Relative Deprivation, Poor Health Habits, and Mortality

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A B S T R A C T

Using individual-level data on males from the 1988–91 National Health Interview Survey Multiple Cause of Death Files, we examine the impact of relative deprivation within a reference group on health. We define reference groups using combinations of state, race, education, and age. High relative deprivation in the sense of Yitzhaki is associated with a higher probability of death, worse self-reported health, higher self-reported limitations, higher body mass index, and an increased probability of taking health risks.

I. Introduction

In 2001 the United States' per capita health care expenditures totaled about $4,887, first overall and 47 percent more than the second highest spending country in the OECD. In spite of this spending, the United States performs poorly in aggregate measures of population health. Among OECD countries, the United States ranks 20th in both women's and men's life expectancy, and the United States has the sixth highest infant mortality rate in the developed world (Organization for Economic Cooperation and Development 2003).[1] These numbers, as well as other evidence, suggest that—at least in developed countries—money and health are not as closely linked

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1. Life expectancy and mortality figures come from OECD Health Data (2003).

as one might guess.[2] One contentious explanation for the weak relationship between income and health at the aggregate level is the "relative deprivation" hypothesis, which argues that individuals are adversely affected when they perceive themselves to be economically deprived relative to their peers. The relative deprivation hypothesis is distinct from more traditional models that argue an individual's health is a function solely of his or her underlying characteristics, such as own income, education, and race. According to the relative deprivation hypothesis, an individual's health is also a function of the incomes of others in his or her reference group. It is typically assumed that a person's health is negatively related to the income of others, so that as person j becomes richer, person i's health deteriorates. Low relative income may cause stress and depression, conditions that may raise the probability of contracting a disease or increase the tendency to engage in risky behavior.

While the concept of relative deprivation has existed in the economics literature for years (Duesenberry 1949; Yitzhaki 1979; Frank 1985), interest in the link between relative deprivation and health is heightened by a group of studies that link income inequality to population health. Income inequality can be seen as a proxy for deprivation, in that as inequality increases, the gap between the "haves" and the "have-nots" grows, and the overall deprivation in society increases. However, income inequality could influence health independently of relative deprivation, and most of the current literature does not attempt to disentangle the two effects. At the aggregate-level, income inequality seems highly correlated with public health measures such as mortality rates (Kaplan, et al. 1996; Kennedy, Kawachi, and Prothrow-Stith 1996; Wilkinson 1996). Studies that use individual-level data find less support for the income inequality hypothesis (Daly, et al. 1998; Mellor and Milyo 2002; Sturm and Gresenz 2002; Fiscella and Franks 1997). To date, few studies use individual-level data to focus specifically on the relative deprivation hypothesis.

In the first part of this paper, we use restricted-use micro-level data from the National Health Interview Survey Multiple Cause of Death Files (NHIS/MCOD) to investigate the relative deprivation/mortality link. We define reference groups using a combination of characteristics including state of residence, age, race, and education. Our results indicate that, even after controlling for reference group effects and individual income, relative deprivation is positively associated with an individual's probability of death. Relative deprivation is also positively linked to cause-specific mortality, notably for deaths due to tobacco-related cancers and coronary heart disease (CHD). In many cases, relative deprivation has a stronger impact on health than own income. While relative deprivation is consistently linked to poor health, measures of relative performance such as centile rank and z-score have an inconsistent impact on health.

The finding that relative deprivation has a large impact on deaths linked to smoking and CHD is suggestive, mainly because these two causes of death that are highly related to behavior. One theory relating relative deprivation to health outcomes argues that individuals respond to the stress, hostility, and low self-esteem caused by relative

2. Some argue that the weak link between income and health is due to the fact that there are diminishing returns to investment in health, and that the United States is operating on the flat of the curve. However, this does not explain why health outcomes in the United States are worse than those in other developed countries.

deprivation by engaging in health compromising behavior. Wilkinson explains "among the many ways people respond to stress, unhappiness and unmet needs, one is to increase their consumption of various comforting foods . . . including alcohol and of course tobacco" (pp. 185–86). The notion that relative deprivation increases the probability of taking health risks is consistent with evidence that individuals of low socioeconomic status tend to smoke more and exercise less than their peers (Lynch, Kaplan, and Salonen 1997; Lantz, et al. 1998). In the second part of this paper, we use data from the National Health Interview Survey (NHIS) and the Behavioral Risk Factor Surveillance System (BRFSS) to explore whether relative deprivation is associated with health-compromising behavior. Using a number of outcomes including smoking, seatbelt use, body mass index, and propensity to exercise, we find that relative deprivation in the sense of Yitzhaki is consistently linked to the probability that an individual engages in risky behaviors. Although we control for individual characteristics and reference group fixed effects, we cannot rule out the possibility that part of the relative deprivation effect is driven by unobserved factors correlated both with low income and poor health.

II. Background

A. The Income Inequality Hypothesis

In a 1992 paper and a subsequent book, Wilkinson (1996) argues that there is a negative correlation between income inequality and average life expectancies across countries, and that this relationship cannot be attributed to omitted country-specific factors such as diet and exercise. Subsequent studies show a similar correlation between income inequality and health across different countries, the U.S. states, and smaller geographic regions such as MSAs (Waldmann 1992; Kaplan, et al. 1996; Kennedy, Kawachi, and Prothrow-Stith 1996). These studies argue that relative deprivation could explain the relationship between income inequality and health. For example, Wilkinson (1997) writes, ". . . income inequality summarizes the health burden of individual relative deprivation."

However, critics raise concerns about the methodology in the income inequality and health data. As demonstrated by Gravelle (1998) and Rodgers (1979), if the relationship between individual health and individual income is concave, there may be a spurious correlation between income inequality and mortality at the aggregate level. The concave relationship between income and health leads to what is known as the "ecological fallacy," where inequality erroneously appears to have a causal impact on mortality rates. A second concern about much of the aggregate-level inequality/mortality literature is that many studies leave potentially important cofactors out of the analysis (Daly, et al. 1998). This concern is heightened by the fact that geographic regions with high inequality appear to be quite dissimilar from areas with low inequality. Within the United States, income inequality and mortality are generally highest in Southern states. In contrast, low inequality/mortality states include Vermont, Utah, and Hawaii, where social norms and behavior may be very different from the rest of the country. In these cross-sectional models, the inequality coefficient may be capturing state-specific omitted effects, such as healthier lifestyles in Utah.

Several recent papers that explore the income inequality hypothesis using individual level data find no evidence for a link between income inequality and poor health outcomes (Mellor and Milyo 2002; Sturm and Gresenz 2002; Fiscella and Franks 1997; Daly, et al. 1998). This flurry of negative findings has led many to conclude that the evidence for a relationship between income inequality and health has disappeared. In a 2003 summary of the literature, Deaton writes that ". . . it is not true that income inequality itself is a major determinant of population health. There is no robust correlation between life expectancy and income inequality among the rich countries, and the correlation across the states and cities of the United States is almost certainly the result of something that is correlated with income inequality."

