and at least some college. Table 1 shows that these risk factors moved in the expected direction over time. In particular, the share of people with at least some college education doubled over those three decades.

Following standard practice in the literature, smoking status is divided into three groups: current smokers, former smokers, and never smokers. Smoking status is determined by responses to two questions, "Have you ever smoked at least 100 cigarettes in your entire life?" and "Do you smoke cigarettes now?" The share of current smokers fell by a third over the time period, from 40 percent in the early 1970s to 25 percent around 2000. Two-thirds of this was people who never started smoking, and one-third was people quitting.

Drinking status is divided into heavy drinkers, light drinkers, and non drinkers. In NHANES I, drinking status was assessed with three questions. Non-drinkers were those who answered "no" to the question, "During the past year have you had at least one drink of beer, wine, or liquor?" Among those who answered "yes", subsequent questions included "How often do you drink?" and "When you drink, how much do you usually drink over 24 hours?" Heavy drinkers were those who drink 3 or more drinks over 24 hours and reported drinking "everyday" or "just about everyday". The next possible response was "about 2 or 3 times a week". In NHANES IV, non-drinkers were defined as those who responded "zero" to the question, "In the past 12 months, how often did you drink any type of alcoholic beverage?" A subsequent question asked people, "In the past 12 months, on those days that you drank alcoholic beverages, on the average how many drinks did you have?" Heavy drinkers were those who reported drinking three or more drinks at least four times per week (i.e., four or more times per week, 16 or more times per month, or 208 or more times per year). Both heavy and light alcohol use declined over time. Heavy drinking fell from 7 to 4 percent of the population; light drinking fell from 72 to 65 percent.

BMI was based on direct measurement of height and weight. In accordance with conventional guidelines (National Institutes of Health, 1998), I classify respondents as underweight (BMI<18.5), normal weight (18.5≤BMI<25), overweight (25≤BMI<30) and obese (30≤BMI). The largest change in weight has been the shift from healthy weight to overweight. Overweight and obesity were 49 percent of the population in the early 1970s; today, they are 68 percent. At the other end of the scale, fewer people are underweight now than in the past (2 percent versus 3 percent).

Blood pressure and total cholesterol are measured according to standard protocols used in the medical examination component of each survey (Burt et al., 1995; Hajjar and Kotchen, 2003; Carroll et al., 2005). Blood pressure is divided into four groups following the recommendations of the seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC VII):[15] normal blood pressure (systolic blood pressure (SBP) ≤ 120 mmHG and diastolic blood pressure (DBP) ≤ 80 mmHG); pre-hypertension (120≤ SBP<140 or 80≤ DBP<90); stage 1 hypertension (140≤ SBP<160 or 90≤ DBP<100); and stage 2 hypertension (160≤ SBP or 100≤ DBP). Cholesterol levels are divided into three groups based on the recommendations of the Third Report of The National Cholesterol Education Program Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (NCEP, 2001): normal cholesterol (total cholesterol<200); borderline high cholesterol (200≤total cholesterol<240); and high cholesterol (240≤ total cholesterol).

Somewhat surprisingly, substantial gains have been made in blood pressure and cholesterol control, even with the increase in obesity (the largest contributor to each). The share of people with stage 2 hypertension fell from 16 percent of the population in the early 1970s to 5 percent around 2000. The share with stage 1 hypertension fell nearly in half as well. Rates of high cholesterol declined by over one-third, almost certainly a result of improved medications.

To gauge the impact of these differing health trends on demand for medical care, we need to weight the various risk factors. The optimal weights to use will depend on the question being asked. One could use longevity weights, quality of life weights, or medical spending weights. In forecasting medical spending, one would clearly like to use spending weights. In practice, the NHANES does not have data on medical spending, and quality of life data are not great. Thus, I use mortality weights. The underlying assumption – likely to be reasonable – is that factors that predict death are also likely to predict medical spending.

To estimate the impact of these risk factors on mortality, I use the epidemiological follow-up conducted as part of the 1971-75 NHANES. Epidemiological follow-ups were conducted at periodic intervals after the initial survey, going into the 1990s. I estimate a logit model for death from any cause within the 10 years subsequent to the initial survey. I choose 10 years to get the long-term impact of these risk factors, but to avoid a situation where most everyone will have died. Previous evidence shows that prediction equations from NHANES are broadly similar to those from other data sources such as the Framingham Heart Study, with the possible exception of increased importance of smoking and diabetes in NHANES data (Liao et al., 1999; Leaverton et al., 1987).

Table 2 shows the odds ratios for death in the subsequent 10 years. The coefficients are all in the expected direction, and most are statistically significant. Among demographic factors, blacks are more likely to die than whites (OR=1.4; p=.010), and marriage is protective of future longevity (OR=0.68; p=.001). People with less than a high school degree have 27 percent higher mortality than people with a high school degree (p=.036).

Behavioral risk factors are also important. Being a current smoker increases the odds of death in the next 10 years by 113 percent (p<.001). Heavy drinking is associated with higher mortality, and light drinking is associated with lower mortality; the net impact is thus unclear, though as I show below, these changes are relatively small.

