Accounting for the Historical Rise in Work-disability Prevalence

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DO RAPIDLY INCREASING PREVALENCE RATES OF various functional disabilities or handicaps mean that the health status of Americans is deteriorating and that there is a corresponding need for new health-promoting interventions? Upward trends in disability rates over the past 30 years may indeed be a natural consequence of growing prevalences of (organ-level) impairments or residual pathologies attributable to more extensive patterns of chronic disease (Nagi 1976). Unless Fries (1983) is right in predicting that a shift is now underway from the current chronic-disease era toward a new era of aging-related problems of health and illness, rising disability trends will continue; the need for new interventions designed to overcome the functional incapacitation and, thereby, the socioeconomic consequences of chronic disease will grow accordingly in priority. Other explanations of these historical changes, however, have been advanced in the recent literature, each with strikingly different policy implications:

1. Because the rise in disablement occurred during a period of dramatic growth in the access to medical care, it may perhaps reflect more frequent use of medical services and the encouragement

The Milbank Quarterly, Vol. 64, No. 2, 1986

that such use gives to adopting sick roles (Colvez and Blanchet 1981; Verbrugge 1984). On this view, rising disablement may not be easily interpreted as indicating either worsening health or the need for new policy interventions.

2. Because disability rates increased during a period of steadily improving life expectancy and corresponding changes in demographic structure, the rise may stem not only from population aging but from selective improvements in survivorship favoring individuals at higher risk of disablement (Shepard and Zeckhauser 1980; Feldman 1983). Disability trends paradoxically reflect improvements in health, and policies are needed only for cushioning the adverse effects of these demographic dynamics on the disabled.
3. Because disability rates increased during a period of unprecedented growth in social insurance and income transfer programs, the rise may reflect expanding economic opportunities to accommodate poor health or even adverse economic incentives to relinquish social-role responsibilities arising from such programs (Chirikos and Nestel 1984). Deteriorating health status may not be indicated by disability trends, but income maintenance policies may need to be modified.
4. The observed increase in disability rates may be an artifact of the manner in which the data are collected (Wilson and Drury 1981, 1984). Whether disability trends reflect anything about health levels is unclear on this view; attention, nonetheless, should be focused on improving methods for measuring and monitoring health status.

Policy makers clearly have a stake in distinguishing among these alternative explanations or hypotheses about the sources of historical changes in disability. Designing suitable health strategies and ranking them by priority depend on the ability of policy makers to account for the extent to which these several kinds of factors have contributed to the rise in prevalence rates over time.

This article attempts such an accounting for one type of functional disablement—persons reporting they are limited in the amount or kind of work they can do or prevented from working altogether because of a health or physical condition. Work-disabled individuals are an especially important target of public policy because they are generally in the age range of 18 to 64 years and, thereby, more vulnerable to economic hardship when functionally incapacitated. Prevalence has risen fairly rapidly in the postwar period with the proportion of the (standardized) prime-age population classified as work-disabled increasing by more than one-half and the absolute size of the pool of work-disabled persons increasing about 2 ¼ times over the past 25 years. Our analysis is designed not only to confirm that some factors identified in the recent literature cited above actually contributed to the historical rise in work-related disablement but also to quantify the relative importance of each of them. A main goal is to break down or decompose the proportion of the overall rate of increase in work-disability prevalence in the United States attributable to various health-related and socio-economic changes. Although only rough orders of magnitude are possible, policy makers should find it more instructive to know that a given factor is estimated to account for, say, about 30 percent of the observed change in disability over a specified period of time—or, conversely, that the rise in disability would have only been 70 percent of the measured amount had that factor remained unchanged—than to know simply that this factor is a statistically significant correlate of disablement. From the viewpoint of health policy, the relative impact of changes in the impaired population and chronic disease prevalence on work-disability trends is of greatest interest so the analysis focuses on these factors.

Limitations in available data on temporal changes in prevalence rates as well as in the correlates of work disability lead us to adopt a somewhat unusual analytic strategy. In this study, cross-sectional survey results and available time-series information are combined to draw inferences about the sources of work-disability changes over time. More particularly, data obtained in a recent survey of a representative sample of American men and women (Bye and Schechter 1982) are used to estimate the net, cross-sectional effect of various health-related and socioeconomic characteristics on the probability of reporting a work disability. Annual percentage rates of change in disability prevalence as well as in disability determinants are computed from temporal profiles constructed from several different data sources for each variable over the period of 1957 to 1982. The cross-sectional results are then used to weight the rates of change in key determinants in order to gauge their relative contribution to the overall historical trend in work-disability prevalence. This analytic strategy requires several strong assumptions, but it yields results unobtainable from studies relying exclusively on either time-series or cross-sectional data alone. The analysis also yields some insights and hypotheses useful in guiding the collection of a more satisfactory data base for such research in the future.

The article is organized in terms of the several analytic tasks needed to account for the historical rise in work-disability rates. The next section summarizes macrotrends in age-adjusted prevalence of work disability for American men and women over the past quarter-century. Then, a multivariate regression model for testing the relation between work disablement and various health-related and socioeconomic determinants is designed and estimated with cross-sectional, microlevel survey data. The results of the regression analysis not only quantify the net impact of several factors on disability but also cast light on such related issues as the inducements to functional incapacity arising from the growth in social insurance programs and the possible inverse relation between trends in mortality and disability. In the fourth section, the macrolevel time-series estimates and the microlevel cross-sectional results are brought together to account for the extent to which various factors have served to increase disability rates over time. The final section summarizes the findings and discusses some of their health policy implications. For expository purposes, technical details on variable definitions, mathematical derivations, and data sources are either summarized in notes in appendix A and/or presented in appendix B at the end of the article.

Work-disability Trends

It perhaps bears repeating here that work disability is defined in this study as reported limitations in the amount or kind of work individuals can do, including the inability to do any work at all. Several household surveys of representative samples of Americans of working age have obtained either reports of household respondents or self-reports defined generally along these lines at different points in time, allowing us to draw on different data sources to profile historical trends and determine how fast disability prevalence has increased over the recent past. Included in these sources, among others, are major-activity limitation data from the National Health Interview Survey (National Center for Health Statistics 1975); work limitation data from special Social Security

Administration (SSA) surveys conducted in 1966, 1972, and 1978 (Haber 1968; Ferron 1981; Lando, Cutler, and Gamber 1982); and work limitation data from the censuses of population in 1970 (U.S. Bureau of the Census 1973) and 1980, recent special surveys conducted by the Bureau of the Census (McNeil 1983), and early surveys conducted for the SSA and Public Health Service (Woolsey 1952). Several data sources are used to piece together historical trends because estimates vary and somewhat different conclusions are yielded when only one is used (see note 1, appendix A). To reduce some potential biases, disability prevalence is measured separately for men and women; moreover, attention is restricted primarily to the period of 1957 to 1982. Only civilian, noninstitutionalized individuals 18 to 64 years of age are included in the estimates, and prevalence rates are age-adjusted (using 1980 as the standard) to eliminate the influence of aging on temporal comparisons (see note 2, appendix A).