What's interesting about the early appeals to relative deprivation in the context of the income inequality literature is that inequality and relative deprivation measure two fundamentally different things. Clearly these two variables are related—areas with high income inequality have higher average relative deprivation. For example, using a definition of relative deprivation based on Runciman (1966), Yitzhaki (1979) shows that total relative deprivation in a reference group is simply mean income times the Gini coefficient. However, income inequality is a group measure while relative deprivation is specific to the individual. Two people living in the same state or country are exposed to the same measure of group inequality, yet these two people can have vastly different measures of relative deprivation. Although recent studies cast doubt on the relationship between income inequality and health, to date few studies look specifically at relative deprivation. Our paper contributes to the existing literature in several different ways. First, we focus specifically on the relative deprivation hypothesis. Second, we define reference groups using not only state of residence but also other demographic characteristics such as age, race, and education. Finally, while we are able to use mortality as one of our key outcomes, we also examine a number of other health outcomes and health related behaviors, such as smoking.

B. Pathways Linking Relative Deprivation and Health

Wilkinson (1997) suggests that relative deprivation influences health primarily through psychosocial stress that affects those with low relative incomes. Individuals who feel they are economically disadvantaged compared to their peers may be depressed and disgruntled, conditions that affect health both directly (via heart disease, high blood pressure, and suicide) and indirectly (via increased smoking, poor eating habits, and alcohol abuse). The relative deprivation hypothesis is distinct from the absolute income hypothesis in that individuals with high absolute income can be relatively deprived, as long as their peers are better-off than they are. Thus, a lawyer may be wealthy in an absolute sense, but deprived in a relative sense.

There is biological evidence to support the notion that relative status plays a role in both psychological and physical health. Studies indicate that socially subordinate monkeys have worse health outcomes than dominant animals (Shively, et al. 1997; Sapolsky, et al. 1997; Cohen, et al. 1997; McGuire and Raleigh 1985). Although some studies suggest the relationship between rank and primate health persists even after the hierarchy of the monkey troop is scientifically altered, the nature of causality has not been conclusively established. Nevertheless, social scientists draw parallels between research on primates and the potential relationship between relative income and health in humans (Frank 1985; Wilkinson 1996; Cohen, et al. 1997). Further evidence of the harmful effects of relative deprivation is found in the Whitehall study that tracked the mortality outcomes of members of the British Civil Service. Evaluation of ten-year age-adjusted mortality rates reveal that the lowest-ranking civil servants were three times more likely to die than the highest-ranking civil servants (Marmot, et al. 1984; Marmot 1986). Although these results are not adjusted for income or education levels, even the lowest ranking civil servants were employed and had access to nationalized health care. The cause of the health differentials found in the Whitehall study is unknown, but one untested theory is that part of the mortality difference between the highest and lowest civil service grades might be driven by relative deprivation.

III. Constructing Measures of Relative Deprivation

The seminal definition of relative deprivation is accredited to Runciman (1966), who argues that an individual is relatively deprived if:

> (i) He does not have *X*, (ii) he sees some other person or persons, which may include himself at some previous or expected time, as having *X* (whether or not this is in fact the case), (iii) he wants *X*, and (iv) he sees it as feasible that he should have *X*.

Thus, we feel relatively deprived if others in our reference group possess something that we do not. While the object of deprivation (*X*) could be measured using any number of attributes (physical strength, attractiveness, intelligence, personal possessions), we follow others in defining *X* as income (Yitzhaki 1979, Hey and Lambert 1980, Berrebi and Silber 1985).

Our starting point for measuring relative deprivation (RD) is based on Runciman's definition and subsequent theory developed by Yitzhaki (1979). For a person i with income y_i who is part of a reference group with N people, Yitzhaki's measure is defined as:

$$(1) \quad RD_i = \frac{1}{N} \Sigma_j (y_j - y_i) \, \forall y_j > y_i$$

This measure posits that relative deprivation for person i is driven by the incomes of people who earn more than y_i.[3] The summation in Equation 1 is divided by the number of people in the reference group (N) to make the measure invariant to size. Dividing by N can also be interpreted as adjusting for the probability of making a comparison. If income for person i is thought of as a draw from a distribution, the relative deprivation measure in Equation 1 can be rewritten as:

$$(2) \quad RD_i = [E(y \mid y > y_i) - y_i] * \text{prob}\,(y > y_i)$$

3. Yitzhaki proposes an analogous relative satisfaction metric that is equal to μ-RD. Because we are using reference-group fixed effects, this measure is a linear combination of the fixed effect and the relative deprivation measure. A second potential measure of relative satisfaction, $\{y_i - E(y \mid y < y_i)\}$*prob $(y < \ln y_i)$, is a linear combination of RD, y_i, and μ.

Intuitively, Yitzhaki's relative deprivation measure is equal to the expected difference between i's income and the expected income of those with incomes greater than y_i, times the probability that income is greater than i's income.

One concern with the measure in Equation 2 is that it does not take into account differences in the scale of the income distribution across reference groups. In other words, if everyone's income doubles, RD_i will double as well. This would certainly be a problem if we were looking at relative deprivation over time and incomes were unadjusted for inflation. Since we deal with cross-sectional data, it is not clear whether we should be concerned about the scale of the reference group income distribution. If people view within-reference group income differences in proportional terms, then *RD* will overstate the relative deprivation of individuals in high-income reference groups. But if absolute differences within reference group matter, then *RD* is appropriate. The latter scenario would make sense if everyone uses a common yardstick to measure relative deprivation (say average U.S. income), but comparisons are only made within reference group.

Since it is plausible that people measure relative deprivation in proportional terms, we construct an additional measure of relative deprivation that does not vary with the scale of the reference group income distribution by substituting $\ln(y_i)$ and $\ln(y_j)$ into Equations 1 and 2. If we assume that income is log-normally distributed, we can use the properties of the truncated normal distribution to find a closed form solution to Equation 2:

$$(3)\quad \text{RD of logs}_i = \{\left[\mu_r + \frac{\sigma_r \phi_i}{(1-\Phi_i)}\right] - \ln(y_i)\}*(1-F_i)$$

Where μ_r and σ_r are the mean and standard deviation of log income for reference group r, Φ_i and ϕ_i are evaluations of the standard normal CDF and PDF at $[\ln(y_i)-\mu_r]/\sigma_r$, and F_i is the CDF evaluated at y_i. The specification in Equation 3 is convenient because we can now solve for i's relative deprivation if we know i's income and the mean and standard deviation of the logs of the reference group income distribution.

We also include two measures of economic performance that are correlated with relative deprivation but instead, measure economic standing relative to the reference group. The first measure of relative performance is the individual's centile rank within the income distribution, where income is sorted in ascending order. While the two Yitzhaki-based relative deprivation measures discussed above presume that the distance between y_i and y_j matters, the primate studies discussed in Section III emphasize rank over distance. Centile rank captures the ordinal spacing between individuals, but unlike the Yitzhaki-based measures, centile rank is not affected by changes in the shape of the income distribution. Although centile rank does not reflect differences in income inequality across groups, it is closely related to relative deprivation. Centile rank it is equivalent to $(1-p(y > y_i))$, the inverse of the second term in Equation 2.

A second measure of relative performance is the individual's z-score, which quantifies the number of standard deviations the individual's own income is above (or below) the reference group mean. Formally,

$$(4)\quad z - \text{score} = \frac{(y_i - \mu_r)}{\sigma_r} = \left(\frac{y_i}{\sigma_r}\right) - \left(\frac{\mu_r}{\sigma_r}\right)$$

where μ_r and σ_r are the reference group mean and standard deviation. While this measure captures distance, it is different from the Yitzhaki-based measures in that it is sensitive to changes in the income distribution below the individual's income. Further, while average Yitzhaki-based relative deprivation increases as income inequality goes up, the mean and standard deviation of z-score are insensitive to changes in the distribution of income.