Without controlling for hypertension or high cholesterol, obesity increases the odds of death by 44 percent (p=.018), however this drops to 28 percent and is no longer statistically significant (p=.112) once blood pressure and cholesterol are controlled for. This finding parallels other research from the Framingham Heart Study, which does not include obesity in the risk equations (Anderson et al., 1991; Wilson et al., 1998), and data showing that the impact of obesity on mortality is declining in more recent surveys (Flegal et al., 2005). Indeed, it is likely that some of the obesity effect we find would be reduced still further if we were able to control for diabetic status. Being underweight is associated with significantly higher mortality, likely because of the loss of lean body mass (and, therefore, weight) associated with chronic and/or severe illnesses (Willett et al., 2005).

Both hypertension and high cholesterol are associated with substantially increased risk. People with stage 2 hypertension have a 54 percent increase in risk (p=.023) above those with normal blood pressure. High cholesterol is associated with a 15 percent higher mortality risk, though this is not statistically significant (p=.277).

I use these coefficients to estimate the mortality risk for every person in the 1971-75 and 1999-2002 NHANES surveys. These risks will vary with all of the risk factors. To standardize the risk assessment, I present age and sex adjusted risks, using the age and sex distribution of the population in 1999-2002 as weights.

Table 3 reports the risk profile in the two time periods, for the population as a whole and for the near elderly and elderly populations. For the entire population, the ten year mortality risk declined from 9.8 percent in 1971-75 to 8.4 percent in 1999-2002 (p<.001), an absolute reduction of 1.4 percentage points, and a relative risk reduction of 14 percent. Among the population aged 55 and older, the absolute risk fell from 25.7 percent to 21.7 percent (p<.001), a relative reduction of 16 percent.

The lower rows of the table show which risk factor changes were most important in this health improvement. I calculate these by taking derivatives of the prediction equation evaluated at the mean risk level [in a logit model, $dp/dx = p(1-p)\beta$]. I evaluate this equation at the average probability in the population.

For the population as a whole, the largest risk factor change was the reduction in smoking, which contributed to a 0.9 percent absolute decrease in mortality risk. Better risk factor control was second in importance. Improved blood pressure control led to a reduction of 0.6 percent in risk and better cholesterol control accounted for 0.2 percent. The increase in obesity offset some, but not all, of these risk reductions.

In the population aged 55 and older, the patterns were the same, although the magnitudes were larger. The most important factor for the older population was better control of medical risk: lower blood pressures contributed a 2.1 percent absolute reduction in mortality risk, and lower cholesterol contributed 0.6 percent. Second in importance was decreased smoking, accounting for a 1.2 percent reduction in risk. Improved education among the older group led to a nearly 1 percent reduction in risk. The impact of obesity was to raise risk by 0.6 percentage points.

The factors responsible for better control of hypertension and high cholesterol likely include increased use of medications and, to a lesser extent, behavioral change. Use of antihypertensive medications rose markedly after the early 1970s (Burt et al., 1995), and use of HMG-CoA Reductase Inhibitors (i.e. statins) to control cholesterol increased markedly in the 1990s (Ma et al., 2005). Other possible factors include reduced fat and salt intake (Cutler and Kadiyala, 2003).

The relatively small impact of obesity on mortality risk is in part a reflection of the fact that I control for blood pressure and cholesterol in our mortality equation. As noted above, the estimate of obesity on mortality nearly doubles without controlling for these risk factors.

To evaluate these findings in a more intuitive setting, I simulate the impact of risk factor changes by considering how a 14 percent reduction in risk at every age would affect life expectancy at each age.

The expected increase in longevity is 1.8 years at age 25, 1.6 years at age 45, 1.4 years at age 65, and 0.7 years at age 85. These are significant changes.

Forecasts of Future Risk

I can then use this methodology to consider whether the demand for very intensive medical care will rise or fall in the future. Forecasting in any field is difficult, but behaviors are particularly difficult to forecast. Still, because of the importance of the issue, I present some simple forecasts. The forecasting methodology is explicitly extrapolative. I want to understand what will happen if current trends continue. I consider in particular changes in smoking and obesity.

Smoking. There are good data to guide a smoking simulation. Since people rarely start smoking after age 25, the share of elderly people in the future that smoke is bounded by the share of people who smoke currently. Specifically, for people who will be age 45 and older in two decades, I assume that the share who will be ever smokers is the same as the share for that age and sex group in 1999-2002. To forecast the division between current and former smokers, I use data on the trend in current smoking rates. As shown in Table 2, current smoking rates fell by 2.7 percent per year (demographically adjusted) between 1971-75 and 1999-2002. I assume this rate continues within each age and sex group. I then subtract the forecast of current smokers from the forecast of ever smokers to estimate the share of former smokers.

For the population 25-44, I do not have past experience to guide the forecasts, since I do not view them as adults in 1999-2002. For these groups, I assume that the current smoking rate is equal to the smoking rate in 1999-2002 among that age group, adjusted down by 2.7 percent per year (the historical trend). I assume the same ratio of former to current smokers in those age groups as we observe in 1999-2002. Thus, the share of ever smokers is trending down as well.

The net impact of the forecast is that current smoking rates would decline from 25 percent of the population in 1999-2002 to 15 percent two decades later. The share of former smokers would be relatively constant, falling from 26 percent to 23 percent. Among the population aged 55 and older, current smoking rates would fall from 16 to 10 percent, and the share of former smokers would remain constant.

Obesity, Hypertension, and High Cholesterol. Forecasting obesity is difficult, since obesity can change rapidly at any age (Cutler, Glaeser, and Shapiro, 2003). Further, obesity is a key input into hypertension and high cholesterol, so we cannot forecast those without understanding obesity trends. Our forecast of these factors is done in several steps.

