*Financial Analysis; Nutrition*

# Predicted National Productivity Implications of Calorie and Sodium Reductions in the American Diet

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**Abstract**

***Purpose.*** *To model the potential long-term national productivity benefits from reduced daily intake of calories and sodium.*

***Design.*** *Simulation based on secondary data analysis; quantitative research. Measures include absenteeism, presenteeism, disability, and premature mortality under various hypothetical dietary changes.*

***Setting.*** *United States.*

***Subjects.*** *Two hundred twenty-five million adults.*

***Measures.*** *Findings come from a Nutrition Impact Model that combines information from national surveys, peer-reviewed studies, and government reports.*

***Analysis.*** *We compare current estimates of national productivity loss associated with overweight, obesity, and hypertension to estimates for hypothetical scenarios in which national prevalence of these risk factors is lower. Using the simulation model, we illustrate how modest dietary change can achieve lower national prevalence of excess weight and hypertension.*

***Results.*** *We estimate that permanent 100-kcal reductions in daily intake among the overweight/obese would eliminate approximately 71.2 million cases of overweight/obesity. In the long term, this could increase national productivity by $45.7 billion annually. Long-term sodium reductions of 400 mg in those with uncontrolled hypertension would eliminate about 1.5 million cases, potentially increasing productivity by $2.5 billion annually. More aggressive diet changes of 500 kcal and 1100 mg of sodium reductions yield potential productivity benefits of $133.3 and $5.8 billion, respectively.*

***Conclusions.*** *The potential long-term benefit of reduced calories and sodium, combining medical cost savings with productivity increases, ranges from $108.5 billion for moderate reductions to $255.6 billion for aggressive reductions. These findings help inform public health policy and the business case for improving diet. (Am J Health Promot 2009;23[6]:423–430.)*

***Key Words:*** Diet, Overweight/Obesity, Hypertension, Absenteeism, Presenteeism, Disability, Health Promotion, Public Health, Prevention Research. Manuscript format: research; Research purpose: intervention testing/program evaluation; Study design: nonexperimental; Outcome measure: behavioral, productivity, absenteeism, mortality, other financial/economic; Setting: United States; Health focus: lost productivity, obesity, uncontrolled hypertension, high cholesterol; Strategy: improved diet; Target population: adults; Target population circumstances: overweight, uncontrolled hypertension, high cholesterol

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## INTRODUCTION

Obesity and hypertension, as risk factors for numerous chronic conditions such as cardiovascular disease and diabetes, are prevalent and pervasive health problems that pose a severe burden on national productivity through work absenteeism, reduced productivity at work and at home, and disability that limits ability to work.[1–10] Both obesity and hypertension are associated with early mortality that can cut short careers.[11–15] The Centers for Disease Control and Prevention (CDC) estimates that obesity could be responsible for 112,000 premature deaths per year, whereas hypertensive disease could be primarily responsible for 54,700 deaths annually and, as a risk factor for cardiovascular complications, could additionally contribute to early mortality.[11,16–18]

Absenteeism is estimated to reduce annual productivity by 0.2% to 1.5% per worker with unhealthy weight and by up to 0.9% per worker with hypertension.[1–3] Presenteeism, defined as reduced productivity while at work, can result from various factors including concentration loss, slower work pace, job repetition, and fatigue.[4] Presenteeism estimates suggest that unhealthy weight is associated with a decline in annual productivity of 1.5% to 3.2%, whereas hypertension is associated with a productivity decline of 0.6% to 10.4%.[3,5–7] The presence of many comorbidities of obesity (e.g., arthritis, back pain, and diabetes) has been found to be associated with increased probability of limitations that can prevent working.[2,8–10]

In this study, we estimated total annual productivity losses to society from overweight, obesity, and uncontrolled hypertension, and subsequently the potential productivity benefits of reducing daily caloric and sodium intake to reduce prevalence of excess weight and hypertension. Because it is not practical to collect such data through direct observation or clinical trials, a simulation model was utilized that combines findings from the literature with analysis of national survey data.