Figure 1 sets out (semilogarithmic) plots of age-adjusted work-disability prevalence by sex and data source. The two National Health Interview Survey (NHIS) series (solid lines) generally show steady growth over time. The wider fluctuations for women may reflect concomitant changes over this period in women's social roles between market and home work; the variations in each series around 1967 to 1969 probably result from slight changes in question format at that time. Substantial growth in age-adjusted rates is also apparent in the "series" portrayed here by *arbitrarily* connecting estimates for consistently defined items from Social Security Administration and Census sources (dotted lines). Note that prevalence rates circa 1950 are quite low. Although it may seem that they are too low, these estimates are nonetheless consistent with comparable results from the Baltimore Study conducted around the same time (Commission on Chronic Illness 1957). Furthermore, they are based on a disability definition more likely to overstate prevalence numerators and refer to a period when high institutionalization rates were likely to understate population denominators. In contrast, more recent estimates such as those derived from SSA surveys are quite high, perhaps too high. The extremely high SSA estimate for 1966 may stem from the sampling strategy used in that survey (Berkowitz, Johnson, and Murphy 1976). Haber (1973), however, disputes this, arguing that methods used in other surveys tend to underestimate the disabled population. Observe that estimates derived from decennial censuses and recent Census Bureau exclusively on either time-series or cross-sectional data alone. The analysis also yields some insights and hypotheses useful in guiding the collection of a more satisfactory data base for such research in the future.

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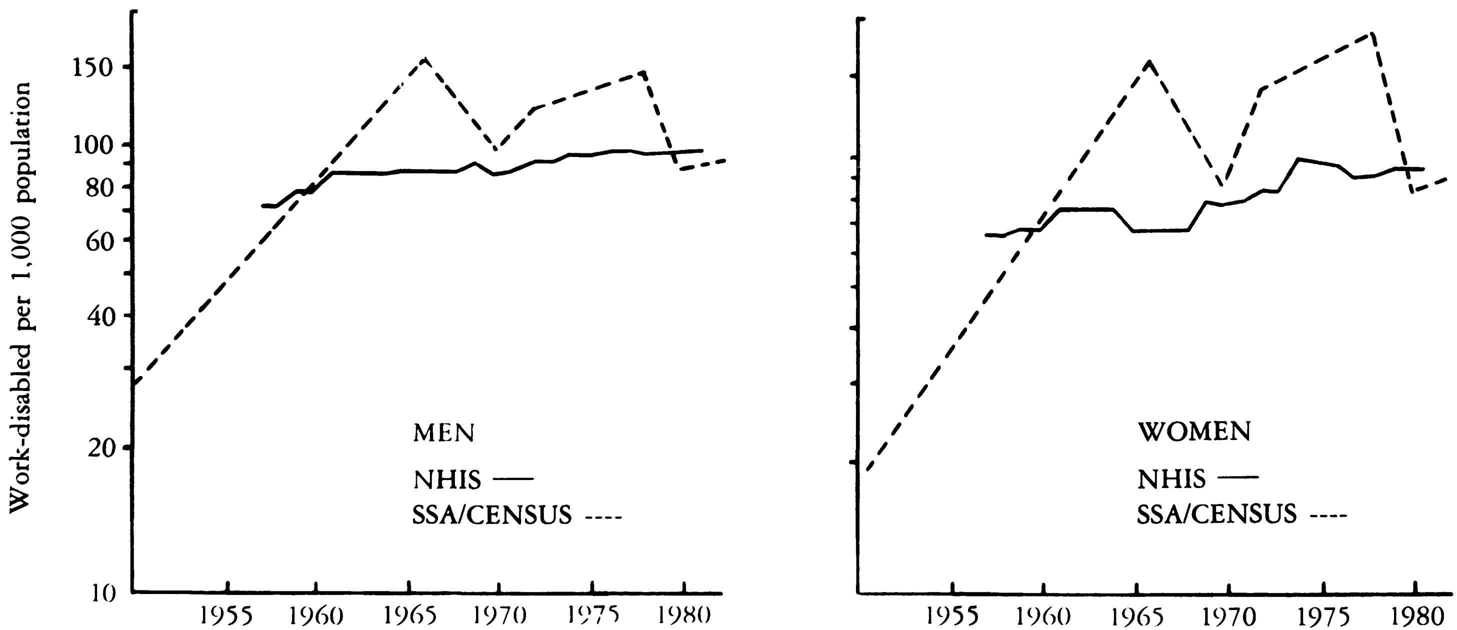

FIG. 1. **Age-adjusted** work disability rates, United States, 1950–1982 by sex and **data** source (**number** of work-**disabled** individuals per 1,000 civilian, noninstitutional population 18 to 64 years of age).

surveys lie substantially closer to NHIS than SSA rates. In fact, comparably defined Census of Population figures suggest a slight decline in age-adjusted prevalence over the period 1970 to 1980, the only evidence contradicting the general conclusion that disability rates have been growing. These figures aside, it seems clear that prevalence rates were substantially higher around 1982 than they were 25 years earlier.