I start by extrapolating past changes in weight. Between 1971-75 and 1999-2002, average BMI increased by 11 percent in total (from 25.6 to 28.3), or 0.4 percent annually. I assume that this annual change in BMI will continue for the next 20 years. I account for this by increasing each person's BMI in the 1999-2002 data uniformly by 7.4 percent for twenty years. I then calculate for each person their obesity status: underweight, normal weight, overweight, or obese. This forecast suggests that 0.6 percent of the population will be underweight (compared to 1.7 percent currently), 20.1 percent of the population will be normal weight (compared to 30.4 percent currently), 33.9 percent of the population will be overweight (compared to 34.7 percent currently), and 45.4 percent will be obese (compared to 33.2 percent currently).

The second step is to use these forecasts to simulate the population's blood pressure and cholesterol in two decades if there were no treatment. To do this, I use data from the 1959-62 National Health Examination Survey (NHES). The NHES data were gathered from a period when blood pressure and cholesterol treatments were very scarce. They thus provide a good structural model for these risks. Following Cutler et al. (2007), I relate systolic blood pressure, diastolic blood pressure, and total cholesterol to age and age squared, interacted with gender, race dummy variables, and BMI and its square. These regressions are shown in Table 4. The general fit of the models is good, with R^2's ranging from 24 percent to 37 percent. The coefficients are all in the expected direction; most importantly, BMI is related to blood pressure and cholesterol.

I use these equations, and the forecast of BMI for the 1999-2002 population to simulate systolic blood pressure, diastolic blood pressure, and total cholesterol. In performing the simulation, I first find the expected value of blood pressure and cholesterol for each person. I then add in a random normal error term, drawn from the same variance as in the 1959-62 data. The latter step allows me to capture heterogeneity in actual values of blood pressure and total cholesterol.

The next step in the simulation is to consider the impact of treatment. In the benchmark simulation, I assume that treatment will be taken by the same share of people and have the same efficacy as medication use does in 1999-2002. The share of people taking medication is known from the 1999-2002 NHANES, which asks explicitly about use of anti-hypertensive and cholesterol-lowering medication. In those data, 60 percent of people with hypertension report taking anti-hypertensive medication, and 35 percent of people with high cholesterol report taking cholesterol-lowering medication.

For those taking medication, I draw values of blood pressure and cholesterol from the distribution of medication users, using the mean and standard deviation of each. This simulation suggests that people taking anti-hypertensive medication have a reduction of 7.9 (9.2) mmHg in systolic (diastolic) blood pressure (to mean levels of 143 (89) in systolic (diastolic) blood pressure), and that people taking cholesterol-lowering medication have a reduction of 30.5 mg/dL in total cholesterol (to a mean level of 244 mg/dL).

Table 5 shows the predicted changes in 10 year mortality risk for each of these simulations. Continued reductions in smoking will reduce mortality risk, by roughly the same amount as changes over the past thirty years. The mortality risk for the entire population aged 25 and older would decline by 0.7

percent, or 8 percent of the baseline rate. The impact on the older population would be an absolute mortality reduction of 1.0 percent, or 5 percent of the baseline rate.

The most surprising finding in table 5 is the impact of future changes in obesity on mortality risk. Even with existing degrees of medication use, the impact of increases in obesity, hypertension, and high cholesterol would lead to a 1.1 percent increase in mortality risk for the total population, or 13 percent of the baseline rate. In the population 55 and older, the increase in risk is 1.3 percent, or 5 percent of the baseline risk.

The reason for this large impact is the non-linear relationship between BMI and weight increase, and between BMI and health risk. At higher levels of BMI, a given percent increase in weight is a greater number of pounds. And because weights are so high to begin with, further increases in weight push many more people into the obese category, where health impacts are particularly severe. Thus, the impact of BMI changes on health is becoming increasingly large.

Lack of good hypertension and cholesterol control is also an important reason why increases in BMI have such large impacts on mortality risk. To understand the importance of incomplete risk factor control, the last row of table 5 shows an alternative simulation where BMI increases the same amount, but all people with hypertension or high cholesterol are assumed to be on medication and medication is assumed to bring people to the 75th percentile of effectiveness. This is an additional reduction of 14 (7) mmHg in systolic (diastolic) blood pressure, and 18 mg/dL in cholesterol. In this simulation, the impact of weight changes on mortality risk is virtually nil, and is significantly smaller than the impact of continued smoking reductions.

The key in this simulation is the effectiveness of medications more than getting more people to take them. Because even the typical person taking medication has high risk factor levels, increasing the share of people taking medication to 100 percent lowers the risk to only 1.0 percent (relative to 1.3

percent at the current level). If medications can be made more effective or used more regularly, however, the benefits would be much greater.

The net impact of risk factor changes on the demand for medical care is thus uncertain. Rising obesity will certainly increase the demand for care, but if this translates into (relatively) cheap and widely used anti-hypertensives and cholesterol-lowering medications, the demand for more acute care may fall. If not, the number of acute events may rise markedly.

III. Medical Technology Changes

The observation that even people taking medication are often not under control leads to the last dimension of medical spending forecasts – what technologies will be around to treat people, and how will they be used? These questions are far and away the most difficult to answer in spending simulations. Because of this, my discussion of this topic is necessarily speculative.