## METHODS

This study estimates the current prevalence of excess weight and uncontrolled hypertension, the proportion of chronic health problems attributed to excess weight and hypertension, and the associated medical costs and lost productivity. Then, we model hypothetical scenarios to simulate what the national prevalence of overweight, obesity, and uncontrolled hypertension would be among the adult population if there were a reduction in daily intake of calories and sodium in the American diet. We compare current disease prevalence and cost to projected prevalence and cost under the hypothetical scenarios. These comparisons are suggestive of the potential long-term benefits to society of changes to the American diet.

In a companion article we describe the data and methods used to estimate current disease prevalence and medical costs associated with overweight, obesity, and hypertension, and we describe the long-term change in national prevalence of chronic health problems possible by reducing daily intake of calories and sodium.[19] In this section we describe the conceptual model, assumptions, and analyses to quantify the national productivity implications associated with improvements to the American diet.

### Conceptual Model

We categorize the adult population into 80 unique risk groups defined by age (18–44, 45–54, 55–64, 65–74, 75+), gender, weight, and hypertension status (uncontrolled hypertension, not uncontrolled). Four weight categories were defined: normal weight (body mass index [BMI] 18.5–24.9), overweight (BMI 25.0–29.9), obese class I (BMI 30.0–34.9), and obese classes II and III combined (BMI $\geq$ 35.0).[20] Uncontrolled hypertension was defined as systolic blood pressure (SBP) $\geq$ 140 mm Hg or diastolic blood pressure (DBP) $\geq$ 90 mm Hg.[21] We used 2007 U.S. Census Bureau population estimates by age and gender and estimated prevalence for overweight, obesity, and uncontrolled hypertension from the 1999 to 2004 National Health and Nutrition Examination Survey (NHANES) to estimate the size of the population in each risk group.[22]

Numerous studies find that health problems linked to excess weight and hypertension reduce national productivity through higher rates of absenteeism, presenteeism, disability, and premature death.[1–18] Using findings from the literature combined with original analysis of the National Health Interview Survey (NHIS), we quantified lost productivity for each of the 80 risk groups defined above. Reducing the amount of calories and sodium in the national diet will, over time, reduce rates of overweight, obesity, and hypertension. We compared current estimates of lost productivity to projected levels of lost productivity associated with the modeled hypothetical diet scenarios to simulate potential long-term benefits of improved diet.

### Assumptions

To our knowledge there are no studies that document the impact of dietary changes on productivity among adults. Our model is based on studies that show an association between diet changes and change in risk factors (e.g., BMI and SBP/DBP), and an association between the presence of risk factors (e.g., overweight, obesity, and hypertension status) and productivity.

### Absenteeism

The 2006 NHIS contains self-reported employment status; work days lost per year because of illness; height; weight; and indication of having been told by a physician that the respondent has hypertension.[23] We calculated average work days lost per year for 64 risk groups defined by age group, gender, weight category, and hypertension status. Differences between the normal weight and the excess weight categories in average work days lost (controlling for demographic and hypertension) were attributed to excess weight. Because hypertension prevalence is correlated with BMI, we jointly modeled the impact of excess weight and hypertension to prevent double counting.

To model potential change in total absenteeism days associated with changes in the prevalence of excess weight and hypertension, we combined Bureau of Labor Statistics data on labor force participation rates ($L$) for each age group ($a$) and gender ($g$)[24]; calculated average work days absent ($\overline{ADays}$) from the NHIS for each demographic, weight status ($w$), and hypertension status ($h$ = yes, no); and calculated net change in the population size for each risk group ($\Delta P$) associated with a scenario-defined reduction in daily intake of calories and sodium (Equation 1.1; see Table 1).