IV. Reference Groups

In order to address the relative deprivation hypothesis, one must consider how individuals define reference groups. The social psychology literature suggests that members of one's reference group are typically selected on the basis of either similarity or geographic proximity (Singer 1981). While geographic proximity is relatively easy to determine, "similarity" is a more nebulous concept. Various studies report that individuals define reference groups along demographic lines such lines as sex, education, and race (Merton and Kitt 1950; Singer 1981; Bylsma and Major 1994). However, it is well acknowledged that there is no perfect formula for determining reference groups. Critics assert that the "Achilles heel" of social evaluation theory is the "failure to explain adequately how the relevant comparisons are selected in the first place" (Pettigrew 1978; p. 36).

Perhaps because of the difficulty of determining reference groups according to "similarity," most studies dealing with health and inequality define relative deprivation within the context of geographical location. U.S.-based studies of income inequality and health typically use state or MSA of residence as the implicit reference group. Restricting inequality measures to geographic boundaries makes sense if we expect that inequality affects health through its impact on public investment in human and social capital. However, if Wilkinson's psychosocial pathways are the more probable culprits, then it's not clear that reference groups should be limited to geographical confines. Individuals may compare themselves to others of similar demographic backgrounds, regardless of geographical location (Frank 1985). Deaton (1999) addresses the issue of "similar circumstances" by using birth cohorts to define reference groups. In this study, we construct reference groups based on observable demographic characteristics such as state of residence, race, education, and age. Groups defined using such characteristics do not necessarily constitute the unobservable true reference groups. Yet, members of such groups have a high degree of similarity and are likely to contain a high proportion of relevant reference people.

V. Empirical Analysis

A. Data

1. National Health Interview Survey and Multiple Cause of Death Files

Our primary sample is a restricted-use version of the National Health Interview Survey Multiple Cause of Death Files (NHIS/MCOD). The NHIS is an annual survey of the United States civilian noninstitutionalized population conducted by the

National Center for Health Statistics, containing about 120,000 observations each year. The NHIS person file includes a wide variety of demographic data (age, sex, race, family income, etc.), as well as health-related information such as height, weight, and self reported health status. Since 1986, NHIS respondents have been tracked using the National Death Index, and information on decedents including year of death, month of death, and cause of death is recorded in the Multiple Cause of Death File (MCOD). After merging the MCOD information into the NHIS, we calculate a binary indicator variable for whether or not the individual died within five years of the survey, which we use to measure mortality.[4] In addition to containing information on deaths, the restricted-use version of the NHIS/MCOD contains data on state of residence. Access to this information gives us an advantage in that we use individual-level income data, explore mortality as our outcome of interest, and include geography as part of our reference group definition.

In order to construct the relative deprivation measure outlined above, we need data on the individual's own income and information about the income distribution for the reference group. The own-income measure used to construct relative deprivation is set at the midpoint of the individual's family income interval from the NHIS (for instance, for the \$0–1,000 category, income is set at \$500). For the topcoded category in the NHIS (income≥\$50,000), family income is set at the reference group conditional mean income given that income is greater than or equal to \$50,000. This conditional mean is taken from the Public Use Microdata Sample of the 1990 Census (PUMS). Rather than rely on data from the NHIS to construct measures of relative deprivation, we instead match income variables from the NHIS to household income[5] data from the PUMS. The 1990 PUMS is the best available source of income data because it has extremely large sample sizes and the income variable is continuous. While household income is topcoded at a level that varies by state, topcoded individuals are assigned household income equal to the median household income in their state given that income is greater than the topcode value.[6] We restrict our sample from the PUMS to male householders and male spouses older than the age of 20,[7] which leaves us with a sample of 3,316,833. We then use this information to construct relative deprivation measures for each individual in the NHIS data set. Reference groups are defined in four different ways: (1) state only, (2) state and age group, (3) state, age group, and race, (4) state, age group, race, and education.[8]

4. We impute month of interview using quarter and week of interview.

5. Although family income is recorded in the NHIS, the survey does not give guidelines as to what constitutes a family. In the PUMS, families are defined as two or more related individuals living together. Single people without children in the PUMS are assigned family income equal to zero because—technically—they are not part of a family. Respondents in the NHIS clearly interpret family income differently because single people in the NHIS report positive family income. Since family income is the only income variable available in the NHIS and family income in the PUMS is not applicable for single people, we construct relative deprivation using the household income variable in the PUMS and the family income variable in the NHIS.

6. Information on topcode imputations for each state can be found on the IPUMS website, http://www.ipums.org/usa/volii/topcode_odd.html.

7. The sample is restricted to householders and spouses to avoid counting two observations from the same household.

8. Age groups are recorded in five-year increments, 21–25, 26–30, etc. The final age group, 86 and older, is open-ended. Race is defined as white non-Hispanic, black non-Hispanic, other non-Hispanic, or Hispanic. Education is high school dropout, high school graduate, some college, or college grad.

Our final data set contains NHIS/MCOD observations for the years 1988–91 linked to measures of relative deprivation taken from the 1990 PUMS.[9] We restrict our sample to include men between the ages of 21 and 64[10] who have nonmissing data for family income, age, education, and race in the NHIS. The total number of observations in our linked data set is 104,320. For the final regression analysis, we only use NHIS respondents for whom the PUMS reference group contained at least 50 observations. This causes sample size to diminish slightly in the more stratified reference groups.

2. Behavioral Risk Factor Surveillance System

As an additional source of data, we use information from the Behavioral Risk Factor Surveillance System (BRFSS) for the years 1989–91 to examine health-compromising behaviors. Started in 1984, the BRFSS is an on-going telephone survey conducted by the states and supported by the Centers for Disease Control (CDC). Households are telephoned at random, and a series of questions are asked to a randomly selected adult member of the household. While initially only 15 states conducted BRFSS surveys, by 1990, 44 states and the District of Columbia participated.[11] Together the 1989–91 BRFSS surveys contain 236,270 observations, but after limiting our sample to men between the ages of 21 and 64, we have 73,085 records. In addition to basic demographic data, the BRFSS contains measures of seatbelt use, exercise habits, body mass index, and current and former smoking behavior. The BRFSS also contains data on household income, which is reported as a seven-level categorical variable[12] with a topcoded value of $50,000. We use data from the 1990 PUMS to calculate the reference group income distribution, which we match to individual income information from the BRFSS.

Table 1 reports descriptive statistics for both the NHIS/MCOD and the BRFSS samples. We divide the basic relative deprivation measures in Equation 1 by 10,000 to make the subsequent regressions easier to read. The levels of relative deprivation are highest and the variance lowest when reference groups are defined over states only. This result is predictable; as reference groups become more similar, income differences become less pronounced. We do not observe this trend in the relative performance measures because they are, on average, insensitive to variance in the income distribution. To get a sense of the magnitude of relative deprivation, if reference groups are defined using state of residence, Connecticut has the highest average RD/10,000 at 2.3, and South Dakota has the lowest at 1.1. For relative deprivation of logs, Louisiana has the highest average at 0.50, and New Hampshire

9. In the interest of confidentiality, a randomized state indicator replaces state identification codes after the merge.

10. Women are excluded from the analysis because, since women are less likely to work than men, relative income deprivation may be a less accurate measure of status for women than it is for men. We drop men older than age 65 from our sample because income differences in the older age groups may mask substantial differences in wealth. Unreported results indicate that relative deprivation has no effect on health for the older-than-65 subsample.