Since percentage rates of change in, rather than the absolute size of, the disabled population are needed for the present analysis, the data used to construct the historical profiles in figure 1 are summarized in terms of annual average-growth rates in age-adjusted prevalence (see note 3, appendix A). (Appendix B shows why continuously compounded percentage rates of change are used throughout the analysis; they may be interpreted here simply as the slope of straight lines fitted to the semilogarithmic historical profiles in figure 1.) Because of the differences in estimates, annual average rates referring to different data sources and time periods were prepared. We use the highest and lowest rates from this set of estimates to form a range of plausible values, choosing arbitrarily the midpoint of the range as an acceptable, working estimate of the long-term rate of change in age-adjusted prevalence. These computations are summarized in table 1. As can

TABLE 1
Growth Rates in Work-disability Prevalence and Population by Sex

	Annual average percentage change	
Prevalence/Population	Men	Women
Age-adjusted prevalence rates[a]		
1957–1982		
High	1.63	2.14
Low	1.15	1.64
1970–1980	1.40	1.50
Civilian, noninstitutional population 18–64 years of age		
1957–1982[b]	1.65	1.56
1970–1980	2.20	1.85

[a] See text.
[b] Estimate.

be seen, the midpoint for the period 1957 to 1982 for men turns out to be about equal to the estimate for the period 1970 to 1980, viz., 1.4 percent per year. For women, these rates differ slightly, but we choose the midpoint of 1.89 percent per year as a plausible estimate. These rates are used in the accounting analysis below. Table 1 also records growth rates in the civilian, noninstitutional population 18 to 64 years of age. Even though prevalence rates are age-adjusted, the age categories available in the published data were perhaps insufficiently detailed to yield substantial differences between age-adjusted and unadjusted figures. The sum of prevalence and population growth rates, then, *approximately* equals the growth rate in the size of the disabled population. The pool of disabled women, for example, grew at about 3.45 percent per year over the period 1957 to 1982. As a benchmark, note that any continuously compounded value growing at that rate will double in 20 years.

Work-disability Determinants

In order to account for the growth in disability prevalence over time, the net effects of various disability determinants must be quantified. This section reports such figures derived from a logistic regression analysis of disability determinants. The regression model is formulated in reference to, and estimated with, cross-sectional data on a representative sample of American men and women 18 to 64 years of age obtained from the public use (computer tape) files of the SSA's *1978 Survey of Disability and Work* (see note 4, appendix A). The key features of this regression analysis may be summarized as follows:

1. The dependent variable indicates the presence or absence of a work disability. Individuals reporting that health limited the amount or kind of work they could do in the survey year or prevented them from working altogether in that year are assigned the value of one; otherwise a zero is assigned. The analysis is thus designed to account for the probability that individuals will be prevalent cases during a given year.

2a. The explanatory variables or determinants include a set of health-related characteristics hypothesized to raise the probability of being work-disabled (appendix B, table B1). The selection and specification of these variables were guided by the findings of earlier studies, the needs of the present analysis, and the limits of the data set. Health factors are profiled in several ways. The first is by dichotomous variables (equalling one) if the respondent had a physical impairment such as chronic deformity or stiffness, paralysis, missing limbs or digits, etc; or if the respondent reported trouble hearing or seeing (sensory loss). Health-related characteristics were also profiled by a vector of categorical self-reports of chronic disease-health conditions by type. Individuals reporting a disease-health condition (the most recently acquired condition if they reported more than one) were classified into one of three mutually exclusive groups of types of conditions: those having recently experienced falling mortality rates such as ischemic heart disease and stroke; those experiencing rising mortality trends such as cancer and emphysema; or those types of conditions such as emotional problems or drug abuse that are either not necessarily fatal or for which mortality trends cannot be easily characterized as improving or worsening (other). Respondents reporting the absence of any chronic disease-health condition are the omitted or reference group for this vector of health characteristics. These measures provide a means of estimating the net effect of incurring any chronic condition on disablement. They also provide a relatively crude test of whether there is an inverse relation between disability and mortality trends. If improving survivorship adds prevalent cases that have equal or even higher probabilities of disablement, these trends may indeed move in opposite directions; if, however, prevalence either does not rise when mortality rates fall and/or if the disability risk of these prevalent cases also falls, the trends may be positively related.

2b. The explanatory variables also include a set of demographic and socioeconomic characteristics hypothesized to influence the probability of disablement (appendix B, table B1). To control for health risks and health-related behavior, dichotomous variables (equalling one) for smoking history, employment in a heavy industry such as manufacturing and mining with potentially higher levels of exposures to health hazards, and employment in a more physically demanding blue-collar occupation are included. Demographic variables include age (measured continuously in years) and dichotomous measures (equalling one) if the respondent is nonwhite, currently married, or residing in a rural area. Also included is a derived measure of livelihood prospects—the hourly earnings individuals could *expect* to earn given their formal schooling, work experience, job tenure, training, etc. This measure represents a proxy for economic inducements or opportunity costs influencing disability status such as the incentives for high wage earners to sustain functional capacity even in the event of a health problem so as to maintain income; it also represents a proxy for the potential for using medical care to the extent that such utilization and income levels are positively correlated. To facilitate the interpretation of the expected livelihood variable, family income other than the earnings of the respondent in 1977 is also included in the model.

3. The respective effects of these explanatory variables on the probability of reporting a work disability are estimated by maximum likelihood (logistic) techniques. The basic regression model incorporates directly each of the 14 variables described above. Other variants of the model were also prepared, but the results from the basic model were sufficiently robust that these estimates are not reported here (see note 5, appendix A). Regression coefficients are used to compute the parametric effect (partial derivative) of each independent variable on the probability of disablement, controlling for all other variables in the equation at their (subsample) mean values; they are also used to compute the relative risk (risk ratio) of each variable at the (subsample) means of the independent variables (see appendix B).

Table 2 records the estimated net effects and relative risks of the set of disability determinants. As can be seen, impairments in physical and sensory functions raise the likelihood of work disability, all other factors being constant. Men and women with physical losses, for example, were six times more likely to be work disabled in 1978 than individuals who had not incurred such losses. The presence of a chronic disease-health condition also significantly raises the probability of disablement. Given the underlying logistic function, the combination of an impairment and chronic condition, of course, raises the disability risk multiplicatively so that, say, otherwise average women with both

TABLE 2
Disability Determinants by Sex

Determinants[a]	Men		Women	
	Net effect[b]	Relative risk[c]	Net effect[b]	Relative risk[c]
Impairment status				
Physical loss	0.1303**	6.02	0.1210**	5.77
Sensory loss	0.0253*	1.44	0.0668**	2.65
Disease-health condition				
Falling mortality	0.0682**	2.63	0.0801**	3.27
Rising mortality	0.1119**	4.43	0.0673**	2.68
Other	0.1059**	4.17	0.0678**	2.70
Other health-related risks				
History of smoking	0.0038	1.05	0.0088	1.14
Heavy industry	−0.0503**	0.48	−0.0390**	0.54
Blue collar occupation	−0.0228**	0.71	−0.0539**	0.43
Socioeconomic characteristics				
Age	0.0036**	1.05	0.0026**	1.04
Nonwhite	−0.0401**	0.55	0.0077	1.12
Married (spouse present)	−0.0051	0.92	−0.0080	0.88
Rural residence	−0.0203*	0.74	−0.0161	0.78
Livelihood prospects	−0.1623**	0.44	−0.1776**	0.50
Other family income (000)	−0.0009	0.98	−0.0006	0.99

[a] See appendix B.
[b] Partial derivative evaluated at the subsample mean (see appendix B).
[c] Ratio of the probabilities of work disablement at specified values of the independent variable (in most cases, the presence or absence of the characteristic or condition) evaluated at the subsample mean (see appendix B).