### Presenteeism

We used findings from the literature to model changes in presenteeism associated with changes in weight and hypertension. Estimates of reduced work performance associated with excess weight range from 1.45% to 3.17%.[5–7] Averaging the results of these three studies yields 4.9 work days lost per year per full-time worker with excess weight (about a 2% productivity decline). Our review found six estimates (ranging from 0.6% to 10.4%) in four studies of reduced work performance associated with hypertension.[3,5,6,25] The simple average across these six estimates (4.4%) equates to 10.6 lost work days per year per full-time worker with hypertension.

Analysis of the NHIS suggests that 78% of the working population with hypertension is overweight or obese. To prevent double counting, we removed the presenteeism effect associated with overweight and obesity from the population with hypertension. This yielded a presenteeism impact of 7.4 lost work days per year per worker with hypertension (a 3.1% productivity decline). Subtracting the overweight/obesity effect from the hypertension effect, rather than vice versa, could overstate the potential productivity gains from reducing excess weight

**Table 1**

**Equations**

$$\Delta ADays_{a,g} = L_{a,g} \times \sum_{w,h} \Delta P_{a,g,w,h} \times \left(\overline{ADays}_{a,g,w,h} - \overline{ADays}_{a,g,w=\text{normal},h=\text{no}}\right) \quad (1.1)$$

$$\Delta PDays_{a,g} = L_{a,g} \times \sum_{w,h} \Delta P_{a,g,w,h} \times \left(\overline{PDays}_{a,g,w,h} - \overline{PDays}_{a,g,w=\text{normal},h=\text{no}}\right) \quad (1.2)$$

$$\Delta Disability_{a,g} = \sum_{w,h} \Delta P_{a,g,w,h} \times \left(Disability\,Rate_{a,g,w,h} - Disability\,Rate_{a,g,w=\text{normal},h=\text{no}}\right) \quad (1.3)$$

$$NPV_{a,g} = \sum_{A=a}^{64} \frac{\left(E_{A,g} \times \left(L_{A,g} + 0.75 \times \left[1 - L_{A,g}\right]\right) \times (1+p)^{(A-a)} \times \left[1 - CM_{A,g}\right]\right)}{(1+d)^{(A-a)}} + \sum_{A=65}^{74} \frac{\left(E_{A,g} \times L_{A,g} \times (1+p)^{(A-a)} \times \left[1 - CM_{A,g}\right]\right)}{(1+d)^{(A-a)}} \quad (1.4)$$

$$\Delta Mortality_{a,g} = \sum_{w,h} \Delta P_{a,g,w,h} \times \left(Mortality\,Rate_{a,g,w,h} - Mortality\,Rate_{a,g,w=\text{normal},h=\text{no}}\right) \quad (1.5)$$

$$\Delta National\ Productivity = \sum_{a,g} \begin{pmatrix} \Delta ADays_{a,g} \times \overline{Daily\,Earnings}_{a,g} \\ + \Delta PDays_{a,g} \times \overline{Daily\,Earnings}_{a,g} \\ + \Delta Disability_{a,g} \times \overline{Annual\,Earnings}_{a,g} \\ + \Delta Mortality_{a,g} \times NPV_{a,g} \end{pmatrix} \quad (1.6)$$

while understating potential gains from reducing hypertension.

We modeled change in national full-time equivalent (FTE) work days lost because of presenteeism as a function of average annual days lost because of presenteeism ($\overline{PDays}$) for each risk group, the change in number of people in each risk group based on the diet scenario modeled, and labor force participation rates (Equation 1.2; see Table 1).

**Disability**

We defined disability as receiving Social Security Supplemental Insurance (SSI) payments because of disability. We identified those cases using the 2004 to 2006 NHIS, and used multivariate logistic regression to capture the hypothesized relationship with excess weight and hypertension, controlling for other factors hypothesized to increase risk of disability.

We estimated logistic regression models to predict the probability of disability. The independent variables included indicator variables for overweight, obese I, obese II and III, and hypertension; and age, gender, education attainment, marital status, health insurance coverage, race and ethnicity. To better capture differences by age, we implemented split sample analysis for age groups 18 to 54, 55 to 64, and 65 to 74 and used age-specific odds ratios from separate multivariate logistic regressions. Using the odds ratios, we calculated disability rates for each risk group defined by age, gender, weight, and hypertension status. The long-term change in national cases of disability associated with changes in national prevalence of overweight, obesity, and hypertension is characteristics by Equation 1.3; see Table 1.

