

The Medical Costs Attributable to Meat Consumption

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Objective. To estimate the medical costs that are attributable to the health effects of meat consumption.

Methods. The prevalence of hypertension, heart disease, cancer, diabetes, gallstones, obesity, and foodborne illness among omnivores and vegetarians are compared in studies that have controlled for other lifestyle factors, and the corresponding attributable medical costs are calculated in 1992 dollars.

Results. Direct health care costs attributable to meat consumption are estimated to be \$2.8-8.5 billion for hypertension, \$9.5 billion for heart disease, \$0-16.5 billion for cancer, \$14.0-17.1 billion for diabetes, \$0.2-2.4 billion for gallbladder disease, \$1.9 billion for obesity-related musculoskeletal disorders, and \$0.2-5.5 billion for foodborne illness. The total direct medical costs attributable to meat consumption for 1992 are estimated at \$28.6-61.4 billion.

Conclusion. Health care costs attributable to meat consumption are quantifiable and substantial.

Key Words: medical costs; meat; vegetarianism; nutrition. © 1995 Academic Press, Inc.

INTRODUCTION

Escalating health care costs have highlighted the need to identify factors that maintain high demand for medical services (1). Dietary factors share with tobacco a great responsibility for illness in American adults, contributing to hypertension, cardiovascular disease, cancer, diabetes, obesity, gallstones, foodborne illness, and other conditions. Unlike the situation with tobacco, little attention has been directed to estimating the contribution of dietary factors to the cost of treating diseases.

Cost-of-illness studies can be done in two ways. Prevalence-based analyses estimate the costs incurred in a given year for given illnesses regardless of disease stage. They are appropriate for estimating the magnitude of annual costs attributable to disease. Incidence-based analyses estimate the lifetime costs of illness and are particularly suited to estimating potential costs and savings that would accrue from interventions. Such analyses require reliable information on

disease incidence at various ages, the course of illness, and the delayed effects of interventions.

Available data permit a prevalence-based estimation of the contribution of meat consumption to medical care costs for several conditions. Differences in disease prevalence between omnivores and vegetarians, controlled for other lifestyle factors, were examined and corresponding attributable costs were estimated.

METHODS

A literature search was conducted for published studies that reported differences in disease prevalence between omnivores and vegetarians for hypertension, heart disease, cancer, diabetes, gallstones, obesity, and foodborne illness. Most such studies involve ovo-lacto-vegetarian diets, i.e., diets excluding red meat, fish, and poultry, but including eggs and dairy products. Vegan (pure vegetarian) diets have been the subject of far fewer research studies.

Because omnivores and vegetarians may differ in many ways apart from diet, studies that controlled for the effects of smoking, exercise, alcohol consumption, and other factors where relevant were selected. Adjustment for differences in body weight was not appropriate to the current analysis because increased body weight is one of the presumed mechanisms by which dietary factors may increase the risk of high blood pressure, heart disease, cancer, diabetes, and gallstones.

Medical costs attributable to meat consumption were considered to be the fraction of direct treatment costs that corresponded to the excess prevalence of disease among omnivores, compared with vegetarians, in studies controlling for potentially confounding factors. Non-medical costs, such as lost productivity, were not considered.

Where necessary, costs were adjusted to 1992 dollars using the medical care component of the consumer price index of the Bureau of Labor Statistics of the U.S. Department of Labor.

RESULTS

Hypertension

An estimated 62,770,000 Americans have (or are being treated for) high blood pressure, defined as systolic

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pressure of 140 mm Hg or greater and/or diastolic pressure of 90 mm Hg or greater (2). The costs of treating hypertension for the year 1992 were estimated as follows (2):

Physician/nurse services	\$5.1 billion
Drugs	\$3.0 billion
Hospital/nursing home services	\$4.4 billion
Total health care costs	\$12.5 billion

Researchers have attempted to isolate the effects of diet on blood pressure and on the prevalence of hypertension by studying populations that are similar except for diet and through randomized, controlled trials.