** $p \leq .05$
* $p \leq .10$

a physical loss and a chronic (falling mortality) condition are 15.3 times more likely to be disabled than similarly situated women with neither problem. That the net effects do not vary much among the different chronic disease conditions is noteworthy. In classifying these conditions in reference to their associated mortality trends, we anticipated that the risks for conditions enjoying survivorship improvements might be substantially lower than those experiencing rising mortality. But our estimates show that the disability risk for women with a falling mortality condition actually exceeds the other chronic conditions; for men, the risk is lower, but only marginally so. These findings imply that mortality and disability trends may move in opposite directions.

Yet, other factors also contribute to disablement. Age, as expected, exerts a significantly positive effect on disability, with relative risk increasing by about 5 (4) percent each year men (women) grow older. Prospects for earning market income also contribute to disablement, and in the direction predicted by the opportunity-cost argument. Controlling for other characteristics (including family income), a standard deviation increase in expected hourly earnings—roughly one dollar for women and two dollars for men—reduces the risk of disablement by about half. In contrast to some of the earlier literature, we fail to detect the anticipated influence of race, marital status, rural residence, and some employment-related health hazards on work disability. Some of these characteristics have statistically insignificant coefficients. Others—such as occupation, industry, and residence—serve to reduce the chances of being disabled, even though such factors might generally be supposed to increase the risk. The unexpected negative signs on these variables may reflect the fact that current (or most recent) industrial attachment, occupation, or location had to be used in the analysis. Disabled individuals may have worked or lived in such areas in the past, but have made adjustments to their functional limitations by changing jobs or areas. Cross-sectional data, of course, cannot portray that history of mobility very well. The unexpected findings for other demographic characteristics, especially race, may simply mean that such differences found in other studies are attributable to health and socioeconomic differences between whites and blacks that are only detected in a multivariate framework. Notwithstanding these findings to the contrary, there can be little question that socioeconomic characteristics play an equally important role in disablement as health-related factors.

Sources of the Historical Rise in Work-disability Prevalence

If all disability determinants changed over time at identical (percentage) rates, the cross-sectional estimates of the net effects of these variables on the probability of being disabled would, of course, gauge their relative contribution to historical (percentage) changes in disability prevalence. Such uniformity, however, is unlikely. Some factors that, say, substantially raise the (cross-sectional) disability risk may have changed little over time and, accordingly, may be an insignificant source of historical growth in disability rates, and vice versa. In order to help sort out these dynamics, this section first presents estimates of the historical changes in key explanatory variables over the period 1957 to 1982. These changes are again summarized as (continuously compounded) annual average percentage rates corresponding to the estimated overall growth rate in age-adjusted disability prevalence reported in an earlier section. Estimated net effects are then used to weight these growth rates to decompose historical changes in disability prevalence by source. The methods and assumptions used in this accounting are presented in appendix B.

Quantifying historical changes in disability determinants proved to be a difficult and time-consuming task. Growth rates of health-related factors were especially difficult to estimate because of the limited availability of data with comparable population denominators and consistently defined numerator terms for several time points. Data adjustments and the preparation of plausible ranges of values given by alternative data sources were again used as they were in estimating disability growth rates above. The methods can only be briefly sketched here because of space constraints. We illustrate them by describing the computations made for prevalent cases of sensory loss; estimates for other variables were prepared in roughly similar ways (see note 6, appendix A).

To begin with, the sensory-loss variable (like other regressors) combines different types of prevalent cases, viz., hearing and visually impaired persons. The first task was to weight the individual items by their respective prevalences for relevant age-sex groups and then to compute an aggregated or combined rate for the several items comprising the category. Comparable aggregate prevalence rates were prepared for as many time points as available, and annual average percentage rates of change were computed for the various time periods encompassed by these data points. Growth rates computed for any segment of, or interval within, the study period were assumed to apply to the entire period. NHIS estimates for the entire population 18 to 64 years of age were the primary data source for these computations. Unfortunately, such NHIS data were available only for three years

(1964, 1971, and 1977) and the definitions of hearing impairments were not fully comparable across these years. Even when adjustments were made to the data for such differences in definitions as borderline hearing difficulties and tinnitus, substantial variations in computed growth rates resulted. These calculations show, however, that the growth in prevalence rates of sensory impairments was fairly moderate—on the order of 0.8 and 0.1 percent per year for men and women, respectively. NHIS figures for the entire population were then supplemented with NHIS figures referring only to the disabled population for several different time periods, and with SSA figures for the entire population for the years 1972 to 1978. These sources suggested somewhat higher growth rates, viz., about 1.2 percent per year for men and 0.3 percent annually for women. As before, we chose arbitrarily the midpoints of this range, setting the estimated rate of change as 1.00 percent for men and 0.2 percent for women for the entire period 1957 to 1982.

Table 3 (columns 1 and 4) sets out these rates as well as the growth rates of other key explanatory variables estimated by similar computational methods. Note that age is held constant by virtue of the age-adjusted estimate of the rate of change in work-disability prevalence and, accordingly, is omitted from these computations. Because the expected earnings figures and family-income control variables may be interpreted from rather different perspectives, they, too, are omitted. They are treated instead as part of the residual or unaccounted growth, calculated by subtracting the sum of the measured items from the total growth rate in disability prevalence. Estimates for the 11 included variables appear reasonable. But the difficulties illustrated in the case of estimating change rates in sensory-loss prevalence were also encountered in estimating growth rates of most other variables, so the results must be interpreted cautiously. (The reader is, of course, free to substitute alternative values to test the sensitivity of the results to other estimates of these historical rates of change.) As can be seen, my calculations suggest that impairment and chronic-disease prevalence grew over the period, while many of the sociodemographic factors declined. As anticipated, some sex differences are detected in the estimated growth rates of these disability determinants.