**Mortality**

Starting with the overall national mortality risk for each demographic as reported by the CDC, and using age-gender-weight–specific relative risk ratios from Flegal et al.,[11] we calculated a mortality rate by weight category and demographic. The mortality rate attributed to hypertension was calculated by combining total primary diagnosis hypertension disease fatalities with fatalities caused by hypertension-attributed cardiovascular complications, and then dividing by estimates of the total population with hypertension. We estimated the portion of cardiovascular complication deaths attributed to hypertension using the population-attributable fractions from Lewington et al.[15] Analysis of the NHIS suggests that approximately 37% of adults with hypertension are obese, so we removed the estimated hypertension-related mortality from the obesity mortality rates to prevent double counting.

To estimate the national productivity lost because of early mortality, we computed the net present value (NPV) of future (lifetime) productivity by age for both men and women. The approach combines Bureau of Labor Statistics data on average annual earnings ($E$) as a proxy for productivity, labor force participation rates, and probability for survival by age and other demographic.[26] We used a real discount rate ($d$) of 3%, a rate often used in public health studies, and assumed that productivity growth ($p$) will increase real earnings by 1% per year.[27] NPV is calculated at age (a) of death based on expected future earnings for all other ages (A) had the premature death not occurred. This calculation uses cumulative mortality (CM) rate to adjust for life expectancy.

People not in the labor force provide services to society in the form of child/elderly care, services in the home, and volunteer work in the community. There is no consensus on the value of productivity for people not in the labor force, and similar to other recent studies,[28,29] we use 75% of the average earnings of peers (controlling for age and gender) in the labor force as a proxy for the value of productivity for the unemployed population aged 18 to 64 (for each percentage point change in this 75% assumption, the national cost of premature mortality changes by approximately 0.3%). For the population aged 65 to 74, we make the conservative assumption to model only lost productivity for employed individuals (because there is insufficient information to know what portion of the elderly population is productivity employed in nonmarket activities such as community service and child care). We make the simplifying assumption that productivity loss is zero for the population aged 75 and older. NPV of lost productivity per person who dies prematurely differs by age and gender is calculated using Equation 1.4; see Table 1.

The difference in cases of premature mortality if national rates of obesity and hypertension were different from current levels is described by Equation 1.5; see Table 1.

### Analysis

Using NHANES, we estimated current prevalence rates of overweight, obesity, and uncontrolled hypertension by demographic group. Then, using the Nutrition Impact Model, we modeled hypothetical scenarios showing how prevalence rates for overweight, obesity, and uncontrolled hypertension would decline via sustained reductions of 100 and 500 kcal per day below energy requirements, and via sustained reductions of 400 mg and 1100 mg sodium per day.[19] BMI changes were estimated using the 2005 Dietary Reference Intakes energy equations.[30] We modeled the relationship between sodium reductions and blood pressure using findings from a meta-analysis by Graudal et al.,[31] but also use estimates from the DASH-Sodium Trial for sensitivity analysis.[32]

With the kcal reductions, the nation would reach a new weight equilibrium in approximately 3 to 5 years. The reduction in prevalence of hypertension associated with a reduction in sodium intake could occur even quicker. Studies suggest that reduction in BMI and blood pressure can, within a few months, start to reduce the risk for cardiovascular disease, metabolic diseases, and other chronic conditions associated with high BMI.[19,33–39] Changing these risk factors does not eliminate cases of chronic health problems already present among the population. Consequently, our analysis comparing hypothetical national health equilibriums illustrates the potential long-term benefits of national changes in diet, showing how modest but sustained changes in diet can achieve profound changes in national health.

The potential long-term, annual productivity gains from reducing national prevalence of overweight, obesity, and uncontrolled hypertension combines estimates of reduced days of absenteeism, FTE days of presenteeism, cases of disability and premature mortality, and the estimated cost per case for each of these events (Equation 1.6; see Table 1).