Medical technology can be grouped into three categories. The first is technology used in intensive settings for people who have significant impairments. Surgery for heart disease is one example of this; treatment for cancer is another. These technologies are expensive, with the hope of extending life or improving its quality. The second category of technology is preventive care. Vaccines are a prime example of this technology; anti-hypertensive medications and cholesterol lowering drugs are further examples. These technologies have short-run costs, but the possibility of long-term savings. (In contrast, life extending technologies increase costs in the short-term and the long-term). The third type of technology is procedural technology that is designed to improve the functioning of the medical system but not necessarily to treat patients. An example of this technology is computer systems that monitor adverse drug interactions or provide advice for physicians on what treatment they should follow (for example, Computerized Physician Order Entry [CPOE] systems in hospitals).

Historically, most of the increased cost of medical care has resulted from the first of these technology types (Newhouse, 1992; Medicare Technical Advisory Panel, 2000). The reason is clear – medical technology moved diseases from untreatable to treatable. For example, coronary bypass surgery replaced watchful waiting as a primary therapy for people with a heart attack in the 1980s and 1990s. Monitoring without intervention is cheap; bypass surgery is expensive. Hence, developing bypass surgery led to increased medical spending.

There is no indication that technological change in intensive therapeutic settings is becoming less rapid. If anything, it is speeding up with the genomic revolution and advances in traditional therapies such as surgeries and diagnostic equipment (JAMA, 2001). Thus, one might expect that medical spending will continue to increase.

But the translation between technological change and spending is becoming complex, even when care is used in the acute setting. Where lack of treatment was once the norm, today most conditions are treated in some fashion. As a result, in the future, new treatments will increasingly substitute for older ones. If the newer procedures are cheaper than the older procedures they replace, the use of new procedures may not lead to as rapid cost increase. To follow the heart attack example, angioplasty recently joined bypass surgery as a recognized therapy for heart attacks. Some angioplasties substitute for bypass surgery. Since angioplasty is cheaper than bypass surgery, the use of this technology saves money in some cases (Cutler and Huckman, 2003).[2]

The ultimate impact of technological change in intensive treatments on medical spending depends on the relative importance of these 'treatment expansion' and 'treatment substitution' effects. It will not necessarily be the case that medical spending continues to rise as medicine becomes more technologically sophisticated.

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[2] In total, though, angioplasty led to more spending, as it substituted for medical management in many people.

Advances in relatively inexpensive care have been common historically, though they may be diminishing over time. Traditional pharmaceuticals often fit the pattern of relatively low expense per person treated. Even branded medications such as statins cost about $3 per day, or about $1,000 per year. Generic prices are often 90 percent cheaper. At this price, cost-effectiveness of this care is generally high.

The major issue with such innovations is whether there are more of them to be found. Economists typically think in terms of low-hanging and higher-hanging fruit. The low-hanging fruit is easy to reach, and is thus picked first. By analogy, the cheap, widely effective way to treat disease is found first, and subsequent innovations are either more costly or less effective. That analogy may not be totally right in health care, however, since our ability to learn about new treatments is changing as well. Antihypertensives were found by trial and error; increasingly, drugs are found by understanding the molecular basis of health problems and designing solutions to them. Having the right knowledge base may lower the cost of developing new therapies.

Further, some technologies may reduce the need for care. For example, different cancers respond to different therapies, even with the cancer started in the same organ. Understanding which cancers will respond to which therapy will help to tailor treatment, so that not everyone need have all forms of care. By cutting the market to those who will most benefit from the care, technology may reduce overall medical costs.

Perhaps the most important potential medical advance is technology that will improve the efficiency with which care decisions are made. I noted earlier that a central issue in treating hypertension and high cholesterol is getting people to take medications that have been recommended to them. The solution to this could well involve new technology – reminder systems about refilling prescriptions, taking pills when they are available, going to the doctor, etc. Similarly, clinicians could be equipped with electronic medical records and decision support software that help them customize care to current medical guidelines.

Such technology has not traditionally been a big factor in the medical care system. Providers do not invest in computer systems regularly, and systems to help patients manage their health are not widespread. To a great extent, this failure is a result of reimbursement issues. Because we do not pay well for care coordination or for care effectiveness, investment in care-improving technology lags (Cutler, 2004). But that needn't be true over the next 30 years. If current ideas take hold, we may well be in a situation a few decades from now where appropriate care is routine and overuse is significantly less common. The result could be a remarkably different pattern of medical spending.

A full model of medical spending would need to take into account the likely course of all these various changes. At one level, this is impossible – no one has an idea about exactly how to do it. At another level, some guesses are possible. Most likely, the right model will have an underlying component to the growth in medical costs from the application of care in very intensive settings. This will increase spending, though perhaps at a declining rate over time. The other components of technology can be modeled as greater efficiency of spending – reducing clinical risk factors and getting more health output per dollar spent. This model could then yield a projection about the health improvement and medical spending associated with long-run demographic and economic changes. Constructing such a model is the next phase of this research.