Columns 2 and 5 in table 3 set out the "weights" derived from cross-sectional regression results to gauge the extent to which change rates in explanatory variables contributed to the overall growth rate in disability. As appendix B records, each weight is the net effect of a given variable (table 2 above) scaled by the ratio of its prevalence rate to work-disability prevalence; accordingly, a weight multiplied by its respective change rate equals the *percentage points* of disability growth attributable to that variable. Thus, prevalent cases of physical impairment for men contributed 0.391 percentage points or 27.9 percent (0.391/1.40) to the historical rise in work-disability prevalence. Put somewhat differently, the total growth in disablement would have been 0.391 percentage points lower or only 72.1 percent of its observed value had the impaired population remained unchanged. All other weight–growth rate products in table 3 can be interpreted similarly.

The computations in table 3 show convincingly that disability trends do not fully stem from deteriorations in impairment or even health-related conditions. Even though physical and sensory losses are commonly supposed to be the main determinants of disablement, they contribute only about one-quarter of the observed rise in disability prevalence. Chronic disease changes add to that proportion, accounting together for about 60 percent of the historical growth in age-adjusted disability rates for men and approximately 62 percent for women. By implication, more than a third of the change can be attributed to socioeconomic dynamics. Residual factors, presumably reflecting changes in the economic environment, are an important source of change. Perhaps significant in this regard is that demographic trends appear to play only a small role in the work-disability picture. Our computations show, for example, that disability for men would have been even higher had demographic shifts not occurred.

Conclusions

Four conclusions may be drawn from the preceding analysis:

First, work-disability trends appear to be real. Several data sources show age-adjusted rates increasing and, measurement problems aside, agree that the pace of these changes is fairly rapid. Equally important perhaps is that disability correlates are also changing over time in ways consistent with a history of rising disability prevalence. Such convergence in available data constitutes at least prima facie evidence that the rising prevalence of work disability is not simply a statistical artifact. To be sure, some portion of recent increases in disability may stem from improvements in statistical or survey methodology.

TABLE 3
Sources of Historical Growth in Work Disability Prevalence by Sex

Source[a]	Men: Annual average percentage change[b]	Men: Weight[c]	Men: Contribution to work-disability growth rate[d]	Women: Annual average percentage change[b]	Women: Weight[c]	Women: Contribution to work-disability growth rate[d]
Growth of impaired population			0.403			0.456
Physically impaired	1.80%	0.217	0.391	2.30%	0.196	0.451
Sensory impaired	1.00	0.012	0.012	0.20	0.023	0.005
Increases in disease prevalence			0.447			0.716
Falling mortality	2.15	0.099	0.213	3.10	0.122	0.378
Rising mortality	2.25	0.037	0.083	3.27	0.033	0.108
Other conditions	2.70	0.056	0.151	5.00	0.046	0.230

Changes in other risk factors			0.107			0.075
Smoking	−0.90	0.017	−0.015	−0.03	0.028	−0.001
Industrial attachment	−0.72	−0.153	0.110	−1.10	−0.040	0.044
Occupation	−0.19	−0.064	0.012	−0.92	−0.035	0.032
Sociodemographic changes			−0.027			0.043
Racial composition	2.00	−0.030	−0.060	2.10	0.006	0.013
Marital status	−0.32	−0.023	0.007	−0.43	−0.034	0.015
Geographic distribution	−0.69	−0.038	0.026	−0.50	−0.029	0.015
Residual (unaccounted) factors[c]	—	—	0.470	—	—	0.600
Total growth rate in work disability	—	—	1.400	—	—	1.890

[a] See text for definitions.
[b] See appendix B.
[c] See appendix B for mathematical derivation.
[d] Product of average annual percentage change and weight.

Wilson and Drury (1981) argue, for example, that NHIS figures have been inflated by the changeover from the "condition" to the "person" approach in asking disability questions, the gradual increase over time in the proportion of self-reported (versus household respondent-reported) data, and historical improvements in questionnaire format and interviewer quality. The present analysis includes these methodological factors implicitly in the residual growth in prevalence but is unable to quantify how much they directly influenced disability trends. Given the estimated size of the residual and the likely contribution of measured variables such as economic incentives to it, the impact of methodological factors is probably not great, certainly not great enough to conclude that disability growth is solely or even primarily a statistical artifact. Additional research is nonetheless needed to clarify the role of methodological factors in interpreting movements in health-related indices. Future studies should draw more fully on available public-use files, including NHIS data tapes, to provide a more disaggregate and precise estimate of the influence of statistical and survey techniques on disability trends.

Second, growing disability rates do index deteriorating population health status because they are to a substantial extent accounted for by physical-sensory impairments and chronic disease conditions. Our estimates suggest that roughly two-thirds of the measured disability growth is accounted for by the significant relative risk of these factors coupled to their rising prevalence rates. This conclusion depends crucially, of course, on how well the growth in prevalent cases of these health-related conditions and the net effects of these variables on the probability of being disabled were estimated. While chronic-disease figures seem plausible, published data provide only a sketchy and incomplete picture of trends in these variables. Furthermore, these data are also subject to biases akin to those affecting the measured increase in disability rates themselves, e.g., methodological factors associated with refinements in questionnaire format, more accurate medical diagnoses, better access to care, and so forth. Research aimed at improving the profile of chronic-disease characteristics of the adult population should be accorded very high priority. Even though estimates of net effects of chronic conditions proved quite robust to alternative specifications of the disability determinants model, they were assumed in the present analysis to be fixed in time. That assumption must be relaxed in future studies to assess whether health conditions actually exert different degrees of influence on disablement at different points in time. Yet these methodological concerns should not obscure the important substantive implication of these findings that considerable functional incapacitation results from the incurrence of chronic disease. Since prime-age adults who are disabled will, among other things, work less and use more medical care, there are substantial social costs to these trends. Interventions designed to reduce these costs warrant priority consideration.

