Trends in Risk Factors in the United States, 1971-1975 v. 1999-2002

David M. Cutler, PhD[1], Edward L. Glaeser, PhD[1], Allison B. Rosen, MD, MPH, ScD[2]

[1]Department of Economics, Harvard University, and National Bureau of Economic Research, Cambridge, MA

[2]Division of General Medicine, University of Michigan Health System, and Center for Practice Management and Outcomes Research, Ann Arbor Veterans Affairs Medical Center, Ann Arbor, MI

Address for Correspondence: David M. Cutler, Department of Economics, Harvard University, 1875 Cambridge Street, Cambridge, MA 02138; phone: (617) 496-5216; fax: (617) 495-7730; e-mail: dcutler@harvard.edu

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ABSTRACT

Background. In the past few decades, some measures of population risk have improved, while others have deteriorated. Understanding the health of the population requires integrating these different trends. We compare the risk factor profile of the population in the early 1970s with that of the population in the early 2000s.

Methods. Data from the NHANES I (1971-1975) and NHANES 1999-2002 are used to measure demographics, smoking, drinking, obesity, blood pressure, and cholesterol. Using the NHANES I epidemiological follow-up, we estimate the impact of each risk factor on 10 year mortality rates. We compare the predicted 10 year mortality for the NHANES I and NHANES 1999-2002 cohorts.

Results. For the population aged 20-74, the 10 year probability of death fell from 9.8 percent in 1971-75 to 8.4 percent in 1999-2002 ($p<.001$). Among the population aged 55-74, the 10 year risk of death falls from 25.7 percent to 21.7 percent ($p<.001$). The largest contributors to these changes are the reduction in smoking and better control of blood pressure. Increased obesity increased risk, but not by as large a quantitative amount.

Conclusions. Despite substantial increases in obesity in the past three decades, the overall population risk profile is healthier now than it was formerly. Both behavioral changes and medical care have reduced risk. Mortality rates may thus continue to decline.

In the past few decades, some measures of population risk have improved markedly, while others have deteriorated. Smoking rates have fallen by more than a third since 1960(1) and alcohol consumption has declined by 20 percent since 1980(2), both leading to better health. On the other hand, obesity rates have doubled in the past two decades(3) and diabetes has increased as a result.(4) Demographically, the population is better educated, and better educated people live longer than less educated people.(5) At the same time, however, the population has a higher share of minority groups, for whom life expectancy is lower. The net impact of these risk factor trends on population health expectations is uncertain.(6)

Understanding trends in risk factors is also essential for public policy. Since social security payments are relatively constant by age, a population with longer expected survival will have higher social security costs than a population with lower survival. A healthier population will have lower near-term medical spending, but greater use of nursing homes and other long-term care needs.(7, 8) Evaluating the future of public programs requires synthesizing the trends in different risk factors.

We examined how population risk factors have changed from the early 1970s through the early 2000s. We focused on risk factors related to cardiovascular disease – demographics, smoking, heavy drinking, obesity, hypertension, and high cholesterol – although many of these risk factors predict other diseases as well. We evaluated the importance of risk factor changes using the relation between risk factors and risk of death in the succeeding ten years.

METHODS

Data: Our data are from the National Health and Nutrition Examination Survey (NHANES). We used data from NHANES I, conducted between 1971 and 1975, and NHANES 1999-2002. Our analysis began with the 1971-75 NHANES because that is the first population health survey that asked about smoking status, a key variable in health risk. Each of the NHANES is a stratified multistage probability sample of the US population as a whole. Details on the design and operation of the surveys have been published elsewhere.(9, 10)

We sampled the population aged 25 to 74 in each of the two surveys. The limitation to the adult population was because most of the risk factors are relevant for that age group. NHANES I only included people up to age 74, so we ended both samples at that age. After eliminating people with missing risk factor information, our sample sizes were 6,764 in NHANES I and 6,255 in NHANES 1999-2002.

Risk Factors: We divide risk factors into two groups: demographics, and medical factors. Demographic factors included age and sex, race, and education. Age is delineated in 10 year age groups beginning at age 25. Race was defined as white, black, or other. Education was divided into three groups: less than a high school degree; a high school degree; and at least some college.

Medical risk factors included smoking, drinking, BMI, blood pressure, and cholesterol. Smoking status is divided into three groups: current smoker, former smoker,

and never smoker. Smoking status is determined with two questions, "Have you ever smoked at least 100 cigarettes in your entire life?" and "Do you smoke cigarettes now?"

Drinking status was 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 1999-2002, 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 are those who reported drinking 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), and when drinking had an average of at least three drinks.

BMI is based on direct measurement of height and weight. We divided BMI groups into the underweight ($BMI<18.5$), optimal weight ($18.5\leq BMI<25$), overweight ($25\leq BMI<30$) and obese ($30\leq BMI$).