## RESULTS

### Prevalence

Using rates from NHANES applied to Census Bureau population estimates, we calculate that of the 225 million adults in the United States in 2007, 74.7 million (33%) are overweight, 37.8 million (17%) are obese I, and 26.7 million (12%) are obese II or III. Approximately 42 million (19%) have uncontrolled hypertension, an estimate half that of national estimates, which typically include both individuals with uncontrolled hypertension and those whose blood pressure is controlled (SBP $< 140$ and DBP $< 90$ mm Hg) with medication.[40,41]

### Absenteeism and Disability

Average annual work days lost attributed to excess weight were 0.31 per overweight worker, 0.70 per obese I worker, and 2.12 per obese II and III worker, although the estimates varied by demographic. Hypertension was associated with an average of 1.35 annual work days lost per worker with hypertension.

Our multivariate regression analysis found strong evidence that obesity and hypertension were associated with increased risk for long-term disability (analysis available upon request). Individuals with self-reported hypertension, on average, were 1.66 times more likely to have received SSI for disability during the past year, controlling for body weight status and other social-economic factors. Individuals with BMI 30 through 34.9 and BMI $\geq 35$ were 1.23 and 1.77 times more likely to receive SSI for disability, respectively, compared with a normal weight group (BMI 18.5–25). These associations were statistically significant for all age groups combined.

### Premature Mortality

Our model suggests that obesity-attributed mortality is highest for the population aged 55 to 64, whereas mortality attributed to hypertension is highest for the population aged 75 and older. The estimated reduction in premature deaths by eliminating obesity is 76,000 (excluding deaths among the obese that are attributable to hypertension). Another 363,000 premature deaths could be prevented by eliminating uncontrolled hypertension. Findings from Ezzati et al.[42] indicate that total hypertension-related deaths in the United States may be as high as 600,000 per year, suggesting that our findings are likely conservative.

The NPV of lost future productivity per case of early mortality ranged from a high of $1.24 million for men aged 18 to 44 to a low of $14,000 for women aged 65 to 74, reflecting differences in annual earnings, labor force participation rates, assumptions regarding the value of work for those not in the labor force, and expected life years remaining. The NPV estimate is sensitive to the chosen discount rate; each per-

**Table 2**

**Productivity Loss Associated With Overweight, Obesity, and Uncontrolled Hypertension**

| | Risk Group | | | | |
|---|---|---|---|---|---|
| | Overweight* | Obese I* | Obese II and III* | With Uncontrolled Hypertension* | Total* |
| Adult population modeled (1,000,000) | 74.7 | 37.8 | 26.7 | 42.1 | 224.7 |
| Excess cases associated with each risk group (1000) | | | | | |
| Absenteeism days | 18,144 | 24,773 | 39,905 | 18,471 | 101,293 |
| Presenteeism (FTE) days | 257,441 | 140,392 | 98,378 | 100,375 | 596,586 |
| Days unable to work because of disability | 12,378 | 4082 | 50,426 | 35,622 | 102,508 |
| Premature mortality | 0 | 16 | 60 | 363 | 440 |
| Excess productivity loss associated with each risk group ($1,000,000) | | | | | |
| Absenteeism | 3518 | 3930 | 6791 | 3295 | 17,534 |
| Presenteeism | 43,521 | 22,847 | 15,347 | 18,446 | 100,161 |
| Days unable to work because of disability | 2543 | 673 | 9714 | 7573 | 20,502 |
| Premature mortality | 1898 | 6874 | 25,870 | 22,859 | 57,501 |
| Total associated costs | 51,480 | 34,323 | 57,721 | 52,174 | 195,698 |
| Excess productivity loss per person in risk group, $ | | | | | |
| Absenteeism | 47 | 104 | 264 | 80 | 78 |
| Presenteeism | 582 | 604 | 597 | 449 | 446 |
| Days unable to work because of disability | 34 | 18 | 378 | 184 | 91 |
| Premature mortality | 25 | 182 | 1006 | 556 | 256 |
| Total cost per person at risk | 689 | 908 | 2244 | 1270 | 871 |

NOTE: Estimates are rounded for presentation and might not add to totals. FTE indicates full-time equivalent.
* The weight risk groups include cases and costs for the portion of uncontrolled hypertension costs attributed to excess weight. Consequently, the Total column is less than the sum of the weight and hypertension columns to prevent double counting costs associated with uncontrolled hypertension.