Third, rising disability may be connected to concomitant reductions in age-adjusted mortality. The analysis shows that the risk of being disabled by chronic conditions in the falling mortality category is roughly equal to the disability risks attributable to other categories of chronic conditions. Since falling mortality rates for a given condition are likely to raise the prevalence of that condition, the disabled pool may remain steady or decline only if the disability risk attributable to that cause also drops. Forecasts of continuing disability growth accordingly hinge on whether cause-specific risks may be expected to remain at their current levels or whether offsetting changes in prevalence, mainly through reductions in disease incidence, will take place. These dynamics are easily illustrated in terms of the predominant condition in the falling mortality category, ischemic heart disease, especially myocardial infarction. Death rates from these causes have been falling steadily for more than a decade. Yet prevalent cases have continued to rise, perhaps as a result of the "salvage" of heart attack victims by improved medical interventions at the time of the attack. The evidence above suggests that the risk of disablement of heart patients is roughly equivalent to other chronic diseases, and is likely to remain so. Consequently, for disability prevalence from heart conditions to fall, incident cases of these conditions must also fall, perhaps as a result of changing lifestyle (risk) factors. Some recent evidence suggests that heart disease incidence has indeed been falling, but apparently not rapidly enough to offset rising prevalence (Pell and Fayerweather 1985). Disability trends attributable to heart disease, therefore, should be expected to rise in the future. This expectation casts some doubt on Fries's (1983) proposition that morbidity is now being "compressed," although it clearly points to the importance of new interventions that help such compression to come about.

Finally, socioeconomic factors also influence disability, with perhaps close to the remaining one-third of the historical rise in prevalence stemming from economic changes. Rising earnings levels should contribute to lower disability growth rates over time. Yet the inverse relation between expected wages and disability risk found above implies that more generous social insurance schemes affording increasingly higher income replacement ratios and, thereby, lower opportunity costs of relinquishing work roles, may also have fueled rising disability trends. To conclude that disability rates would be fully one-third lower in the absence of recent developments in social insurance programs is unwarranted, but potential changes in these programs may modify projected disability trends. One crucial unknown here is the extent to which other kinds of changes in the economy may serve to offset these effects. Our findings that individuals employed in service industries and white collar occupations are more likely to be work-disabled, for example, may actually suggest that the structure of economic activity is becoming more accommodating to the disabled. As the economy becomes even more service-oriented, work-disability trends may begin to level off correspondingly. Another unknown is the role of medical care utilization, which is also reflected by the expected earnings measure used in the regression analysis. The finding that disability risk and expected livelihood are inversely related may imply that prevalence rates will fall as medical-care utilization increases in the future. Since this conjecture was not tested directly in the present study, future analyses should examine in more detail whether increased access to care helps to reverse upward trends in disability.

Appendix A

1. The format of interview questions and the details for some published estimates account for these differences. The following definitions and procedures illustrate the point. NCHS (NHIS) work-disability prevalence has in recent years been obtained by first asking respondents (about themselves or other family members) whether, during the past 12 months, men 17 years and older worked or did something else; whether women 17 years and older worked, kept house, or did something else; or whether individuals 45 years and older who neither worked nor kept house had retired and, if so, whether health was the reason for retiring (National Center for Health Statistics 1975). Those persons

working or keeping house are then asked if they can *now* fulfill those role responsibilities at all or whether they are limited in them because of health. Disability is measured as the percentage of individuals classified as limited/prevented in these major social activities. For men aged 18 to 64 these percentages must primarily reflect limitations in work roles because this demographic group has always had high labor-force participation rates. However, a smaller (albeit rapidly growing) proportion of women performed market work so their prevalence figures do not necessarily represent just work disability. Ideally, market and housework disability would be tabulated separately, permitting the construction of a consistently defined series of work disablement for women. Regrettably, published NHIS estimates for comparably defined major-activity limitations over a long period of time do not allow these categories to be separated. NHIS major-activity-limitation prevalence figures, therefore, tend to provide a biased estimate of female work disability relative to other data sources. The analysis was stratified by sex to offset this measurement bias. Historical comparisons of female prevalence rates in this study necessarily assume that the ratio of work to housework disability is constant in time.

In contrast, SSA survey respondents are not asked in the work-limitation part of the interview about work activity in the reference year but rather are queried first about limitations or complete inability to work; women in early surveys and all respondents in 1978 have an opportunity to respond to questions about both market and home work limitations. Furthermore, additional questions about the onset and duration of the disablement are included to permit classification between "severe" and "occupational" disability; these categories are distinguished from a "secondary" work-limitation category which includes individuals with difficulties in keeping house (Haber 1968; Ferron 1981; Lando, Cutler, and Gamber 1982). When these categories are combined, SSA disability estimates can be compared to NHIS figures; however, disaggregated categories are not comparable. Published SSA survey data, moreover, add a duration criterion (typically, limitations lasting 6 months or more) so that the underlying reference period differs somewhat from NHIS estimates.

The disability definition used in the 1980 census of population is more ambiguous because respondents are asked whether they have had a health problem lasting more than 6 months that limits or prevents work "at a job." Estimated prevalence of work disability for women differs as a result. In the 1970 Census (U.S. Bureau of the Census 1973), roughly similar ambiguities are present, except that duration is not imposed as a condition but asked separately. The disability definitions used in the early SSA–Public Health Service surveys (Woolsey 1952) and more recently by the Bureau of the Census (McNeil 1983) differ in ways likely to overstate prevalence rates. The early SSA-PHS surveys counted individuals as disabled if they were "not able to do regular work or other duties *today* (the survey day) because of illness or disability"; or if they had a "physical or mental condition that allows them to work only occasionally or not at all." The Census Bureau's *Current Population Report* definition is akin to those used in the NHIS and SSA except that it includes some individuals irrespective of their self-report on the work-limitation question, e.g., individuals under 65 years of age who receive SSI benefits or who are covered by Medicare.

2. Population characteristics for 1980 were used as the standard because of data availability and because the cross-sectional regression analysis refers to a period close to 1980. All age-adjusted prevalence rates were computed by summing the products of age-specific rates from the several sources described above and 1980 age-sex population figures. Age-adjusted NHIS prevalences were computed with age-specific rates referring to various years over the period 1957 to 1981 published periodically in NHIS reports, viz., National Center for Health Statistics, *Vital and Health Statistics* series B, number 36; and series 10, numbers 12, 17, 51, 61, 63, 72, 79, 80, 85, 111, 115, 126, 130, 137, 139, and 141. These rates either collapse or, in some early years, prorate responses referring to any major-activity limitation and assume that age-specific rates for persons 17 to 44 years apply without significant bias to the age grouping of 18 to 44 years. Adjusted prevalence for other data sources noted above, however, use age-specific rates according to disability duration (6 months) recorded in, or interpolated from, each source to ensure comparability with the disability definition used in the 1980 census of population.