Blood pressure and total cholesterol were measured according to standard protocols in each survey.(11-13) Blood pressure was 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:(14) normal

blood pressure (systolic blood pressure (SBP) ≤ 120 mm HG and diastolic blood pressure (DBP) ≤ 80 mm HG); pre-hypertensive (120mm HG≤ SBP<140 mm HG or 80≤ DBP<90 mm HG); stage 1 hypertension (140mm HG≤ SBP<160 mm HG or 90≤ DBP<100 mm HG); and stage 2 hypertension (160mm HG≤ SBP or 100≤ DBP). Cholesterol levels were divided into three groups based on the recommendations of the Third Report of the Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults:(15) normal cholesterol (cholesterol<200); borderline high cholesterol (200≤cholesterol<240); and high cholesterol (240≤ cholesterol).

Risk Prediction: Epidemiological follow-ups were conducted for the NHANES I cohort at periodic intervals after the initial survey. We estimated a logit model for death from any cause within the 10 years subsequent to the initial survey. 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.(16-18) The estimates of the prediction equations take account of the complex sample design using the STATA program.

RESULTS

Table 1 shows the characteristics of the entire population, and separately for the population aged 55-74. There were large changes in many of the risk factors. The share of the population with some college more than doubled for the older population and nearly doubled for the entire population. Smoking declined by over one-third, and heavy

drinking fell as well. In contrast, BMI increased markedly and the population became more racially diverse. Even with the increase in BMI, rates of high blood pressure and high cholesterol declined. The share of people with stage 2 hypertension decreased by two-thirds, and the share with stage 1 hypertension decreased by 45 percent. The share of people with high cholesterol fell by 37 percent.

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. Being a current smoker increases the odds of death in the next 10 years by 113 percent ($p<.001$). Obesity increases the odds of death by 26 percent, though this is not statistically significant once blood pressure and cholesterol are controlled for ($p=.112$). Stage 2 hypertension is associated with a 54 percent increase in risk ($p=.023$). Among the demographic factors, blacks have higher mortality rates (OR=1.402; $p=.010$) as do individuals with lower educational attainment (OR=1.269; $p=0.036$), while married people (OR=.682; $p=.001$) have lower mortality rates.

Table 3 reports the impact of risk factor changes between 1971-75 and 1999-2002 on 10 year mortality probabilities. For the entire population, the mortality risk declined from 9.8 percent in NHANES I to 8.4 percent in NHANES IV ($p<.001$), an absolute reduction of 1.4 percentage points (14 percent relative risk reduction). 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.

For the population as a whole, the largest risk factor change was the reduction in smoking, which contributed to a 0.9 percent decrease in mortality risk. Better blood

pressure control led to a reduction of 0.6 percent in risk. The increase in obesity offset some, but not all, of these risk reductions.

In the population aged 55 and older, the patterns are the same, although the magnitudes are much larger. The most important factor for the older population was better control of blood pressure, contributing 2.1 percent to lower mortality. In addition, improved education among the older group led to additional reductions in mortality risk.

DISCUSSION

Changes in health behaviors have been neither uniformly positive nor negative. Studies focusing on smoking reduction and medical control of hypertension and high cholesterol have focused on the successes in these areas,(11-13) while others studies have worried about the potential harms from obesity and uncontrolled diabetes.(19) Our analysis is the first study to compare the mortality impact of these differing trends.

Taken as a whole, we find that the population's risk profile is substantially more favorable today than it was three decades ago. Mortality risk has declined by about 14 percent, for the entire population and the population aged 55 and older. There are three reasons for this change. The first cause is the dramatic and continuing reduction in smoking. The share of people currently smoking cigarettes has fallen by one-third since the early 1970s. Because smoking more than doubles 10 year mortality risk, reductions in smoking of this magnitude have large impacts on mortality projections.

Forecasting smoking is difficult to do, but it is possible that smoking will continue to fall over the next few decades. Future generations of older Americans will have grown up with stronger warnings about the harms from cigarettes, and may thus smoke less. In

addition, recent price increases as a result of tobacco taxes and the Master Settlement Agreement should lead additional people to stop smoking.(20)

The second factor leading to better health is the increasing education of the population. Better educated people live longer than less educated people, and so the increase in education has led to substantial improvements in longevity. For the population aged 55 and older, the impact of improved education is on par with the effect of reductions in smoking. Since education has been increasing over time, the trend towards greater education among the elderly is sure to continue. For example, 23 percent of the population aged 45-54 did not finish high school, compared to 32 percent among the population aged 55 and older.