11. States that did not participate were Alaska, Nevada, Wyoming, Kansas, Arkansas, and New Jersey.

12. The income categories in the BRFSS are: <=$10,000, $10,000–$14,999, $15,000–$19,999, $20,000–$24,999, $25,000–$34,999, $35,000–$50,000, >=$50,000.

Table 1
Descriptive Statistics, Men 21 to 64, NHIS/MCOD and BRFSS data sets. Means and Standard Deviations

Variable	Reference Group Defined by			
	State	State, Age	State, Age, Race	State, Age, Race, Education
NHIS				
RD/10,000	1.679	1.649	1.579	1.454
	(1.108)	(1.227)	(1.181)	(1.180)
RD of logs	0.4672	0.4604	0.4470	0.4133
	(0.5289)	(0.5227)	(0.5065)	(0.4776)
Centile rank	0.5034	0.4844	0.4900	0.4905
	(0.2958)	(0.3060)	(0.3030)	(0.2972)
Z-score	−0.0810	−0.0968	−0.0949	−0.0999
	(0.7232)	(0.8017)	(0.8064)	(0.8152)
Percent died in five years	2.44	2.44	2.44	2.45
Income	38,237	38,237	38,272	38,432
	(21,659)	(21,659)	(21,657)	(21,645)
Age	39.1	39.1	39.1	39.2
	(11.8)	(11.8)	(11.8)	(11.8)
Percent white	78.8	78.8	79.1	80.8
Observations	104,320	104,320	103,834	101,577

BRFSS				
RD/10,000	1.740	1.656	1.615	1.613
	(1.119)	(1.219)	(1.193)	(1.263)
RD of logs	0.477	0.464	0.453	0.440
	(0.479)	(0.470)	(0.454)	(0.437)
Centile rank	0.4867	0.4738	0.4758	0.4573
	(.2943)	(0.3045)	(0.3031)	(0.2967)
Z-score	–0.1112	–0.1070	–0.1109	–0.1855
	(0.7530)	(0.8767)	(0.8792)	(0.8333)
Income	40,369	40,369	40,427	40,584
	(27,249)	(27,249)	(27,260)	(27,308)
Age	38.9	38.9	38.94	38.99
	(11.9)	(11.9)	(11.9)	(11.9)
Percent white	79.6	79.6	80.2	81.8
Observations	73,085	73,085	71,936	69,606

has the lowest at 0.39.[13] The descriptive statistics from the NHIS are comparable to those of the BRFSS.

B. The Model

For our baseline results, we estimate the following equation:

$$(5) \quad M_{ir} = \beta_o + \beta_1 R_{ir} + \sum_{k=1}^{26} income_{kir}\, \Theta_k + \delta_r + X_{ir}\, \Gamma + \varepsilon_{ir}$$

Where M_{ir} is a binary variable indicating whether the individual died within five years of the NHIS interview, and i and r are subscripts for individual and reference group, respectively. R_{ir} is one of the relative income measures discussed above (RD/10000, RD of logs, z-score, centile rank). To control for income independently of the relative income effect, we add a complete set of dummy variables for the 27 income categories in the NHIS. The independent income effect is captured in the term $income_{kir}$—this term equals 1 if the individual's income is in group k, zero otherwise.

The term δ_r is a reference group fixed-effect, meant to capture unobservable factors common to all individuals within a reference group. Finally, X_{ir} is a vector of dummy variables that control for individual-specific characteristics such as age, education, and marital status. Since we estimate Equation 5 for each of the 4 reference groups described earlier, the set of variables that enter δ_r and X_{ir} change depending on how reference groups are defined. Specifically, X_{ir} excludes age, race, and education when these terms are fully identified by δ_r.

C. Results

1. Relative Deprivation and Mortality

In Table 2, we report the baseline results estimated from Equation 5, first for the logit model and then for several linear probability models. For the logit model (Column 1) Table 2 shows marginal effects as opposed to regression coefficients. Each cell in the table shows a result from a separate regression. A comparison of Columns 1 and 2 demonstrates that results from the logit model are extremely similar to results from the OLS model. For this reason, and because OLS models were easier to estimate given the large number of fixed effects in our equations, we discuss OLS results only for the remainder of the paper.[14]

Even after controlling for individual income and a number of covariates, the Yitzhaki-based relative deprivation measure appears to be strongly related to the probability of dying. The relative deprivation effect varies depending on the measure and how reference groups are defined, and the weakest effect is found where reference groups are broadly defined using state of residence. The coefficients are largest in the state/age-group models, where a one standard deviation increase in relative

13. These statistics are based on the PUMS data, and exclude estimates for Washington, D.C.

14. When we run the models without the relative deprivation terms, we get the standard result that income is negatively associated with mortality. For example, in a regression where we regress five-year mortality on log income, a state fixed effect, and controls for individual characteristics, we find that a one log point increase in income is associated with an 0.9 percentage point (36 percent) decline in the probability of death.

Table 2
Five-Year Mortality Equations, Men Aged 21–64

Relative Deprivation Measure	Logit Marginal Effects on Relative Deprivation: Reference Group Defined by	Linear Probability Estimates of Coefficients on Relative Deprivation: Reference Group Defined by			
	State	State	State, Age	State, Age, Race	State, Age, Race, Education
All-Cause Mortality (2.44%), N=104,247					
RD/10,000	0.0040	0.0041	0.0120	0.0106	0.0069
	(0.0023)	(0.0023)	(0.0016)	(0.0015)	(0.0013)
RD of logs	0.0200	0.0235	0.0564	0.0508	0.0359
	(0.0105)	(0.0128)	(0.0072)	(0.0069)	(0.0066)
Centile rank	0.0081	0.0138	0.0544	0.0523	0.0249
	(0.0210)	(0.0173)	(0.090)	(0.0085)	(0.0075)
Z-score	0.0074	0.0149	0.0339	0.0326	0.0244
	(0.0075)	(0.0093)	(0.0028)	(0.0029)	(0.0030)

Note: Robust standard errors in parentheses. The means and sample sizes reported in the table are for the models using states as a reference group. Sample sizes for other reference groups are slightly smaller. Reference group fixed effects included in all regressions. Unreported covariates include income, marital status, family size and year of interview. Age-group, race, and education are also included as covariates when not fully identified by the reference group fixed effect. Each coefficient reported above comes from a separate regression.

deprivation appears to increase mortality by 1.4 percentage points (57 percent) in the RD/10,000 model or 2.8 percentage points (115 percent) in the RD of logs model. These results seem sizeable, but they are not inconsistent with other literature on socioeconomic status and mortality. For instance, Marmot (1986), found that British civil servants from the lowest socioeconomic class were three times more likely to die than their high-status counterparts. It is also true that a one standard deviation movement in relative deprivation is a large change. For RD/10,000, a one standard deviation (1.2 point) increase is equal to the average difference in RD/10,000 between Connecticut and South Dakota.

2. *Relative Performance and Mortality*

In contrast to the Yitzhaki-based results, both measures of relative performance are *positively* related to mortality. The results for z-score might conflict with the Yitzhaki-based results because z-score is picking up more than Runciman's relative deprivation effect. Looking at Equation 4, note that the measure of z-score for person i in reference group r can be written as two different components: y_i/σ_r and μ_r/σ_r. This last term is a constant for all members of the reference group and as a result, is captured by the group fixed-effect in Equation 3. Therefore, the z-score model is identified by including only one term in the regression: y_i/σ_r. This term is essentially y_i divided by a measure of income inequality. The positive coefficient on z-score suggests that the basic income/mortality relationship is steeper in areas with higher income inequality.