3. Annual rates of change in adjusted prevalence were estimated principally by fitting semi-log linear time-series regressions of prevalence rates calculated for each year of the study period, including interpolated values for the SSA/Census series. Specifically, letting p represent adjusted prevalence in a given year and t represent time, regressions

of the form $\ln p = a + b(t)$ were estimated. Note that the estimated slope coefficient b is equivalent to the continuously compounded annual rate of change (r) on prevalence between two time points. If t and $t + 1$ represent these points, then $p(t+1) = p(t) \exp(rt)$ or $\ln p(t+1) = \ln p(t) + r(t)$.

4. This survey used a stratified national probability sample of approximately 12,000 nondisabled and disabled Americans to obtain detailed data on family background, work experience, health conditions, attitudes, work limitations, income, job satisfaction, government policies, and disability benefits of each group (Bye and Schechter 1982). About 6,900 persons were identified through the national probability sample of households used in the 1976 National Health Interview Survey (NHIS frame) and a representative sample of about 5,200 disability beneficiaries (SSA frame) were identified from Social Security files. The present analysis relies exclusively on data from the NHIS frame. This frame provides representative data on the general universe of disabled and nondisabled persons between 18 and 64 years of age, including, of course, some who are Social Security beneficiaries. Usable returns for approximately 5,600 sample cases reflect the national probability sampling weights and the stratification of the 1976 NHIS respondents into five disability categories ranging from nondisabled to severely disabled. This classification scheme is based on several items in the 1976 NHIS, including work limitations, chronic conditions, and medical care service use. While weighted proportions yield nationally representative figures, unweighted NHIS frame data include proportionally more individuals reporting that they were limited or prevented from working because of a health problem than estimated national prevalence in 1978. Because we wanted to use unweighted data for the logistic regression analysis, randomly selected subsamples of 2,001 men and 2,320 women were drawn from the available NHIS frame, the proportion work-disabled in each group corresponding to the overall probability of work disability in each group. Comparison of unweighted means of the regression variables for these subsamples and their weighted counterparts from the total available NHIS frame suggests that the random sampling scheme does not bias the general health and socioeconomic characteristics of these sex-specific subsamples. We believe the subsamples used in the regression analysis, therefore, are highly representative of all American men and women aged 18 to 64 in 1978.

5. Several variants of the model were respecified to test for interaction effects between and among the health-related variables and/or for nonlinear (quadratic) age effects. These results did not differ significantly from those presented in the text. The basic model was also reestimated with the chronic disease–health condition vector measured in terms of the condition of longest, rather than shortest, duration to test whether this simplifying assumption influenced the results. It did not.

6. Rates of change in the explanatory variables were estimated from a variety of data sources for various subperiods over the recent past. Changes in racial composition, marital status, and geographical distribution were estimated straightforwardly from census of population data for the period 1960 to 1980. Changes in occupational composition and industrial attachment for the same period were estimated from data from the Bureau of Labor Statistics (U.S. Bureau of Labor Statistics 1980). Changes in smoking prevalence were estimated from published and unpublished NHIS data presented in the 1983 *Statistical Abstract of the United States*.

Estimates of changes in disease prevalence are based principally on NCHS figures, with some supplementary sources for major conditions in each category. Estimates for falling mortality conditions used annual change rates over several subperiods for prevalences of heart-related disease and stroke, ulcer and hernia, endocrine problems/diabetes, and kidney problems weighted by 1978 prevalence. Prevalence rates of heart problems for the entire population from NCHS sources for the period 1958 to 1972 (viz., *Vital and Health Statistics* series B, number 13; series 11, number 10 and series 10, number 94) and for the activity-limited or disabled population for the period 1961 to 1974 (viz., *Vital and Health Statistics* series 10, numbers 17, 51, 80 111) were used. These figures were supplemented with prevalence changes for the entire population between 1972 and 1978 derived from SSA survey data (Ferron 1981; Lando, Cutler, and Gamber 1982) and more detailed trend data over the postwar period on the disease in special studies (e.g., Pell and Fayerweather 1985). Annual change rates in digestive system disorders were estimated from NHIS figures for the period 1968 to 1975 for the entire population and for the activity-limited population for 1961 to 1974 (*Vital and Health Statistics* series 10, numbers 17, 83, 111, 123). Changes in the remainder of the conditions included in this category were estimated from the SSA survey data and the activity-limited NHIS population noted above.

Procedures for estimating rising mortality diseases follow similar lines: rates of change in the prevalence of chronic bronchitis and asthma, gallbladder disease, liver disease, and neoplastic diseases were first estimated and then a weighted rate based on 1978 prevalence distributions was prepared. NHIS chronic bronchitis and asthma figures were compared for the entire population for the period 1957 to 1970 (*Vital and Health Statistics* series B, number 12 and series 10, number 84); for the NHIS activity-limited population noted above for the period 1961 to 1974; and for SSA survey respondents noted above for the period 1972 to 1978. Gallbladder and liver problem prevalence rates were measured over the period 1968 to 1975 (*Vital and Health Statistics* series 10, numbers 83, 123). Prevalence change rates for neoplastic diseases were computed for the entire population from 1972 to 1978 SSA data and for the NHIS activity-limited population for the period 1961 to 1974, cited above. Changes in the "other" category relied primarily on mental-neurological conditions reported in the SSA surveys (all other prevalence assumed to be constant) as well as mental and nervous conditions reported for NHIS disabled populations in the period 1961 to 1974 (*Vital and Health Statistics* series 10, numbers 17, 51, 80, 111). This residual category was, of course, the most difficult to estimate and, thereby, the most likely to have biased estimates of the annual rate of change in prevalence.

Sensory changes, as described in the text, use weighted visual and hearing impairment prevalences. These computations rely primarily on prevalence for the entire population over the period 1964 to 1977 (*Vital and Health Statistics* series 10, numbers 46, 48, 99, 101, 134, 140) supplemented by NCHS examination data (*Vital and Health Statistics* series 11, numbers 32, 215) and prevalence of the impairments reported for the NHIS disabled population cited above. Estimated changes in prevalence of physical losses are weighted by rates of arthritis and rheumatism, paralysis and nonparalytic impairments such as loss of extremities and digits, osteomyelitis and other bone diseases, synovitis, gout, and related impairments. Changes in arthritis-rheumatism and the other categories are based primarily on the period 1969 to 1976 while changes in paralytic and nonparalytic impairment of back and spine and loss of extremities, etc., is traced over the period 1963 to 1977 (*Vital and Health Statistics* series 10, numbers 48, 92, 99, 124, 134). These figures were supplemented by SSA survey data (cited above) for the period 1972 to 1978, and NHIS data on the activity-limited population over the period 1961 to 1974 for various impairments and arthritis-rheumatism.