Most Mormons avoid tobacco, alcohol, and caffeine, are generally health conscious, and are omnivores. Like Mormons, nearly all Adventists avoid tobacco, alcohol, and caffeine, but roughly half are omnivores and half are vegetarians. Some Adventist omnivores might be more appropriately described as semivegetarians. In one study, less than 20% of Adventist omnivores consumed three or more 3-oz beef servings per week, and none had more than three servings of poultry or fish per week (3).

A comparison of Adventist vegetarians and Mormon omnivores with similar levels of physical activity, all of whom avoided tobacco and alcohol, showed that blood pressures were higher among omnivores. The differences were 8 mm Hg systolic and 6 mm Hg diastolic among men and 8 mm Hg systolic and diastolic among women (4). The mean body mass index (BMI) of omnivores (25.1 kg/m²) was significantly higher than that of vegetarians (22.9 kg/m²), and there was a strong correlation between body weight and blood pressure.

Similarly, systolic and diastolic blood pressures of Adventist omnivores have been found to be 3–9 and 2–3 points higher, respectively, than those of Adventist vegetarians. Use of salt, alcohol, and tobacco did not differ between the two groups (3, 5). Exercise habits did not differ between white omnivores and white vegetarians although, among blacks, vegetarians were found to exercise more and to be less likely to use blood pressure medications. Mean BMI values for Adventist omnivores (27.4 kg/m² for whites, 31.4 kg/m² for blacks) were higher than those for vegetarians (24.6 kg/m² for whites, 26.3 kg/m² for blacks) (5). Adjustment for BMI reduces, but does not eliminate, blood pressure differences between the two dietary groups. Similar blood pressure differences have been found in comparisons of other groups of omnivores and vegetarians in studies that control for age, sex, and exercise habits (6, 7).

Randomized, controlled trials have shown that when normotensive or hypertensive omnivores adopt vegetarian diets while keeping other lifestyle factors constant, systolic blood pressure drops approximately 5 mm Hg in 6 weeks, an effect that is independent of changes in body weight (8–11).

Of particular relevance to medical costs are studies of hypertension prevalence. Hypertension is more common among omnivores than among vegetarians. A study based on a 1976 survey of 27,766 Adventists found that, after adjusting for age, smoking, and education, the odds ratio of self-reported hypertension among omnivores, compared with vegetarians, was 1.75 for women and 1.74 for men ($P < 0.001$ for both sexes). The mean BMI of omnivores (25.7 kg/m² for men, 25.2 kg/m² for women) was higher than that of vegetarians (24.2 kg/m² for men, 23.6 kg/m² for women) (12).

A later study of Adventist omnivores and vegetarians who did not differ with respect to salt intake, tobacco or alcohol use, or exercise habits found physician-diagnosed hypertension in 37% of omnivores, compared with 14% of vegetarians ($P < 0.001$) (3). A follow-up Adventist study showed that, among whites, blood pressure medications were used by 22% of omnivores, compared with 7% of vegetarians and, among blacks, by 44% of omnivores and 18% of vegetarians (5). In these two comparisons, vegetarians had 32 and 41% the prevalence of hypertension of omnivores, respectively.

In a randomized, controlled, 6-week intervention trial of a vegetarian diet in hypertensive subjects, 30% had systolic blood pressures that dropped below 140 mm Hg, compared with 8% of subjects who remained on their usual diets (10). In a trial of a vegan diet in subjects taking medication for hypertension, 20 of the 26 subjects were able to discontinue their use of anti-hypertensive medications within 1 year, at which time systolic blood pressure was lower in 18 subjects, unchanged in 4, and higher in 4, compared with the beginning of the study. Diastolic pressures were lower in 15 subjects, unchanged in 3, and higher in 8 (13).

The mechanisms by which a vegetarian diet reduces blood pressure, aside from its effect on body weight, are not clear. The effect is independent of salt or fat intake and is not fully accounted for by the presence or absence of any nutrient or group of nutrients (14–16).