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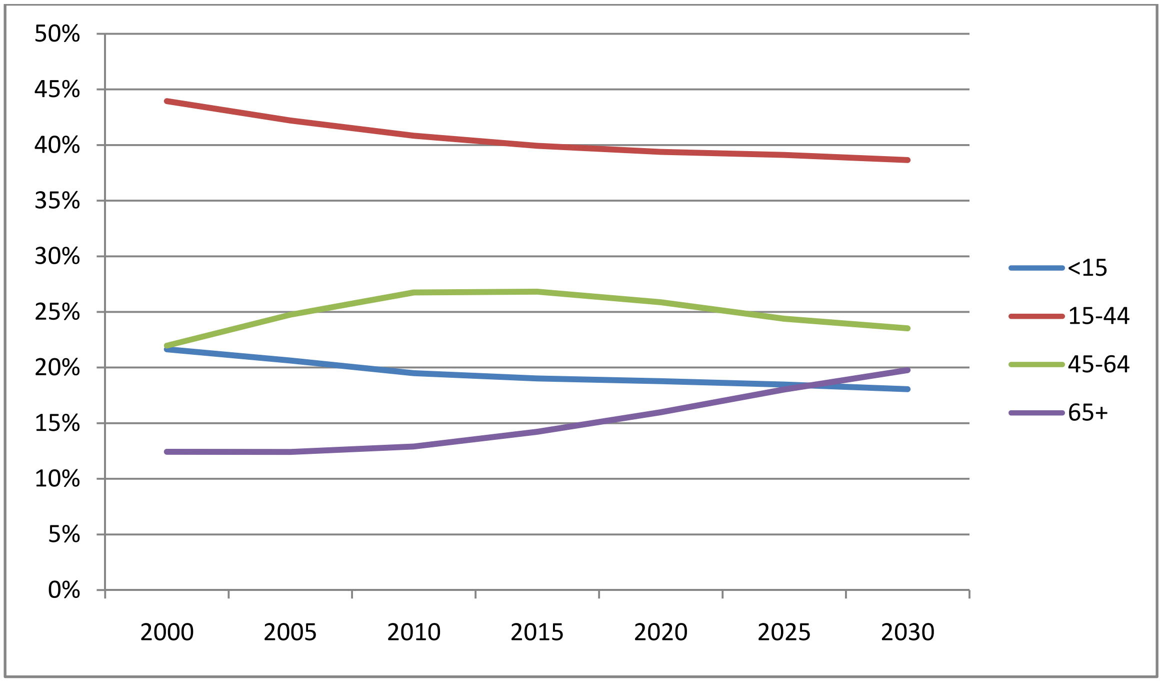
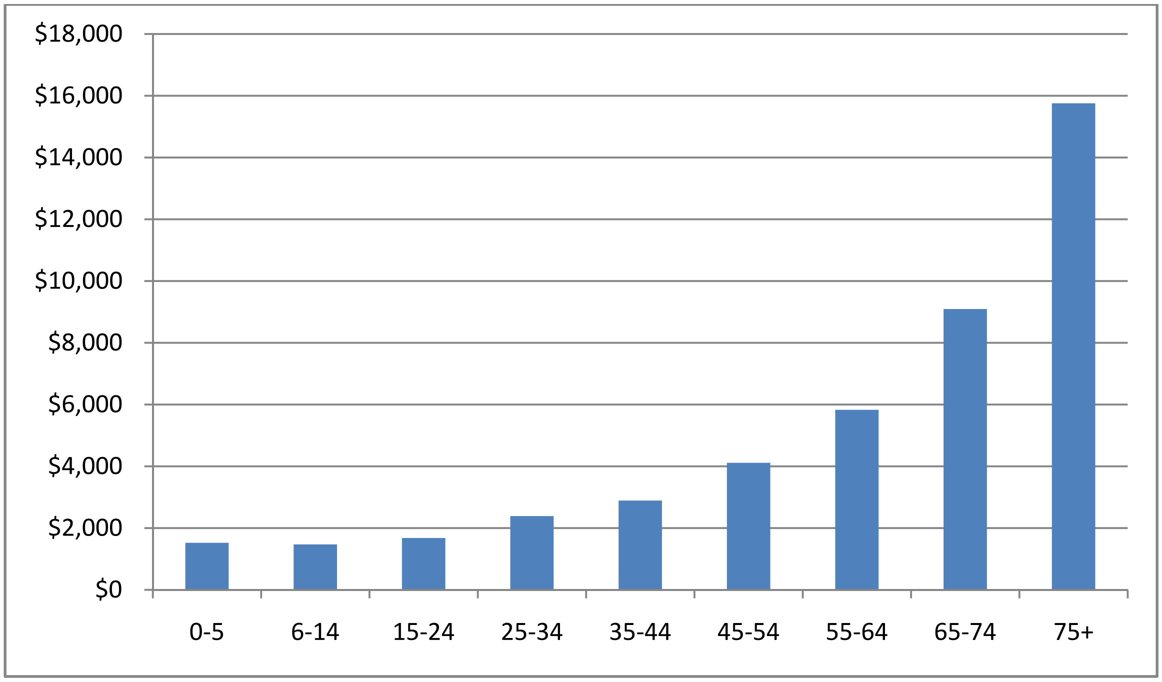
Figure 1: Forecast Changes in Age Distribution in the United States, 2000-2030