**Table 3**

**Potential Long-term Productivity Gain through Calorie and Sodium Reduction**

| | | Reduction in Daily Intake* | | | |
|---|---|---|---|---|---|
| | | Calories | | Sodium | |
| Comorbidity Group | Current Total Cases in the United States (1000) | 100 kcal | 500 kcal | 400 mg | 1100 mg |
| Population covered | 224,669 | | | | |
| Cases averted (thousands) | | | | | |
| Overweight | 74,700 | 36,870 | 74,700 | — | — |
| Obese I | 37,782 | 21,816 | 37,782 | — | — |
| Obese II and III | 26,724 | 12,532 | 26,664 | — | — |
| Hypertension | 42,080 | 6030 | 11,248 | 1596 | 3466 |
| Associated cases | | | | | |
| Absenteeism days | | 28,813 | 75,177 | 1292 | 3040 |
| Presenteeism (FTE) days | | 125,132 | 434,884 | 6349 | 13,923 |
| Disability work days lost | | 28,570 | 72,771 | 1778 | 4208 |
| Premature mortality | | 62 | 135 | 10 | 22 |
| Productivity gains ($1,000,000) | | | | | |
| Absenteeism | | 4937 | 12,730 | 234 | 569 |
| Presenteeism | | 20,569 | 69,910 | 1138 | 2559 |
| Disability work days lost | | 5717 | 14,059 | 371 | 892 |
| Premature mortality | | 14,575 | 36,564 | 752 | 1795 |
| Total associated costs | | 45,798 | 133,263 | 2495 | 5815 |

NOTE: FTE indicates full-time equivalent.
* Estimates are rounded for presentation and might not add to totals. Some comorbidity cases are jointly attributed to excess weight and hypertension. Consequently, total potential savings from eliminating all cases of excess weight and uncontrolled hypertension is less than the sum of the indirect benefits from eliminating each individual risk factor.

centage point increase in the discount rate causes estimates of total mortality costs to drop by 6%–7%.

### National Productivity Loss

If there were no cases of excess weight and hypertension, we estimate that national productivity would be $196 billion higher than current levels, indicating the maximum potential benefits achievable by eliminating these risk factors (Table 2). Specifically, overweight and obesity are associated with a $144 billion decline in national productivity, of which 63% is attributed to obesity. Over half of this productivity loss comes in the form of presenteeism. Uncontrolled hypertension is associated with $52 billion in productivity loss; approximately half is associated with premature mortality. Because hypertension is a comorbidity of excess weight, the total productivity associated with both uncontrolled hypertension and excess weight ($196 billion) is less than the sum of the weight- and hypertension-related productivity losses.

### Potential National Health and Economic Benefits of Improved Diet

We modeled reductions in daily caloric intake ranging from 100 to 500 kcal below current estimated energy requirements (i.e., a level of caloric intake below that required to maintain current body weight). If all above–normal-weight adults permanently reduced daily caloric intake by 100 kcal, a new weight equilibrium would be reached over a period of 3 to 5 years.[19] The number of obese adults would decline by more than 34 million (Table 3). The net decrease in overweight adults would be close to 37 million, tempered by the movement of many formerly obese adults into the overweight category. Given a 500-kcal reduction in daily caloric intake below current estimated energy requirements, almost the entire adult population would shift into the normal weight category within 3 to 5 years.