Blood pressure differences of the magnitude that typically differentiates omnivores and vegetarians can have a significant effect on the risk of heart disease. A 5-mm Hg reduction in systolic blood pressure in 55- to 59-year-old men is associated with a 7% reduction in major coronary events (17). Effects are even greater when modifications begin earlier. A 5-mm Hg reduction in systolic blood pressure in men 35 years of age or younger is associated with a difference of nearly 10 mm Hg at age 65. A difference of this magnitude between the ages of 65 and 74 years is associated with a 14% reduction in the risk of heart attack, after adjusting for obesity (17).

The highest reasonable estimate of the excess hypertension prevalence that may be attributed to meat consumption comes from the Adventist studies of hyper-

tension prevalence described above and ranges from 59 to 68% (3, 5). A conservative estimate comes from the randomized, controlled intervention trial cited above (10). Of the 30% of hypertensive subjects who returned to normal blood pressure after beginning a vegetarian diet, 8% could reasonably have been expected to do so without a dietary change, that being the number whose pressures normalized while remaining on an unrestricted diet (10). When it is assumed that 22–68% of hypertension treatment costs can be attributed to meat consumption, corresponding annual medical costs are \$2.8–8.5 billion.

Heart Disease

An estimated 6,160,000 Americans had coronary heart disease in 1992, defined as angina pectoris and/or a history of heart attack (2). About 45% of the 1,500,000 Americans who have heart attacks each year are under age 65 (2).

In 1992, an estimated 1,028,000 cardiac catheterizations, 468,000 coronary artery bypass grafts, and 399,000 procedures to remove coronary artery obstructions were done. The percentages of these procedures done in individuals ages 65 and over were 47.3, 53.8, and 48.1, respectively (18). According to the American Heart Association, the estimated costs of treating heart disease (in any form) in 1992 (2) were as follows:

Physician/nurse services	\$7.3 billion
Drugs	\$2.0 billion
Hospital/nursing home services	\$31.1 billion
Total health care costs	\$40.4 billion

A study of 24,044 Adventists, surveyed in 1960, found a history of heart disease (in any form) in 5.1% among omnivores, compared with 3.6% of ovo-lacto-vegetarians ages 35–64 ($P < 0.05$), indicating that 29% of heart disease among omnivores may be considered excessive. At age 65 and older, figures for omnivores and vegetarians were 19.1 and 16.2%, respectively ($P < 0.05$), indicating an excess of heart disease among omnivores of 15%. Virtually all subjects were nonsmokers (19). The 1976 survey of 27,766 Adventists found the odds ratio for coronary heart disease among omnivores, compared with vegetarians, to be 1.46 for women and 1.33 for men. Differences are significant for both sexes ($P < 0.001$) (12).

Differences between omnivores and vegetarians in coronary heart disease death rates are similar to differences in the prevalence figures given above. A 20-year prospective study found that the relative risk of a coronary heart disease death among nonvegetarian Adventists was 1.62, compared with vegetarian Adventists, for persons below 65 years of age. For those 65 and above, the relative risk was 1.26 (20). Similarly, a 12-year study of health-food store patrons found that,

while this population overall had a lower-than-average risk of death from coronary heart disease, the standardized mortality ratio for vegetarians (0.428) was 29% lower than that for omnivores (0.601) (21). The mean cholesterol values were higher for omnivores (5.78 mmol/liter in men, 6.12 mmol/liter in women) than for vegetarians (5.27 mmol/liter in men, 5.67 mmol/liter in women). The mean BMI values of omnivores were also higher (24.6 kg/m² in men, 23.7 kg/m² in women) than those of vegetarians (22.1 kg/m² in men, 22.3 kg/m² in women, respectively). Data were not stratified by age. Adjustment for smoking did not change the results. Another 12-year study, adjusted for smoking, found that the death rate ratio for coronary heart disease among vegetarians, compared with omnivores, was 0.62 (confidence interval = 0.41–0.91) (22).