To verify this conjecture directly, we use data where reference groups are defined using state/age/race/education[15] to estimate additional models where we replace z-score with the interaction of income and reference group inequality (results available upon request). We estimate these regressions using three different income inequality measures: the Gini coefficient, the Theil index and the coefficient of variation. Recall that the first-order effect of group inequality is captured by the reference group dummy variable so we cannot add the measure of inequality directly to the model. In all three models the interaction between income and income inequality is negative and precisely estimated, suggesting that the marginal health benefit of an increase in income is greater in areas with higher income inequality. A similar result is found in Deaton (1999). Therefore, it is our suspicion that the z-score is not capturing the effects of relative deprivation, but rather, detecting differences in the income/mortality gradient across reference groups.

The results from the centile rank model are perhaps more puzzling than those for z-score, since as demonstrated in Equation 2, Yitzhaki's measure is the expected value of income given that income is greater than y_i, multiplied by (1-centile rank). The discrepancy between the centile rank and the RD results suggests that the RD results are driven by the distribution of income above y_i. To test this possibility directly, we decompose the log-based Yitzhaki measure[16] into two terms: $\{E[\log(y) \mid \log(y) > \log(y_i)] - y_i\}$ and $p(y > y_i)$. The latter term is equivalent to (1-centile rank). Table 3 shows results found first by adding the terms into the

15. Because the results were generally not sensitive to the choice of reference group, we present results for the state/age-group/race/education models only in the remaining sections of the paper.
16. We focus on logs rather than levels to ensure that our results are not driven by outliers in the tail of the distribution.

Table 3

Five-Year Mortality Equations, Men Aged 21–64. Reference Groups Defined Using State, Age, Race, and Education

	Coefficients on the Components of Relative Deprivation Measured Using RD of Logs				
	(1)	(2)	(3)	(4)	(5)
$P(y > y_i)$ = (1-centile rank)	–0.025			–0.025	–0.026
	(0.008)			(0.008)	(0.008)
$E(y \mid y > y_i) - y_i$		0.020		0.020	–0.002
		(0.004)		(0.004)	(0.006)
RD of Logs = $P(y > y_i)^*[E(y \mid y > y_i) - y_i]$			0.036		0.039
			(0.007)		(0.011)

Note: Robust standard errors in parentheses. Reference group fixed effects included in all regressions. Unreported covariates include income, marital status, family size, and year of interview. Age-group, race, and education are also included as covariates when not fully identified by the reference group fixed effect. Dependent variable equals one if individual died within five years of NHIS (2.44 percent), N = 104,247.

equation separately (Columns 1 and 2), then by including the relative deprivation interaction term only (Column 3), next by including both terms as separate covariates in the same regression (Column 4), and finally by including both terms and relative deprivation together (Column 5). We consider the case where reference groups are defined using state, age, race, and education.

There are several key findings in Table 3. First, inverse centile rank is always negatively correlated with poor health, and the magnitude and statistical significance of this result are stable regardless of whether we include $[E(\log(y) \mid \log(y) > \log(y_i)) - \log(y_i)]$ or the interaction term in the regression. These results are consistent with Table 2's puzzling result that increases in centile rank are associated with increases in the probability of death. Second, in Columns 2 and 4, the conditional mean income term $[E(\log(y) \mid \log(y) > \log(y_i)) - \log(y_i)]$ is positively associated with mortality, suggesting that, as the conditional mean income in the reference group rises, health declines. But, when we add the interaction term (RD) to the model in Column 5, the coefficient on the conditional mean drops by an order or magnitude and is no longer statistically significant. In contrast, the relative deprivation term is precisely estimated and similar in magnitude to our baseline results (Column 3). Moreover, for the median individual, the effect of an increase in the conditional mean term is Column 5 is the same as it is in Columns 2 and 4.[17]

The centile rank results can be better understood by considering two individuals, both with the same level of income, but with different centile ranks. For a given mean income, it must be the case that the individuals' centile ranks differ because the variance in the distribution of reference group income differs for the two individuals. Specifically, for individuals below the mean income, higher centile rank is associated with higher variance. For those above the mean, higher centile rank is associated with less variance. If we split our sample and run separate regressions for those above and below the mean, we find that the positive centile rank effect is driven entirely by those below the mean. For example, in the state/age/race/education models, the coefficient (standard error) on centile rank for those below the mean is 0.0004 (0.0001), while for those above the mean it is 0.0000 (0.0002). Thus, the seemingly counterintuitive results for the centile rank could simply be capturing a more general effect of income inequality on health.

3. The Effect of an Increase in Income

Figure 1 presents the coefficients on the income dummies taken from Equation 5, for the models in which reference groups are defined using state, age group, race, and education. The five lines in Figure 1 show the income coefficients for regressions that control for each of the four relative deprivation measures, plus the coefficients from an additional regression with income controls but no relative deprivation term. These coefficients demonstrate a positive association between income and mortality for individuals with incomes less than \$6,500, a result that might arise from the fact that a very small percentage of our sample has incomes in this range.[18] Above \$6,500

17. At the median, $\partial M_{ir}/\partial E\{[\log(y) \mid \log(y) > \log(y_i)]\text{-}y_i\}=0.039{*}p\ (y > y_i)=0.039{*}0.5=0.20$.
18. This anomalous finding might stem from the fact that only 4 percent of respondents have incomes less than \$6,500, and some of these are likely to be coding errors.