The reduced prevalence of overweight and obesity associated with reduced caloric intake would gradually result in lower prevalence of chronic conditions. If cases of overweight and obesity were lower by 37 million and 34 million, respectively (the amount achievable with a daily reduction of 100 kcal), then annual productivity would be $45.8 billion higher (in 2007 dollars). This includes:

- 29 million additional work days by reducing absenteeism and short-term disability ($4.9 billion value),
- the equivalent of 125 million additional work days by reducing presenteeism ($20.6 billion value),
- 29 million additional work days by reducing long-term disability ($5.7 billion value), and
- 62,000 premature deaths prevented ($14.6 billion value).

A more aggressive 500-kcal reduction in daily caloric intake—resulting in the elimination of the majority of overweight and obesity cases—would yield potential benefits of $133.3 billion. Total premature deaths would decline by 135,000 per year. Approximately 59,000 deaths averted would come by reducing prevalence of hypertension attributed to overweight and obesity; the remaining 76,000 deaths averted would come from reducing other diseases (e.g., type 2 diabetes, heart disease) attributed to obesity.

We simulated the impact on uncontrolled hypertension of a reduction in daily sodium intake of 400 to 1100 mg per day. The 400-mg reduction by adults with uncontrolled hypertension would reduce hypertension cases by close to 1.6 million. There could be an annual reduction of 1.3 million absent days, 6.3 million FTE days with presenteeism, 1.8 million days lost because of disability, and 10,000 premature deaths. Potential annual economic benefits associated with a 400-mg reduction are $2.5 billion, rising to $5.8 billion given an 1100-mg daily reduction. These economic estimates exclude potential benefits of reduced sodium intake for people with controlled hypertension—i.e., the reduced need for medication to control blood pressure.

## DISCUSSION

Findings from this study reiterate the large economic burden imposed by obesity, overweight, and hypertension in the form of lost productivity, and quantify potential long-term productivity gains achievable by modest-to-aggressive reductions in calories and sodium in the American diet. At the national level, the current estimated productivity loss associated with overweight and obesity ($144 billion) and hypertension ($52 billion) is estimated at $196 billion annually, approximately equal to their estimated medical costs ($192 billion).[19]

This study suggests that modest but sustained reductions in sodium intake alone (e.g., reductions by 400 to 1100 mg/d) among those with hypertension may increase the nation's annual productivity by an estimated $2.5 billion to $5.8 billion, respectively. Sustained reductions in energy intake alone (e.g., 100 to 500 kcal/d below estimated energy expenditure) among adults who are overweight or obese could improve national productivity by $45.7 billion to $133.3 billion annually, or roughly $2 to $6 per overweight worker per day. Combined with medical cost savings of $60.3 billion to $116.5 billion,[19] the economic benefit from modest to aggressive reductions in calories and sodium range from $108.5 billion to $255.6 billion.

We used conservative assumptions when estimating the indirect costs of excess weight and hypertension, and the corresponding benefits of improved diet. For example, we valued each life saved using estimated NPV of future productivity (given a normal life expectancy). Alternate approaches to valuing each life saved resulted in significantly higher value-of-life estimations—especially for premature deaths among the elderly. We excluded from our calculations any impact of poor health on early retirement and underemployment. We used average earnings as a proxy for the value of lost time, excluding fringe benefits, which may account for one-third of the total compensation.[9,43] Using receipt of disability-related SSI payments is a conservative approach to quantifying disability.

Estimates of lost productivity associated with chronic health problems are less precise than are estimates of excess medical costs, because a major component of productivity loss (i.e., presenteeism) is based on self-reported data. Also, studies reporting associations between a health condition and the productivity measure of interest often do not control for other health conditions. Our estimates take into account the association between excess weight and hypertension to prevent double counting of potential cost savings.

The extent to which absenteeism and presenteeism costs are borne by the employer, by the employee via reduced wages, or shared between both parties is uncertain. Obese employees have been found to incur wage penalties, earning 0.7% to 6.3% less than their nonobese colleagues.[44] Whether this wage penalty reflects differences in productivity is unknown.