Compared with omnivores, vegetarians have total cholesterol and LDL cholesterol levels that are 9–32 and 7–37% lower, respectively (21, 23–29). When omnivores adopt vegetarian diets for 6 weeks, total and LDL cholesterol levels have been shown to drop 3–11 and 4–17%, respectively (29, 30).

According to Hodgson (31), 44.5% of heart disease treatment costs are for persons under 65 years of age. When it is assumed that an omnivorous diet accounts for 29% of heart disease in that age group and 19% of heart disease at ages 65 and above, the excess health care costs attributable to meat consumption are \$9.5 billion annually.

The portion of heart disease that may be attributable to the increased prevalence of hypertension, diabetes, or obesity among omnivores is included in these figures, but excluded from estimates of treatment costs of these respective conditions reported herein.

Cancer

More than 1.2 million Americans are diagnosed with cancer (excluding basal and squamous cell skin cancers and *in situ* carcinomas except bladder) annually, and more than 500,000 die of the disease, accounting for one in every five deaths in the United States (32). The most common forms of cancer in the United States are prostate, breast, lung, and colorectal. Direct medical costs for cancer treatment for 1990 were \$35.3 billion (33).

It has long been apparent that a portion of cancer risk is attributable to dietary factors (34). Colorectal and lung cancers are particularly noteworthy. Colorectal cancer is diagnosed in 152,000 Americans and kills 57,000 annually (32). Women and men who consume beef, pork, or lamb daily have 2.5 and 3.6 times the incidence of colon cancer, respectively, compared with those who consume these products less than once per month (35–38). Higher colon cancer incidence rates in omnivores have been attributed to higher levels of cho-

lesterol and bile acids, particularly secondary bile acids, in their intestinal tracts, compared with vegetarians (39–43).

Lung cancer is diagnosed in 170,000 Americans every year and kills 149,000 annually. Lung cancer rates are lower in vegetarian populations, even in studies that control for smoking. Among nonsmokers, mortality ratios for Adventists, compared with non-Adventists, are 0.67 for men and 0.42 for women (44). Comparisons of Adventist omnivores and vegetarians have also linked meat consumption to increased incidence of cancers of the ovary and prostate (45). The lower prevalence of obesity in vegetarians and their increased consumption of vegetables and fruits are in accordance with recommendations to reduce cancer risk (46–48).

Overall cancer death rates among vegetarians are below population averages in most studies. A recent British study compared vegetarians and nonvegetarian controls over 12 years of follow-up. The cancer death rate ratio comparing vegetarians and meat eaters, adjusted for smoking, BMI, and socioeconomic status, was 0.61 (95% confidence interval 0.44 to 0.84) (22). The adjustment for BMI leads to an underestimation of the true effect of diet. These results are similar to those of an earlier 11-year German study that found standardized mortality ratios for all cancers to be 0.48 for males and 0.74 for females, compared with the general population. Smoking did not account for the differences (49, 50). In contrast, the 1976 Adventist survey did not find a statistically significant difference in cancer prevalence between omnivores and vegetarians (12).

The highest reasonable estimate of cancer treatment costs attributable to meat consumption comes from the British and German studies of cancer mortality. When it is assumed that differences in mortality figures reflect differences in treatment costs and that 40% of cancer mortality is attributable to an omnivorous diet, the excess annual medical costs attributable to meat consumption are estimated to be \$16.5 billion in 1992 dollars. The 1976 Adventist survey, however, indicates that no vegetarian advantage in cancer prevalence must be considered a possibility.

Diabetes

Approximately 7.3 million Americans have diabetes mellitus, the vast majority of which is non-insulin-dependent. Direct medical costs of diabetes and its complications for 1992 have been estimated at \$45.2 billion (51). Of this figure, approximately \$6.2 billion is related to the heart disease treatment. The remainder, \$39.0 billion, is necessitated by uncomplicated diabetes, its neurological, vascular, renal, endocrine, and ophthalmic complications, and other conditions that occur disproportionately in persons with diabetes.