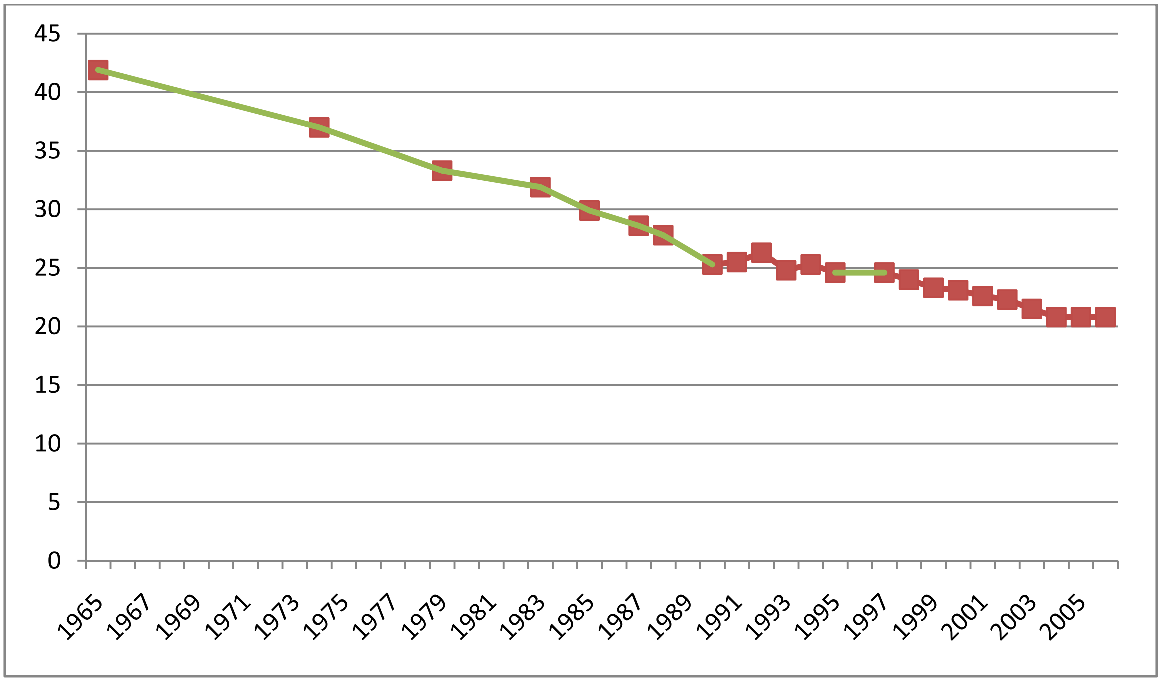
Source: Bell (1997).

Figure 2: Medical Spending by Age, 2000



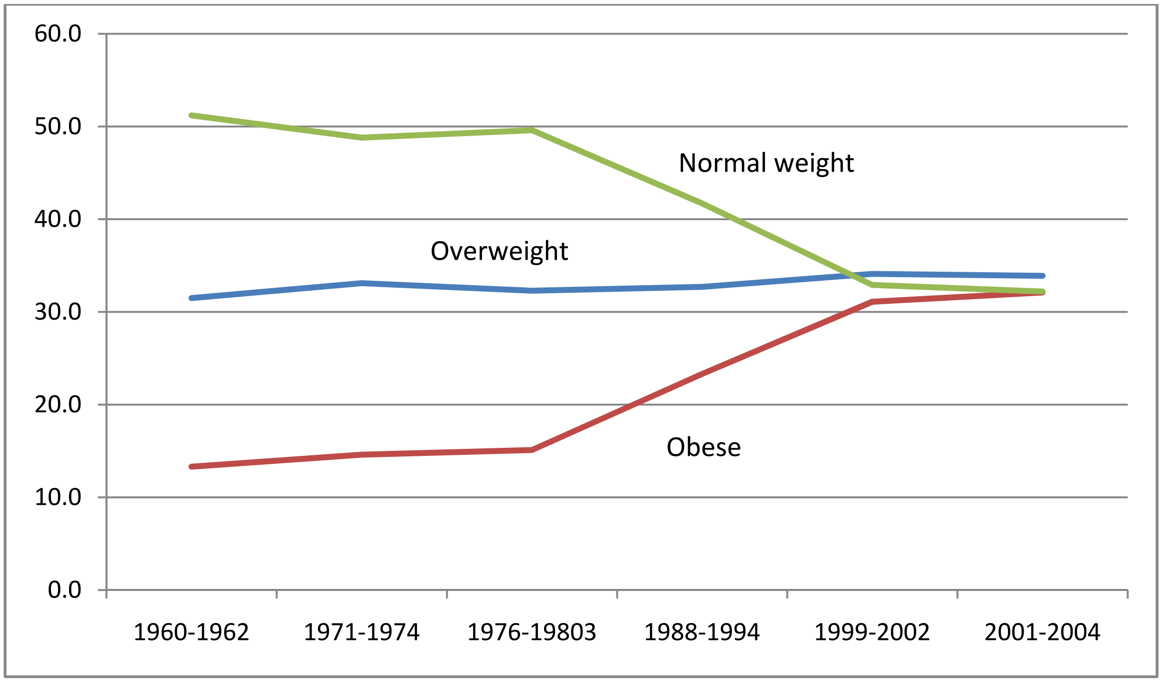
Source: Meara, White, and Cutler (2004).