The reason for the link between education and health is not totally clear. Some evidence suggests that education is causally related to health; for example, delaying the age at which people can leave high school or subsidizing local community colleges improves later life health.(21-24) Other studies suggest that education proxies for social position and that position in the social hierarchy is the fundamental cause of better health.(25, 26) In this latter hypothesis, raising average education would not affect the social status of the typical person, and thus would not lead to further health improvements.

The third factor leading to a more favorable health profile is better control of chronic disease, especially diseases that result from obesity. Hypertension control has improved markedly in the past three decades, particularly in the older population. The share of the population aged 55 and older with stage 2 hypertension fell from 31 percent to 12 percent, and the share with stage 1 hypertension fell from 32 percent to 24 percent.

For the older population, the impact of this reduction for 10 year survival is twice as large as the impact of reduced smoking. Rates of high cholesterol have declined as well, although the impact of this change is not as large in magnitude.

Controlling for blood pressure and cholesterol, being obese does not have a statistically significant effect on 10 year mortality, although the odds ratio is reasonably large (OR=1.28; p=.106). Without controlling for blood pressure or cholesterol, the odds ratio for obesity is larger and statistically significant (OR=1.44; p=.018). Thus, obesity does matter for health, but adjusting for the risk conferred by the sequelae of obesity blunts a significant part of the effect. This finding parallels other research from the Framingham Heart Study, which does not have obesity in the risk equation [Wilson et al.], and data showing that the impact of obesity on mortality is declining in more recent surveys [Flegal et al.]. 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. However, hemoglobin A1c levels were not recorded in NHANES I.

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,(11) and use of statins to control cholesterol increased markedly in the.(27) Other possible factors include reduced fat and salt intake.(28)

The impact of rising obesity on future health status will depend to a significant extent on whether the consequences of obesity are well controlled. While blood pressure control has been significant in the past thirty years, only 30 percent of people with hypertension have their blood pressure well controlled.(12) Similarly, only 18 percent of

people with high cholesterol are medically well controlled.(29) Continued high rates of poor risk factor control will lead to significant problems in our more obese population.

Our analysis has some limitations, which are deserving of note. Most importantly, we do not consider the impact of different risk factors on the use of medical services. Knowledge of mortality risk is only one dimension in measuring the impact of population health changes. In addition, we do not have information on all of the important risk factors. For cardiovascular disease risk, the most important omissions are hemoglobin A1c and perhaps some of the more novel risk factors (such as C-reactive protein or albuminuria), although other risk factors may be important as well. Finally, our analysis might understate the role of some risk factors to the extent that they changed subsequent to the NHANES I survey and so affected mortality to a greater or lesser extent.

In sum, we show significant improvements in the health profile of the US population between the early 1970s and the early 2000s, as a result of reduced smoking, better control of medical risk factors such as hypertension and cholesterol, and better education among the older population.

Table 1: Sample survey Characteristics

	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, %				
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
Prehypertension	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

Abbreviations: NHANES, National Health and Nutrition Examination Survey.

Table 2: Effect of Risk Factors on 10 Year Mortality

Variable	Odds Ratio*	p-value*
Race (relative to white)		
Black	1.402	.010
Other race	.245	.119
Married	.682	.001
Education (relative to high school graduate)		
<High School	1.269	.036
At Least Some College	1.062	.739
Smoking status (relative to never smoker)		
Current smoker	2.126	.000
Former smoker	1.233	.117
Drinking status (relative to never drinker)		
Heavy drinker	1.021	.906
Light drinker	.771	.034
BMI (relative to optimal)		
Underweight, BMI<18.5	2.408	.000
Overweight, 25≤BMI<30	.762	.020
Obese, BMI≥30	1.278	.112
Blood pressure (relative to normal)		
Prehypertension	.904	.581
Stage 1 hypertension	1.131	.486
Stage 2 hypertension	1.535	.023
Cholesterol (relative to normal)		
Borderline high	1.029	.819
High	1.150	.277

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

Table 3: Summary Measures of Population 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.