Omnivores have a higher prevalence of diabetes than

vegetarians, as is demonstrated in studies of Seventh-Day Adventists. The type of diabetes is not differentiated in such studies. Overall, Adventists have 45% of the rate of diabetes of the general population (52). A 1960 survey of 25,698 Adventists, ages 30 to 89 years, found the age-adjusted prevalence ratio of diagnosed diabetes to be 1.9 in nonvegetarian men (95% confidence limits 1.4–2.6) and 1.6 in nonvegetarian women (95% confidence limits 1.3–2.0), compared with vegetarians. Adventist omnivores have a higher prevalence of overweight than vegetarians. Adjustment for age and percentage of desirable weight reduces the omnivore/vegetarian prevalence ratios slightly, to 1.8 (95% confidence limits 1.3–2.5) for men and 1.4 (95% confidence limits 1.2–1.8) for women (52). Figures unadjusted for weight, however, are appropriate for estimating the effect of dietary differences on diabetes risk.

A 21-year mortality study, which excluded those subjects who were known to be diabetic at the outset, found the age-adjusted risk of diabetes being listed on a death certificate as a contributing or underlying cause of death was 2.2 (95% confidence limits 1.5–3.4) for male omnivores and 1.4 (95% confidence limits 1.0–1.9) for female omnivores (52).

The 1976 survey of Adventists found the odds ratio for diabetes, adjusted for age, smoking, and education, among omnivores to be 1.66 for women and 1.53 for men, compared with omnivores. Both differences are significant ($P < 0.001$). As noted earlier, mean BMI was higher for omnivorous subjects (12).

Clinical trials using vegetarian and near-vegetarian diets, based on whole grains, legumes, vegetables, and fruits, have demonstrated that diabetics' need for medication can often be substantially reduced, as can the prevalence of neuropathy and retinal damage, although all of these studies have used combined interventions, including exercise (53–57).

Approximately 57% of persons with diabetes are women (58). When it is assumed that diabetes treatment is distributed among men and women proportionately to disease prevalence in the two sexes, and that diabetes is 1.5–1.9 times more common in omnivorous men and 1.6–1.7 times more common in omnivorous women than in vegetarians, of the \$39.0 billion in medical costs for treatment of diabetes, the excess medical costs attributable to meat consumption are estimated at \$14.0–17.1 billion.

Gallbladder Disease

In 1992, 525,000 Americans (360,000 women and 165,000 men) had their gallbladders surgically removed, according to the National Center for Health Statistics' National Hospital Discharge Survey (18). Hospital costs per patient for laparoscopic gallbladder removal were reported to be \$4,726 in Virginia (59) and

\$6,471 in Colorado for cases in 1990–1991 (60), putting the annual cholecystectomy costs at approximately \$3.2 billion in 1992 dollars. Costs above those of laparoscopic surgery, such as diagnostic and emergency procedures, add to these costs.

A history of cholecystectomy is more common among omnivores than among vegetarians. The 1976 Adventist survey found the odds ratio of a history of cholecystectomy, adjusted for age, smoking, and education, among female omnivores to be 1.12, compared with vegetarians ($P < 0.01$). The odds ratio for male omnivores, compared with vegetarians, was 1.08, but not statistically significant (12).

In a study of 632 British female omnivores and 130 female vegetarians ranging in age from 40 to 69, 6.8% of omnivores had a history of cholecystectomy, compared with 1.5% of vegetarians. Sonographic examinations revealed that an additional 17.8% of omnivores had asymptomatic gallstones, compared with 10% of vegetarians. The differences between omnivores and vegetarians are significant ($P < 0.01$). After adjustment for age and BMI, the odds ratio of developing gallstones in omnivores compared with vegetarians was 1.9 (95% confidence limits 1.1–3.3) (61).

Overweight, which is more common among omnivores, is associated with higher risk of gallstones (62). In addition, international comparisons suggest that diets high in cholesterol and fat and low in fiber increase the risk of gallstones (63).