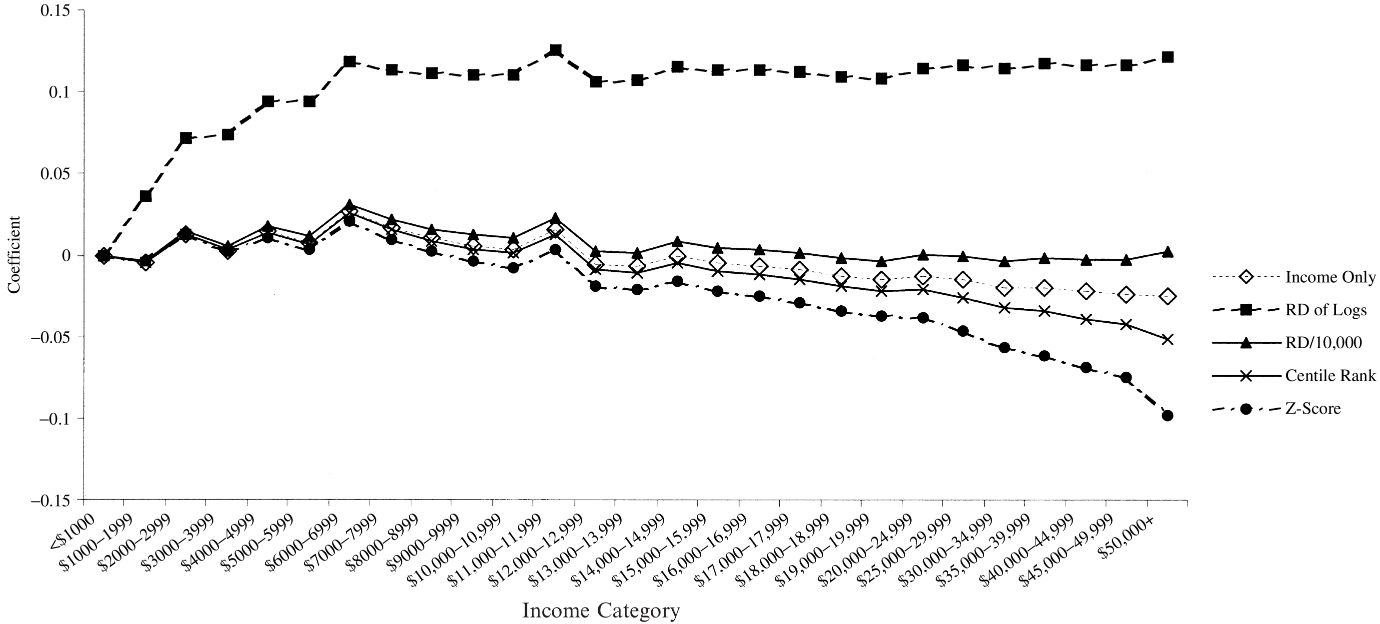

Figure 1
Income Dummy Variables Reference Groups are State, Agegroup, Race, and Education

income is protective in all but the RD of logs model, where an increase in income has essentially no impact on the probability of death. However, these coefficients do not fully illustrate the impact of income on health, because an increase in individual income should have two effects. First, an increase in income decreases relative deprivation, which might benefit health. Second, an increase in income may have a direct impact on health. A companion paper (Eibner and Evans 2004), demonstrates that—when we evaluate the net effect of an increase in income in models that include relative deprivation—the relative deprivation effect in combination with the income effect leads to a decrease in mortality. Further, models that include income only and models that include both income and relative deprivation predict the same change in mortality for a given change in income.

An interesting implication of the results from the Yitzhaki-based relative deprivation measures is that an upward shift in the distribution of income could have an ambiguous impact on population health. By definition, increasing all incomes by a fixed percentage will increase relative deprivation for most individuals. For example, using the definition of relative deprivation in Equation 1, increasing all incomes by 10 percent will increase relative deprivation by 10 percent for all but the highest income individual in each reference group (for whom RD is equal to zero). If relative deprivation is a health hazard, then the increase in relative deprivation that accompanies a general increase in population income could explain the weak link between national income and population health. In Eibner and Evans (2004) we explore this possibility in detail, and find that increasing incomes by 10 percent among all individuals is associated with 614 additional deaths over a five-year period. If we increase income by 10 percent for individuals in the top half of the income distribution only, total deaths increase by 1,693 over a five-year period.

4. Limitations and Sensitivity

An important limitation of this work is that we are unable to control for unobservable "bad" characteristics that may be correlated with both mortality and with relative deprivation. For example, an individual with a high discount rate relative to his peers may spend less time working and more time engaging in risky behaviors (Fuchs 1982). Unfortunately, we don't have an experimental strategy that allows us to fully rule out this type of explanation. However, we are able to control for a number of observable characteristics, such as education, that might proxy for an individual's discount rate.

A second concern is that our results may be sensitive to the way we construct relative deprivation (or relative performance) measures for topcoded individuals. The income variable in the NHIS is topcoded at $50,000, and imputing the topcoded values using the conditional mean from the PUMS may provide a very rough estimate of actual income. Thus, we estimated several models to ensure that our results were unaffected by the way we imputed topcoded values. In one case, we interacted the relative income term with a dummy variable for whether or not the individual's income was topcoded. In other models, we used fixed incomes for all topcoded values. Finally, we dropped all topcoded individuals and reestimated Equation 6. None of these adjustments changed our basic conclusions.

Finally, we wondered if relative deprivation might have a different impact for individuals at the top of the income distribution than for individuals at the bottom.

However, when we estimated separate coefficients for individuals above and below the median income, we found no statistically significant difference in the relative income effect for individuals above and below the median.

D. Can Relative Deprivation Explain the Link Between Inequality and Health?

A number of authors have demonstrated a statistically precise and quantitatively large correlation between income inequality and health. Some of these authors have speculated that this correlation may be attributable to the impact of relative deprivation. In this section, we examine whether a positive correlation between inequality and mortality is present in these data. We then add a measure relative deprivation to the regressions to see how relative deprivation affects the relationship between income inequality and health.

We start by regressing a dummy variable for whether the individual died within five years of the NHIS survey on mean income in the individual's state and the state Gini coefficient in household income (Column 1, Panel 1, Table 4).[19] These results show no association between state mean income and the probability of death, but a positive association between the Gini coefficient and mortality. In Column 2 we add the same controls used in Table 2, and in Column 3 we add fixed effects for the individual's census division of residence. We find that the state-level Gini coefficient continues to be positively associated with mortality even after we add individual controls and division fixed effects. Based on the results in Columns 2 and 3 of Table 4, a one standard deviation (0.022) increase in the Gini coefficient is associated with a 0.2 percentage point (8 percent) increase in the probability of death. Moreover, after we add controls for individual characteristics, the mean income in the state is positively linked to mortality. This could be the result of relative deprivation; holding the individual's income constant, an increase in the affluence of others is associated with worse health outcomes.

In Column 4 we add the relative deprivation of logs,[20] with reference groups defined using state, age-group, race, and education. In this regression, both the Gini coefficient and the relative deprivation measure appear to be positively related to mortality, though the coefficient on the Gini is now of borderline statistical significance. After controlling for relative deprivation, mean state income is no longer associated with a higher probability of death. Although the impact of relative deprivation is slightly smaller than it was in Table 2, a one standard deviation (0.5) increase in relative deprivation is still associated with a 1.3 percentage point (53 percent) increase in the probability of death. These results suggest that income inequality and relative deprivation measure distinct phenomena. However, the results in Table 4 are not directly comparable to the results in Table 2, since—due to the fact that the Gini coefficient and mean income are measured at the state level—the regressions in Table 4 include a census division fixed effect rather than a reference group fixed effect.

19. To avoid concerns about serial correlation in the error term caused by merging aggregate-level variables into individual-level data we adjust for clustering at the state-level. Gini coefficients of household income are calculated using the 1990 PUMS.

20. Results were similar when we used the basic Yitzhaki measure (RD/10,000). When we substitute centile rank or *z*-score, the relative deprivation terms had a positive (counterintuitive) sign, but the coefficient on state mean income remained positive and statistically significant.

Table 4
Linear Probability Models, NHIS/MCOD, Men 21–64 Relative Deprivation Defined Using RD of Logarithms

	No Relative Deprivation			RD Defined over: State, Age, Race, and Education
A. Died in five years (104,247 observations, sample mean = 2.44 percent)				
State Mean	–0.0016	0.0018	0.0020	–0.0002
Income	(0.0011)	(0.0007)	(0.0012)	(0.0013)
State Gini	0.1239	0.0804	0.0873	0.0768
	(0.0393)	(0.0298)	(0.0449)	(0.0468)
RD of logs				0.0280
				(0.0058)
B. Fair or poor health (104,009 observations, sample mean=8.31 percent)				
State Mean	–0.0193	–0.0017	0.0018	0.0021
Income	(0.0035)	(0.0022)	(0.0034)	(0.0036)
State Gini	0.5417	0.2676	0.2294	0.2663
	(0.1308)	(0.1046)	(0.1264)	(0.1303)
RD of logs				0.0080
				(0.0153)
Controls?	No	Yes	Yes	Yes
Division FEs?	No	No	Yes	Yes

Note: Robust standard errors in parentheses, clustered by state. Individual control variables are income, age group, race, education, marital status, family size, and year.