1. Achievements in Public Health: Tobacco Use -- United States, 1900-1999. Morbidity and Mortality Weekly Report 1999;48:986-993.
2. Lakins N, Williams GD, Yi H, Hilton ME. Apparent Per Capita Alcohol Consumption: National, State, and Regional Trends, 1977-2003. Washington, D.C.: National Institute on Alcohol Abuse and Alcoholism; 2005 August 2005. Report No.: Surveillance Report #73.
3. Flegal KM, Carroll MD, Ogden CL, Johnson CL. Prevalence and trends in obesity among US adults, 1999-2000. Jama 2002;288(14):1723-7.
4. Gregg EW, Cheng YJ, Cadwell BL, Imperatore G, Williams DE, Flegal KM, et al. Secular trends in cardiovascular disease risk factors according to body mass index in US adults. Jama 2005;293(15):1868-74.
5. Elo IT, Preston SH. Educational differentials in mortality: United States, 1979-85. Soc Sci Med 1996;42(1):47-57.
6. Preston SH. Deadweight?--The influence of obesity on longevity. N Engl J Med 2005;352(11):1135-7.
7. Lubitz J, Cai L, Kramarow E, Lentzner H. Health, life expectancy, and health care spending among the elderly. N Engl J Med 2003;349(11):1048-55.
8. Chernew ME, Goldman DP, Pan F, Shang B. Disability And Health Care Spending Among Medicare Beneficiaries. Health Aff (Millwood) 2005.
9. Miller HW. Plan and operation of the health and nutrition examination survey. United states--1971-1973. Vital Health Stat 1 1973(10a):1-46.
10. Statistics NCfH. NHANES 1999-2000 data files: data, docs, codebooks, SAS code. In; 2006.
11. Burt VL, Cutler JA, Higgins M, Horan MJ, Labarthe D, Whelton P, et al. Trends in the prevalence, awareness, treatment, and control of hypertension in the adult US population. Data from the health examination surveys, 1960 to 1991. Hypertension 1995;26(1):60-9.
12. Hajjar I, Kotchen TA. Trends in prevalence, awareness, treatment, and control of hypertension in the United States, 1988-2000. Jama 2003;290(2):199-206.
13. Carroll MD, Lacher DA, Sorlie PD, Cleeman JI, Gordon DJ, Wolz M, et al. Trends in serum lipids and lipoproteins of adults, 1960-2002. Jama 2005;294(14):1773-81.
14. Chobanian AV, Bakris GL, Black HR, Cushman WC, Green LA, Izzo JL, Jr., et al. Seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. Hypertension 2003;42(6):1206-52.
15. Executive Summary of The Third Report of The National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, And Treatment of High Blood Cholesterol In Adults (Adult Treatment Panel III). Jama 2001;285(19):2486-97.
16. Liao Y, McGee DL, Cooper RS, Sutkowski MB. How generalizable are coronary risk prediction models? Comparison of Framingham and two national cohorts. Am Heart J 1999;137(5):837-45.
17. Leaverton PE, Sorlie PD, Kleinman JC, Dannenberg AL, Ingster-Moore L, Kannel WB, et al. Representativeness of the Framingham risk model for coronary heart

disease mortality: a comparison with a national cohort study. J Chronic Dis 1987;40(8):775-84.
18. McGee D, Gordon T. The results of the Framingham Study applied to 4 other US based epidemiologic studies of cardiovascular disease. In: Kannel WB, Gordon T, editors. The Framingham Study: an epidemiologic investigation of cardiovascular disease. Washington, D.C.: US Government Printing Office; 1976.
19. Olshansky SJ, Passaro DJ, Hershow RC, Layden J, Carnes BA, Brody J, et al. A potential decline in life expectancy in the United States in the 21st century. N Engl J Med 2005;352(11):1138-45.
20. Chaloupka FJ, Warner KE. The Economics of Smoking. In: Culyer AJ, Newhouse JP, editors. Handbook of Health Economics, Volume 1B. Amsterdam: Elsevier; 2000. p. 1539-1627.
21. Lleras-Muney A. The Relationship Between Education and Adult Mortality in the United States. Review of Economic Studies 2005;72:189-221.
22. Oreopoulous P. Do Dropouts Drop Out Too Soon? Wealth, Health, and Happiness from Compulsory Schooling. In: University of Toronto. Toronto; 2005.
23. Arendt N. Does Education Cause Better Health? A Panel Data Analysis Using School Reform for Identification. Economics of Education Review 2005;24:149-160.
24. Spasojevic J. Effects of Education on Adult Health in Sweden: Results from a Natural Experiment [PhD dissertation]. New York: City University of New York Graduate Center; 2003.
25. Wilkinson R. Unhealthy Societies: The Afflictions of Inequality. London: Routledge; 1996.
26. Link BG, Phelan J. Social conditions as fundamental causes of disease. J Health Soc Behav 1995;Spec No:80-94.
27. Ma J, Sehgal NL, Ayanian JZ, Stafford RS. National trends in statin use by coronary heart disease risk category. PLoS Med 2005;2(5):e123.
28. Cutler DM, Kadiyala S. The Return to Biomedical Research: Treatment and Behavioral Effects. In: Topel R, Murphy K, editors. Measuring the Gains from Medical Research. Chicago: University of Chicago Press; 2003.
29. Ford ES, Mokdad AH, Giles WH, Mensah GA. Serum total cholesterol concentrations and awareness, treatment, and control of hypercholesterolemia among US adults: findings from the National Health and Nutrition Examination Survey, 1999 to 2000. Circulation 2003;107(17):2185-9.