The prevalence of cholecystectomy history is relevant to estimates of medical costs, while asymptomatic gallstones are not. If it is assumed that male omnivores have no higher incidence of cholecystectomy than vegetarians, and that 11% of the costs of cholecystectomy in women are attributable to meat consumption, the corresponding costs would be \$0.24 billion. If, as the data from the British study (61) suggest, as much as 75% of cholecystectomy costs are attributable to an omnivorous diet, the corresponding medical costs total \$2.4 billion.

Overweight

The National Center for Health Statistics (NCHS) defines overweight as a BMI at or above the 85th percentile of men and women ages 20–29 years. This corresponds to a BMI of 27.8 kg/m² (about 24% over desirable weight) for men and 27.3 kg/m² (about 20% over desirable weight) for women. The percentage of adults, ages 20–74, who met the NCHS criteria for overweight increased from 25.4% in the National Health and Nutrition Examination Survey (NHANES) II survey (conducted 1976–1980) to 33.3% in NHANES III (1988–1991), an increase of 31.1%. The latter survey found that 34.7% of women and 31.3% of men were overweight (64).

Overweight increases the risk of hypertension, car-

diovascular disease, some forms of cancer, diabetes, and gallbladder disease. The medical costs of these conditions were discussed above. In addition, overweight contributes to musculoskeletal disorders and many other conditions (65–70). Only the costs associated with musculoskeletal disease will be considered further. Direct costs for the treatment of all musculoskeletal disorders in 1980 were estimated to be \$13.1 billion (71). Wolf and Colditz estimate that at least 10% of the costs of musculoskeletal disorders can be attributed to obesity (72).

The mean BMI of groups of omnivores has been shown to be 1–5 kg/m² higher than that of vegetarians in studies that are controlled for smoking and exercise (3–5, 73).

Studies of overweight in various populations often use definitions of overweight different from those of the NCHS. A study of 25,698 Adventists found the age-adjusted prevalence ratio of overweight, defined as 30% or more above desirable weight, was 1.9 among omnivorous males (95% confidence limits 1.6–2.1) and 1.6 among omnivorous females (95% confidence limits 1.4–1.7), compared with vegetarians (52). Omnivores and vegetarians were similar with respect to smoking, exercise, and alcohol consumption.

A comparison of 5,728 British vegetarians (mean age 38.7) and 5,015 omnivores (mean age 39.3) found that 27% of omnivores but only 14% of vegetarians had BMIs greater than 24. Smoking rates were low and similar in the two groups (22).

When it is assumed that 10% of the \$13.1 billion in medical costs for musculoskeletal disorders are attributable to obesity and that these costs rose by 31% between 1980 and 1992 as a result of the increased prevalence of obesity, and when the resulting cost estimate is inflated from 1980 dollars to 1992 dollars, the resulting costs for musculoskeletal disorders attributable to obesity is \$4.4 billion.

The Adventist study noted above suggests that 38% of the prevalence of obesity among women and 47% among men is attributable to meat consumption. These figures are similar to the 48% that derives from the British study cited above. When it is assumed that treatment for obesity-related musculoskeletal disorders varies proportionately with the prevalence of obesity, the estimated cost of obesity-related musculoskeletal disorders attributable to meat consumption is \$1.9 billion.

Foodborne Illness

The vast majority of cases of foodborne illness are never reported, and even treated cases are often not precisely diagnosed (74, 75). The Department of Agriculture estimates that, in 1993, there were 3.61–7.13 million cases of foodborne illness, of which 2.15–4.97 million (59.6–69.7%) were associated with meat and

poultry consumption (76). Steahr and Roberts estimate the medical costs for foodborne illness (from all sources) at \$6 billion annually for the years 1987–1990 (74). If 59.6–69.7% of costs are attributable to meat and poultry consumption, the annual costs for that period would be \$3.6–4.2 billion. Adjustment to 1992 dollars brings the estimate to \$4.7–5.5 billion. A more conservative figure comes from the U.S. Department of Agriculture Economic Research Service, which estimated the medical costs of illness caused by five pathogens (*Salmonella*, *Campylobacter jejuni* or *coli*, *Escherichia coli* O157:H7, *Listeria monocytogenes*, and *Toxoplasma gondii*) from meat or poultry products for 1993 at \$0.234–0.760 billion (77). Adjustment to 1992 dollars brings the range to \$0.22–0.72 billion.