The persistently strong coefficient on the Gini coefficient, even in models with division fixed effects, is in contrast to the results from Mellor and Milyo (2002) who use data from the Current Population Survey (CPS) to examine the effect of income inequality on self-reported health status. To further compare our results with Mellor and Milyo's, we estimate additional models using self-reported health status as our dependent variable (Table 4, Panel B). Following Mellor and Milyo, we construct a binary dependent variable that equals one if the individual reported being in fair or poor health, zero otherwise.

Even after changing the dependent variable, our basic results remain largely the same. In Columns 2, 3, and 4, the coefficient on state Gini is about 0.25, suggesting that a one standard deviation (0.022) increase in the Gini coefficient increases the probability of reporting fair or poor health by 0.6 percentage points (7 percent). When we add relative deprivation to the model, both the Gini coefficient and relative deprivation of logs have a deleterious impact on health, although the coefficient on relative deprivation is not precisely estimated. We suspect that the difference between our results and Mellor and Milyo's stems from the fact that they have a better measure of individual income than we do. The CPS reports family income as a continuous variable with a high topcoding value, while income in the NHIS is recorded using 27 categories, topcoded at $50,000.

E. Other Outcomes

1. Cause-Specific Mortality

One reason that relative deprivation may be linked to mortality is that individuals who feel deprived may be particularly likely to engage in health-compromising behaviors, such as smoking. If the link between behavior and relative deprivation is causal, we would expect relative deprivation to have an especially pronounced effect on mortality that is strongly linked to behavior. To test this conjecture, we reestimate Equation 5 using cause-specific mortality as opposed to all-cause mortality as our outcome of interest. The four causes of death that we investigate are coronary heart disease (CHD), tobacco-related cancers,[21] all other cancers (non-tobacco related), and accidents/external events.[22] The first two causes are highly related to behavior. Cigarette smoking, for instance is the direct cause of 87 percent of all lung-cancer cases, and has been called "the most important of the known modifiable risk factors for coronary heart disease" (American Heart Association 2000). Nonsmoking related cancers and accidents, however, may be less related to behavior. To the extent that relative deprivation leads to increased risk-taking, we might expect it to have a bigger impact on heart disease and smoking-related cancers than it does on the other two causes of death.

The first panel of Table 5 shows results for the cause-specific mortality models, where reference groups were defined using state, race, age group, and education.[23] For CHD

21. This category includes malignant neoplasms of the lip, oral cavity, and pharynx (ICD-9 codes 140–149), and malignant neoplasms of respiratory and intrathoracic organs (ICD-9 codes 160–165).
22. This category includes motor vehicle accidents, other accidents, suicide, homicide, legal intervention, and other external causes (ICD-9 codes E800–E899).
23. Results were similar when we used other combinations of demographic characteristics to define reference groups

Table 5
Other Outcomes Reference Groups Defined Using State, Age, Race, and Education

	N	Mean	Coefficient (Robust SE) on Relative Deprivation			
			Relative Deprivation Defined Using			
			RD/10,000	RD of Logs	Centile Rank	*Z*-Score
A. Cause-Specific Mortality (From NHIS/MCOD)						
Coronary heart disease	101,530	0.0067	0.0027	0.0124	0.0040	0.0091
			(0.0007)	(0.0033)	(0.0039)	(0.0015)
Smoking Related cancers	101,530	0.0029	0.0014	0.0076	0.0048	0.0046
			(0.0007)	(0.0033)	(0.0030)	(0.0012)
All other Cancers	101,530	0.0042	0.0009	0.0038	0.0004	0.0033
			(0.0006)	(0.0024)	(0.0029)	(0.0011)
Accidents and adverse events	101,530	0.0037	0.0003	0.0032	0.0026	0.0008
			(0.0004)	(0.0027)	(0.0034)	(0.0014)
B. Health Status (From NHIS)						
Self reports	101,305	0.0826	0.0068	0.0268	0.0525	0.0549
Poor health?			(0.0018)	(0.0100)	(0.0129)	(0.0048)
Limited in activity?	101,503	0.1320	0.0150	0.0957	0.1114	0.0872
			(0.0025)	(0.0124)	(0.0160)	(0.0061)

C. Health-Related Behaviors (From BRFSS)						
Current smoker?	69,353	0.2860	0.0199	0.1059	0.0071	0.0467
			(0.0058)	(0.0275)	(0.0379)	(0.0108)
BMI	69,091	25.79	0.1543	0.6605	0.1744	0.1868
			(0.0530)	(0.2473)	(0.3288)	(0.0949)
Exercises?	69,533	0.7317	–0.0249	– 0.1060	0.0550	–0.0503
			(0.0061)	(0.0283)	(0.0380)	(0.0106)
Wears seat belt?	69,410	0.5390	–0.0234	– 0.1216	–0.0052	–0.0389
			(0.0070)	(0.0318)	(0.0540)	(0.0125)

Note: Robust standard errors in parentheses. Unreported control variables are a reference group (state*age-group*race*education) fixed effect, year, marital status. Controls for family size are included in NHIS data only (Panels A and B).

and tobacco-related cancers, the impact of relative deprivation is positive and proportionately larger than it was in the all-cause mortality models. Looking at coronary heart disease mortality, a one-standard-deviation movement in RD/10,000 increases the probability of death by 0.3 percentage points (48 percent), and a one standard deviation increase in RD of logs increases the probability of death by 0.6 percentage points (88 percent). These results can be compared to the fourth column of Table 2, where a one standard deviation increase in RD/10,000 increased the probability of death due to any cause by 33 percent. Results for tobacco-related cancers (Row 3, Panel A) are similar to the results for heart disease. A one standard deviation increase in RD/10,000 is associated with a 0.2 percentage point (58 percent) increase in the probability of death due to smoking related cancers, and a one standard deviation increase in RD of logs is associated with a 0.4 percentage point (125 percent) increase in smoking-related mortality.

There is conflicting evidence on the impact of relative performance on cause-specific mortality. We find no statistically significant impact of centile rank on deaths due to smoking related cancers or coronary heart disease. As with the all cause mortality models, *z*-score appears to be positively related to the probability of death due to these causes. For mortality due to all other cancers, accidents, and adverse effects, relative deprivation does not play as much of a role as it did for the other causes, as neither of the Yitzhaki-based RD measures are related to either nonsmoking cancer deaths or accidents/adverse events. The statistical insignificance of these results is not surprising in the nonsmoking related cancers model, since these cancers are less related to behavior than mortality due to lung cancer and coronary heart disease. While a large percentage of traffic fatalities are linked to alcohol consumption, our accidental death variable includes other causes of mortality such as fires, poisonings, prescription drug errors, and homicide.

Again, we find conflicting results for the relative performance measures. There is no statistically significant impact of centile rank in these models, but *z*-score is positively linked to deaths do to all other cancers.

2. *Self-Reported Health and Limited Activity Status*

Mortality is a convenient measure of health because it is easily observable and precisely measured. However, death is a rare event for younger people, and it is possible that relative deprivation has an adverse impact on morbidity without directly affecting mortality. To explore this issue we look at two additional outcomes: self-reported health status and limited activity status. Both self-reported health status and limited activity status are measures that can be taken from the NHIS. We measure poor or fair health status using the binary variable described in Section VD. Limited activity status measures whether or not the individual is physically restricted or unable to perform activities, which might include work, school, or other pastimes. The NHIS limited activities question has four possible responses: (1) unable to perform major activity, (2) limited in kind/amount of major activity, (3) limited in other activities, (4) not limited. We create a binary variable that is equal to one if respondents report any limitation. In total, 13.2 percent of our sample reports being limited in some capacity.