Figure 3: Age Adjusted Smoking Rates



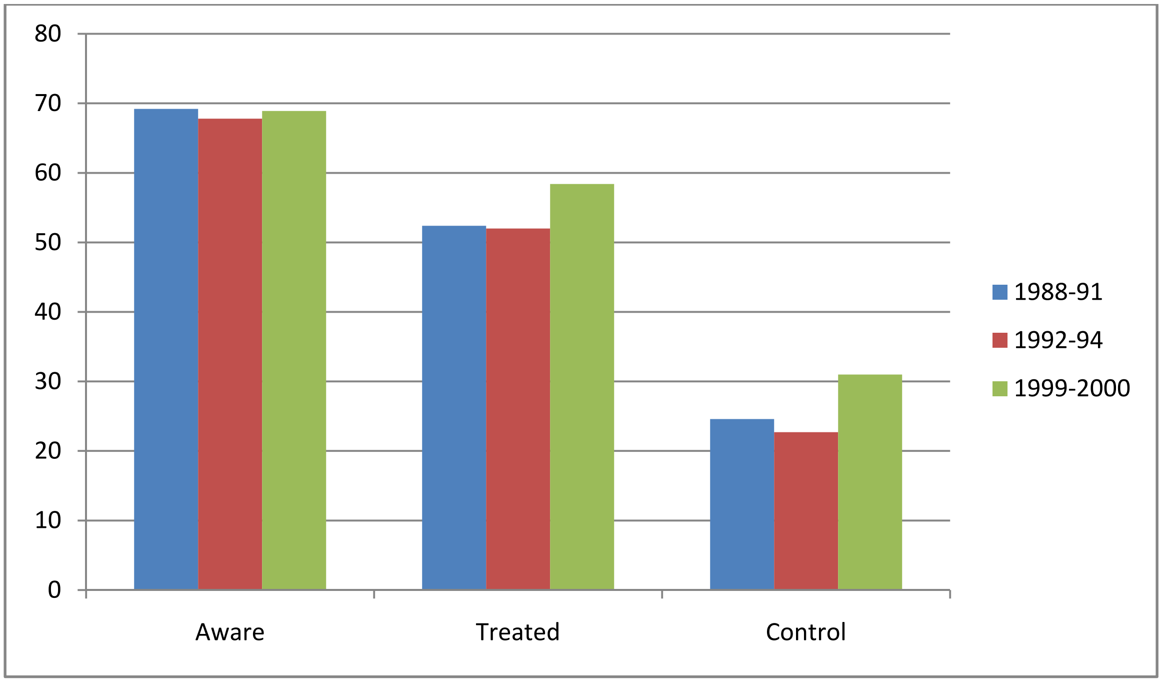
Source: National Health Interview Survey.

Figure 4: Age Adjusted Rates of Overweight and Obese



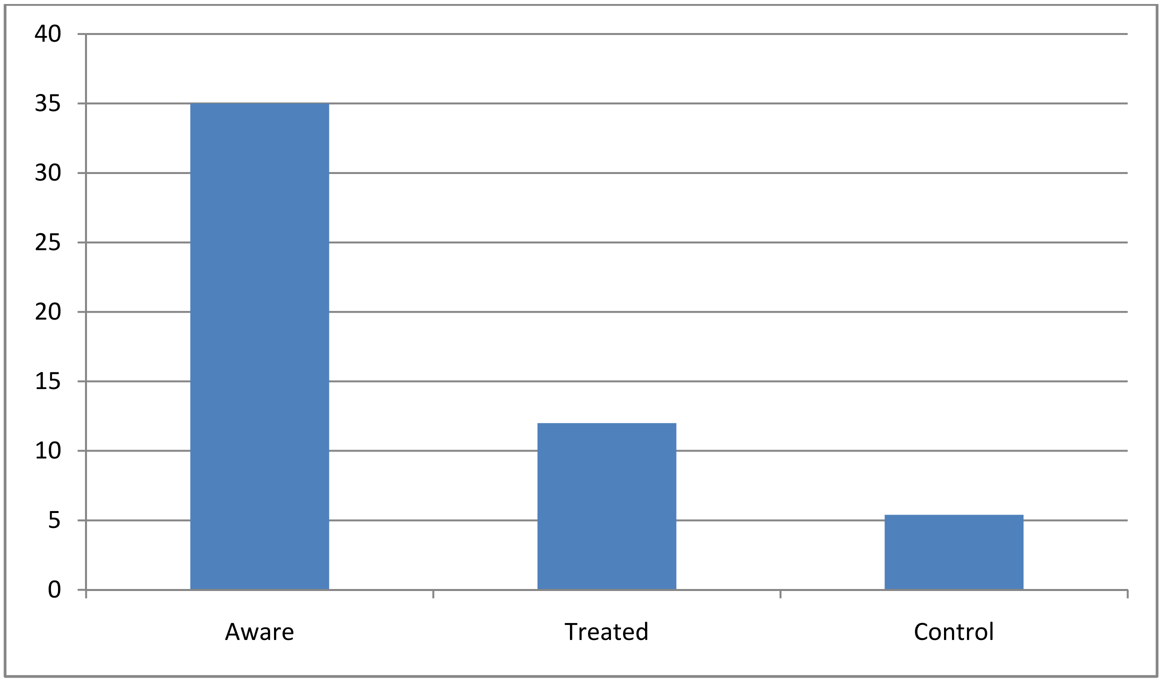
Source: National Health and Nutrition Examination Survey.

Figure 5: Trends in Hypertension Awareness, Treatment, and Control



Source: Hajjar and Kotchen, 2003.

Figure 6: High Cholesterol Awareness, Treatment, and Control, 1999-2000



Source: Ford et al., 2003.