Reduced Health Care Usage among Vegetarians

Limited data suggest that omnivores do, in fact, use more health care services than vegetarians. Freeland-Graves (78, 79) found that, among 150 young vegetarians (average age 25.8 years, range 18–41) and 150 nonvegetarians matched for age and sex, more than twice as many nonvegetarians as vegetarians had been hospitalized during the past 5 years (27% vs 12%, $P < 0.01$), and twice as many nonvegetarians as vegetarians were taking prescription medication (22% vs 11.3%, $P < 0.05$). The omnivores were less likely to abstain from alcohol, compared with vegetarians (12% vs 32%, respectively), and were more likely to smoke (16.2% vs 8.0%, respectively), although the relevance of these factors to illness in this young population is probably less than it would be for older subjects.

In another study, the use of health care services and medications among 27,766 Seventh-Day Adventists was examined (12). Significantly more omnivores reported having been hospitalized during the previous year, compared with vegetarians (9.2% vs 7.2% for men, $P < 0.001$; 13.3% vs 11.9% for women, $P < 0.01$). Among omnivores, 29.9% of men and 21.3% of women reported that they used no medication regularly. Among vegetarians, these figures were higher (70.3% for men, 57.3% for women). The difference between the two dietary groups is significant ($P < 0.001$). Omnivorous women were also more likely to have had emergency surgery during the previous 12 months, compared with vegetarians (11.8% vs 9.5%, $P < 0.001$). Omnivorous men were more likely to have had an emergency X ray during the previous year (12.9% vs 11.2%, $P < 0.01$). These differences persisted after adjustment for smoking. As noted earlier, the mean BMI was higher among omnivores in both sexes.

Costs Attributable to Meat Consumption

The excess medical costs attributable to meat consumption are estimated from the proportion of the

forementioned diseases in omnivores compared with vegetarians and are listed in Table 1.

DISCUSSION

The current analysis shows that costs attributable to meat consumption are indeed substantial. Because omnivores and vegetarians may differ in many respects aside from diet, particularly in rates of smoking, exercise, and alcohol consumption, studies selected for this analysis have accounted for these factors to the extent possible. Such attempts at control may lead to an underestimate of true differences. Studies of Adventists may understate differences between omnivores and vegetarians, because Adventist omnivores tend to be modest in their meat consumption. The small dietary differences between omnivores and vegetarians in this group make it all the more remarkable that the prevalences of disease in these groups are so strikingly different.

Several additional factors may cause these figures to be underestimates. The current analysis omits conditions for which data are not sufficient. For example, some evidence suggests that stroke, diverticular disease, and rheumatoid arthritis are more common among omnivores (12), but they have been excluded from the current analysis. The costs of diabetes presented herein exclude care given in federal, military, and Veterans Administration facilities or free-standing dialysis centers, all outpatient care for the sequelae of diabetes, such as renal failure, cataracts, or glaucoma, and treatment necessitated by undiagnosed diabetes (51). The costs of treatment of obesity or of its consequences other than the conditions noted above were not considered. Costs for foodborne illness are low estimates, because they omit pathogens from fish, and the study on which our lowest estimate was based was limited to only five infective organisms.

Our figures would be overestimates if reducing meat consumption or a compensatory increase in fruit and vegetable intake had potential adverse effects that required medical care. However, existing literature does not substantiate such risks. The issues of greatest importance in this regard relate to the adequacy of protein, riboflavin, vitamin B-12, iron, and calcium.