In the Panel B of Table 5 we report results using self-reported health status and limited activity status as our dependent variables. These results closely resemble the baseline results in Table 2. A one standard deviation increase in RD/10,000 is related to a 0.8 percentage point (10 percent) increase in the probability of reporting poor health, and a 1.8 percentage point (14 percent) increase in the probability of reporting activity limitations. However, both relative performance measures have the opposite effect, such that an increase in *z*-score or centile rank is associated with an increase in the probability of poor health.

3. *Health-Compromising Behaviors*

If relative deprivation affects mortality by increasing the probability that an individual takes health risks, then we would expect to see a direct link between relative deprivation and health-compromising behavior. In Panel C of Table 5, we use data from the BRFSS to determine whether increases in relative deprivation change the probability that an individual smokes, exercises or wears a seat belt. Additionally, we examine the link between relative deprivation and body mass index (BMI).[24]

The results in Panel C of Table 5 parallel the results for the mortality and health status outcomes, in spite of the fact that we are using a different data set to measure health-related behaviors. Both of the relative deprivation measures are positively related to health-compromising behavior, which suggests that an increase in relative deprivation leads to worse health habits. For example, a one standard deviation increase in RD/10,000 is linked to a 2.4 percentage point (8.3 percent) increase in the probability of smoking, a 0.19 point (0.7 percent) increase in BMI, a 3.0 percentage point (4 percent) decrease in the probability of exercise, and a 2.8 percentage point (5.2 percent) decrease in the probability of seatbelt use. Similarly, RD of logs is associated with a higher probability of smoking, higher BMI, and lower probabilities of exercise and seatbelt use. Again, we find mixed results for the relative performance measures. There is no relationship between centile rank and health-compromising behaviors, but an increase in *z*-score is associated with an increase in the probability of taking health risks.

VI. Conclusion

Researchers in the social sciences are increasingly concerned about the interplay between income inequality, relative deprivation, and health. Yet studies of these relationships are difficult to conduct, mainly because of a lack of appropriate individual-level data linking health outcomes to income and reference group information. In this paper, we use unique data from the NHIS/MCOD restricted-access files that allow us to observe income, mortality, and state of residence at the individual level. With these data we can examine the relationship between relative deprivation and mortality while simultaneously controlling for individual income and reference group fixed effects. We find that there is a positive and statistically significant link between Yitzhaki-based relative deprivation and the probability that an individual dies within five years of the NHIS survey.

24. BMI = (weight in kilograms)/(height in meters)^2. According to the Centers for Disease Control, a BMI value between 18.5 and 24.9 is healthy, a BMI value between 25 and 29.9 is overweight, and a BMI value above 29.9 is obese.

Our results indicate that relative deprivation in the sense of Yitzhaki may have a detrimental effect on health. From a theoretical standpoint, relative deprivation is thought to impact health via risky behavior. We find that for heart disease mortality and tobacco-related cancers, the relative deprivation effect is proportionately stronger than it was in the all-cause mortality models. Likewise, we examine relative deprivation's impact on various health habits using data from the BRFSS. We find that the Yitzhaki-based measures are related to a higher probability of smoking and a lower probability of seatbelt use. Further, we find that Yitzhaki-based relative deprivation is positively associated with body mass index and negatively associated with the probability of exercise. To our knowledge, this is the first work to look specifically at behavior and relative deprivation.

Two measures of relative performance, centile rank and z-score, do not fare as well. Both centile rank and z-score are positively related to mortality. These findings are difficult to interpret. The results for centile rank are not robust to the choice of health outcome, and the counterintuitive findings may stem from the fact that centile captures neither income inequality nor differences in income between members of the same reference group. The results for z-score are very robust, and always counterintuitive in sign. We suspect the z-score results are picking up the fact that the income/health relationship is steeper when there is high reference-group inequality. The two relative deprivation measures in which we have the most confidence, RD/10,000 and RD of logs, paint a consistent picture of the impact relative deprivation on health.

Three other results are of special note. First, all models predict that an increase in own income will reduce an individual's probability of death. This effect is driven by relative deprivation, rather than the main effect of income on health. Nearly all models regardless of how or whether deprivation is measured predict the same change in mortality from a fixed change in income. Second, although much of the previous work using aggregate data defines reference groups at the state level, we find the weakest evidence of the deleterious impacts of relative deprivation in models where reference groups are defined by state of residence. Finally, relative deprivation seems to have the strongest impact on health when it reflects income differences between individuals as opposed to income rank. When we measure relative status using centile rank, which ignores the magnitude of the income difference between individuals, our results are often statistically imprecise and in many cases, counterintuitive in sign. Yet, when we use relative deprivation measures that quantify income differences between individuals, our results suggest that relative deprivation is linked to mortality, morbidity, and an array of deleterious health habits.

We should stress that these results are only suggestive of a causal link between relative deprivation and poor health. It is possible that our results simply reflect a statistical correlation. For example, Fuchs (1982) has long argued that the persistent differences in health socioeconomic status can be generated by differences in the discount rate. If individuals who have low incomes relative to their peers are myopic, unmotivated, reckless, foolish, or otherwise different than those with higher incomes, then our results may in part by picking up an omitted variable.

In spite of this limitation, these results hint at a relationship between economic conditions, psychological factors, and individual behavior. The relationship we investigate may provide insights to other observed correlations in the data. For example, the fact that relative income affects health may help explain why the gradient between income and health persists even at high levels of income (Adler, et al. 1994; Deaton 2001) or why mortality appears to be pro-cyclic (Ruhm 2000). Likewise, there may be a link between rising income inequality over the past 25 years and rising inequality in health outcomes (Preston and Elo 1995) and in health habits (Evans, Ringel, and Stech 1999). These results may also help explain the paradox that, while there is a strong relationship between income and health at the individual level, there is much weaker evidence of a link between income and health in aggregate data for developed countries (Preston 1975; Ruhm 2000; Deaton and Paxson 2001). For example, a nationwide productivity shock that increases all incomes by a fixed percent will by construction also increase relative deprivation for most, possibly undoing some of the health benefits of higher aggregate incomes. Using the results in this paper, Eibner and Evans (2004) find that a 10 percent increase in aggregate income would actually raise aggregate mortality for men 21–64 by about 0.9 percent.

Thirty years since Kitigawa and Hauser's work on differential mortality in the U.S., there is still debate about the nature of the relationship between income and health. Relative deprivation may explain part of this puzzle, but more research is needed in order to distinguish causality from correlation. Finding exogenous variation that can establish or falsify a causal link between relative deprivation and mortality may be difficult. In practice, one would need to identify a group of people whose incomes remained constant while incomes in their reference group changed. For example, we are investigating the possibility of using the fact that during the 1980s, wages of high-skilled public sector workers fell relative to their counterparts in the private sector in such a manner. In any event, we believe the future of the research in this area will follow the trend towards individual-level micro data established by Fiscella and Franks (1997) and Mellor and Milyo (2002) and continued in this paper. Since mortality rates are relatively low for those in younger age cohorts, research in the future will probably gravitate towards other measures of health and health habits.

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