Table 1: Characteristics of the Sample

	Entire Population		Population 55+	
Risk Factor	NHANES I 1971-75 (n=6,764)	NHANES 1999-2002 (n=6,255)	NHANES I 1971-75 (n=2,453)	NHANES 1999-2002 (n=2,188)
Female, %	52.5	51.1	54.1	51.9
Race, %				
White	89.0	85.8	90.8	88.6
Black	10.0	9.9	8.5	8.0
Other race	1.0	4.3	0.7	3.5
Married, %	79.0	64.9	72.5	70.1
Education, %				
<High school	34.4	19.8	55.3	31.7
High school	37.2	24.9	26.0	27.1
At least some college	28.4	55.3	18.6	48.8
Smoking, %				
Current smoker	40.3	24.8	28.5	16.3
Former smoker	21.2	26.0	27.9	40.6
Never smoker	38.5	49.2	43.6	43.1
Drinking, %				
Heavy drinker	6.7	4.4	5.8	4.5
Light drinker	72.3	65.3	60.3	55.1
Non drinker	20.9	30.3	33.9	40.5
BMI, %				
Underweight, BMI<18.5	2.8	1.7	2.9	0.9
Optimal weight, 18.5≤BMI<25	47.7	30.4	40.1	25.0
Overweight, 25≤BMI<30	34.6	34.7	37.5	36.4
Obese, 30≤BMI	14.8	33.2	19.5	37.7
Blood Pressure, %				
Normal blood pressure	22.4	43.4	8.9	22.5
Pre-hypertension	38.2	38.9	28.1	43.6
Stage 1 hypertension	23.6	13.1	32.4	22.3
Stage 2 hypertension	15.7	4.6	30.6	11.7
Cholesterol, %				
Normal cholesterol	35.4	47.4	19.6	35.6
Borderline high	34.9	34.4	34.7	41.8
High	29.7	18.3	45.7	22.6

Note: NHANES is the National Health and Nutrition Examination Survey.

Table 2: Effect of Risk Factors on 10 Year Mortality

Variable	Odds Ratio	Standard error
Race (relative to white)		
Black	1.402**	.195
Other race	.245	.221
Married	.682**	.077
Education (relative to high school graduate)		
<High School	1.269**	.144
At Least Some College	1.062	.191
Smoking status (relative to never smoker)		
Current smoker	2.126**	.250
Former smoker	1.233	.165
Drinking status (relative to never drinker)		
Heavy drinker	1.021	.175
Light drinker	.771**	.094
BMI (relative to optimal)		
Underweight, BMI<18.5	2.408**	.582
Overweight, 25≤BMI<30	.762**	.089
Obese, BMI≥30	1.278	.197
Blood pressure (relative to normal)		
Pre-hypertension	.904	.166
Stage 1 hypertension	1.131	.201
Stage 2 hypertension	1.535**	.289
Cholesterol (relative to normal)		
Borderline high	1.029	.130
High	1.150	.148
N	6,525	

Note: Data are from NHANES I. The regression includes 10 year age dummy variables interacted with gender.

Table 3: Impact of Risk Factors on Predicted 10-Year Mortality

	Total Population	Population 55+
Predicted mortality, 1971-75	9.8%	25.7%
Predicted mortality, 1999-02	8.4	21.7
Change	-1.4	-3.9
Effect of:		
Smoking	-0.9	-1.2
Blood pressure	-0.6	-2.1
Education	-0.2	-0.9
Cholesterol	-0.2	-0.6
Drinking	0.1	0.2
BMI	0.3	0.6

Note: Estimates are adjusted to the age and sex distribution of the population in 1999-2002. Effects of changes in race and marital status are not reported.

Table 4: Prediction Equations for Blood Pressure and Cholesterol

	Blood Pressure		
	Systolic	Diastolic	Total Cholesterol
Age	-.355**	.963**	4.57**
	(.148)	(.089)	(.35)
Age^2	.010**	-.009**	-.010**
	(.002)	(.001)	(.004)
Female	-8.55**	.918	35.95**
	(4.27)	(2.578)	(10.14)
Female*Age	-.116	-.162	-2.31**
	(.201)	(.121)	(0.48)
Female*Age^2	.006**	.002*	.034**
	(.002)	(.001)	(.005)
Black	6.31**	4.63**	-7.88**
	(0.77)	(0.46)	(1.83)
Other race	-7.72**	-1.40	-19.54**
	(1.78)	(1.08)	(4.20)
BMI	1.57**	1.42**	8.05**
	(0.34)	(0.20)	(0.80)
BMI^2	-.006	-.010**	-.124**
	(.006)	(.004)	(.014)
Constant	90.50**	26.23**	-14.81
	(5.46)	(3.30)	(13.01)
N	6,257	6,257	6,098
R^2	.373	.240	.244

Note: Data are from the 1959-62 National Health Examination Survey.

Table 5: Impact of Possible Future Risk Factors on Predicted 10-Year Mortality

	Total Population	Population 55+
Predicted mortality, 1999-02	8.4	21.7
Effect of:		
Continued reduction in smoking	-0.7	-1.0
Continued increase in obesity	1.1	1.3
Continued increase in obesity and more effective medications	0.0	0.1

Note: Estimates are adjusted to the age and sex distribution of the population in 1999-2002. Effects of changes in race and marital status are not reported.