TABLE 1
Estimated Medical Costs Attributable to Meat Consumption, 1992 (in Billions)

Hypertension	\$2.8–8.5
Heart disease	\$9.5
Cancer	\$0–16.5
Diabetes	\$14.0–17.1
Gallbladder disease	\$0.2–2.4
Obesity (musculoskeletal)	\$1.9
Food-borne illness	\$0.2–5.5
Total	\$28.6–61.4

It was once believed that plant-based diets require careful planning to ensure protein adequacy. However, it is now known that a varied plant diet consumed in sufficient quantity to maintain body weight easily satisfies amino acid requirements, even without intentional combining of foods (80).

In Western countries, vegetarian diets are generally adequate in riboflavin (81). However, the mean daily riboflavin intake in China (0.8 mg) falls below the recommended dietary allowance (RDA) of 1.2 mg, and in some Chinese counties more than 90% of the population falls below this value. There is, however, no evidence of widespread deficiency symptoms or significant treatment costs, suggesting that the RDA may have a generous margin of safety (82).

Vitamin B-12 deficiency might be expected to be more common among those following pure vegetarian diets without sufficient planning, but we are aware of no evidence showing this factor to lead a substantial percentage of vegetarians into medical treatment.

The absorption of nonheme iron in plant foods is lower than that of heme iron in meats. However, plant-based diets generally provide adequate iron (81, 83–85). In Western countries, iron deficiency does not affect vegetarians disproportionately (83). Moreover, reductions in heme iron intake and lower iron stores are associated with a reduced risk of heart disease, cancer, and other conditions (86–91).

Calcium balance requires both adequate intake and minimal losses. Green vegetables and legumes provide calcium which, except for spinach, is of high bioavailability (92–95). The calcium adequacy of plant-based diets is supported by studies showing that populations following such diets generally have lower rates of hip fracture than those whose diets are based on animal products, perhaps because reduced meat consumption is associated with lower urinary calcium losses (96, 97).

Plant foods may be somewhat lower in available zinc, compared with meats, but a plant-based diet also reduces zinc excretion (98, 99). Zinc intake and zinc levels have been shown to be adequate in long-term vegetarians (84, 85).

Those who do not die as a result of heart disease, cancer, or other serious illness may develop other diseases that require treatment. However, the estimates presented above are based on studies of current disease prevalence, and the costs of additional illnesses that may occur in elderly individuals have not been excluded. Moreover, diet-related diseases tend to cluster. Obesity, hypertension, heart disease, cancer, and diabetes often occur in combination. In contrast, those individuals who live to particularly old ages frequently do so in reasonably good health, and when death does come, it is often not preceded by major diseases necessitating treatment (100).

It should be noted that the effects of including meat in the diet are not attributable solely to the constitu-

ents of meat itself. When meat is included in the diet, plant products are necessarily reduced. The health effects of an omnivorous diet may result from the presence of meat, the displacement of plant foods, or both.

A substantial portion of America's health care costs is attributable to identifiable factors. Most notably, the medical care expenditures attributable to cigarette smoking were \$50 billion in 1993 (101). The combined medical costs attributable to smoking and meat consumption exceed the predicted costs of providing health coverage for all currently uninsured Americans (102).

The fact that disease is costly does not necessarily mean that preventing it saves money. Preventive programs have costs of their own, and the health benefits of lifestyle changes may not be realized until well into the future (103). Randomized, controlled trials of the long-term effects of meatless diets or smoking cessation have never been conducted and are not anticipated, and the feasibility of reducing medical care expenditures by such interventions is beyond the scope of this report. Existing data are insufficient to estimate the time course by which dietary interventions may yield health benefits or economic savings. Nor do the data presented here reveal whether modest reductions in meat consumption would have benefits or whether the results of preventive steps would differ between males and females. Recent studies showing that major dietary changes are acceptable to at least some people make studies of the cost effectiveness of dietary interventions all the more timely (104, 105).

In summary, a large body of evidence shows that substantial medical costs are attributable to meat consumption. Further research is necessary for weighing the cost effectiveness of interventions that seek to change dietary behavior.

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