Our estimates of excess work days lost for overweight and obese workers are consistent with estimates reported in two recent studies. The simple average of these two studies, after factoring out the absenteeism effect of hypertension, suggests annual lost work days of 0.5, 1.5, and 2.0 associated with overweight, obese I, and obese II and III, respectively.[1,3] Estimated work days lost because of hypertension are also consistent with reported findings. The simple average (0.4%) in annual productivity loss from four published studies (0%, 0.3%, 0.4%, 0.9%) is equivalent to approximately one work day per year (assuming 240 total work days per year).[3] Although our estimate from the NHIS is slightly larger than the average reported elsewhere, our estimate includes short-term disability, whereas the aforementioned studies include only sick days.

The goal of this study was to simulate the potential national health benefits and productivity gains from small but sustained dietary change, a methodology that cannot replace clinical trials, but one that provides useful information by integrating the body of available research. Although simulation models are powerful tools for understanding complex relationships, the following data and study limitations should be considered when interpreting findings from this study.

For example, this study used a static approach that compares the health and productivity outcomes associated with competing hypothetical equilibriums. The scenarios modeled assume no change in level of physical activity so that the benefits of diet intervention alone can be quantified. The model provides no estimates of the dynamics and timeframe to reach the new equilibrium. Both the calorie reduction and sodium reduction scenarios would likely take 3 to 5 years before a new equilibrium weight and blood pressure status is reached, and whether such diet interventions are sustainable is unknown. We modeled a reduction in daily caloric intake below estimated energy requirements; to the extent that people currently consume calories in excess of energy requirements (which results in weight gain), the calorie reduction needed to actually lose weight might be greater than the levels modeled here. The full potential benefits of improved diet will likely take many years to materialize as new cases of disease are prevented and the population reaches a new health equilibrium.

We identified no studies that directly document changes in productivity associated with dietary changes among adults. Our model is based on studies that show an association between dietary changes and risk factors such as overweight, obesity, and hypertension status, and on studies that show an association between these risk factors and productivity (via their impact on disease risk).

The studies on which our model relies to quantify the productivity benefits of improved diet on presenteeism and mortality risk report findings by risk group, rather than by continuous clinical measures such as BMI, SBP, and DBP. Lacking impact on clinical measures, we were unable to quantify movement within a risk group. Instead, we quantified risk reduction when people moved from a higher to a lower risk group using the difference in mean probability of an adverse event between the higher and lower risk groups. Because our comparisons are between hypothetical national health equilibriums, using difference in group means should provide reasonable estimates of potential long-term national productivity gains.

Productivity is challenging to quantify from both a societal and an employer perspective. The value of an hour of productive labor is difficult to quantify in some occupations, and there is substantial variation across workers in the value of their productivity. In some employment situations, employees who fall behind in their work because of absenteeism or presenteeism simply work longer hours to make up for lost time or productivity. In other employment situations, reduced productivity by one employee can have a ripple effect that reduces the productivity of coworkers. The use of average wages and controlling for demographics (age group and gender) provides a proxy for the value of productivity for different population groups that would benefit from improved diet.

**SO WHAT? Implications for Health Promotion Practitioners and Researchers**

Just as changes in diet and lifestyle over the past several decades have contributed to rising rates of obesity and hypertension, so can improvements to diet and lifestyle reverse the obesity epidemic. This study suggests that modest but sustained changes in national diet (primarily reducing caloric intake and secondarily reducing sodium intake) can have large economic implications. This information is useful to employers, researchers, practitioners and other stakeholders by contributing to the evidence behind dietary guidance. This study suggests that there exists the potential for a strong business case to improve national diet. To verify this assertion, though, additional research is needed on the cost and effectiveness of environmental, educational, and policy strategies that could facilitate improved national dietary intake.

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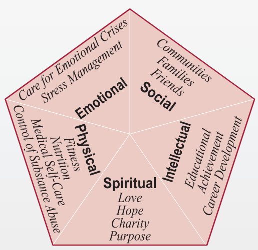


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