Appendix B

Calculations Using Regression Estimates

The work disability regression model, estimated for sex-stratified subsamples, takes the following logistic form:

$$p_x = 1/1 + \exp -(\Sigma_i \beta_i x_i + \beta_o) \quad (1)$$

where p_x = prob(work disability = 1 | X),
x_i = the i^{th} independent variable (i = 1,2,...,14),
and β_i = the i^{th} maximum likelihood coefficient
and β_o the intercept to be estimated. (The β_o is hereafter suppressed to simplify the notation).

The estimated coefficients, statistics distributed as chi-square with one degree of freedom testing the hypothesis that the respective coefficient is zero, means, and variable definitions are given in table B.1.

The net effect or partial derivative of each independent variable is evaluated at the subsample means of the regressors ($\bar{x}_i$),

$$\frac{\partial p_x}{\partial x_i} = f_i = \hat{\beta}_i \left[\frac{\exp (\Sigma_i \hat{\beta}_i \bar{x}_i)}{(1 + \exp (\Sigma_i \hat{\beta}_i \bar{x}_i))^2} \right] \quad (2)$$

Relative risk (RR) is evaluated for each independent variable at alternative values of that variable and the means of the remaining regressors, including the intercept. For dichotomous variables, the alternative values are simply the presence and absence of the condition, so that

$$RR_i = \exp(\hat{\beta}_i) \left[\frac{1 + \exp(\Sigma_j \hat{\beta}_j \bar{x}_j)}{1 + \exp(\hat{\beta}_i + \Sigma_j \hat{\beta}_j \bar{x}_j)} \right] \quad (3)$$

where *i* denotes the explanatory variable in question and *j* indexes the remainder of the regressor set. The continuously measured variables are evaluated at two specific values of the variable. For age, (subsample) mean age and mean age plus one year are used; for wage and income variables, the (subsample) mean and mean plus one standard deviation are used.

Decomposing the annual average growth rate in work disability begins by writing the total differential of equation (1) and differentiating it completely with respect to time (t), viz.,

$$\frac{dp_x}{dt} = \sum_i f_i \frac{dx_i}{dt} \qquad (i = 1,2,\ldots 14) \tag{4}$$

The calculations assume that each of the variables is an exponential function of time. Letting subscripts (t) and (0) represent terminal and base year time periods,

$$p_{x(t)} = p_{x(0)} \exp(r^*t) \tag{5a}$$

and

$$x_{i(t)} = x_{i(0)} \exp(r_i t) \tag{5b}$$

so

$$\begin{aligned} \frac{dp_x}{dt} &= r^* p_{x(0)} \exp(r^*t) \\ &= r^* p_{x(t)} \end{aligned} \tag{5c}$$

and

$$\begin{aligned} \frac{dx_i}{dt} &= r_i x_{i(0)} \exp(r_i t) \\ &= r_i \, x_{i(t)} \end{aligned} \tag{5d}$$

Equation (4) may now be written:

$$r^* p_{x(t)} = \Sigma_i f_i r_i x_{i(t)} \tag{6}$$

Both sides are divided by $p_{x(t)}$ to obtain the proportional growth rate:

$$r^* = \Sigma_i f_i r_i x_{i(t)} / p_{x(t)} \tag{6a}$$

In table 3, the value of $(f_i x_{i(t)} / p_{x(t)})$ of 6a is labelled "weight" and multiplied to its respective r_i in accounting for the contribution of each variable to the total growth rate, r^*.

TABLE B1
Estimated Coefficients, Test Statistics and Means of Logistic Regression Variables by Subsample

	Men			Women		
Variables	Coefficient	Chi-square	Mean	Coefficient	Chi-square	Mean
Physical impairment[a]	2.0392	153.28	0.2624	1.9784	169.40	0.2552
Sensory impairment[b]	0.3965	2.69	0.0740	1.0927	18.00	0.0543
Falling mortality disease[c]	1.0679	32.41	0.2279	1.3089	52.89	0.2388
Rising mortality disease[c]	1.7510	37.54	0.0525	1.1002	19.13	0.0772
Other disease[c]	1.6568	45.29	0.0830	1.1078	22.46	0.1069
Smoking history[d]	0.0592	0.10	0.6972	0.1441	0.96	0.4931
Heavy industry[e]	−0.7876	19.96	0.4783	−0.6371	5.16	0.1625
Blue collar occupation[f]	−0.3570	4.16	0.4398	−0.8816	7.14	0.1013
Age[g]	0.0565	64.28	39.96	0.0418	47.66	38.92
Nonwhite[h]	−0.6272	5.75	0.1184	0.1251	0.33	0.1280
Married[i]	−0.0794	0.14	0.7086	−0.1302	0.52	0.6595
Rural residence[j]	−0.3174	3.07	0.2979	−0.2636	2.48	0.2862
Expected (ln) livelihood[k]	−2.5395	56.76	6.3104	−2.9038	58.38	5.8424
Other family income (000)[l]	−0.0144	2.01	7.1530	0.0118	1.92	13.3617
Intercept	10.9388	29.41	—	11.9991	30.55	—
Model chi-square	—	670.17	—	—	780.37	—
N	—	—	2,001	—	—	2,320

[a] Dummy variable taking the value of one if the respondent reported one or more of the following conditions: arthritis, rheumatism, amputation of any limb or digit, paralysis, chronic pain or stiffness in limbs or back, back or disc trouble, muscular dystrophies or palsies, accidents or injuries; zero otherwise.

[b] Dummy variable taking the value of one if the respondent reported one or more of the following conditions: deafness, blindness or cataract/ other visual difficulties; zero otherwise.

[c] A vector of dummy variables taking the value of one if the respondent's most recently acquired disease or health condition was categorized in one (but only one) of the following three mutually exclusive categories: falling mortality, rising mortality or other; respondents reporting the absence of any disease or health condition are the omitted reference group for this dummy vector. Respondents were able to report more than 27 specific conditions or illnesses exclusive of physical and sensory loss that a doctor told them they had in 1978; many reported multiple conditions. Durations of conditions were used to choose one condition to be categorized for the disease-health vector, viz., the condition with the shortest duration. Conditions of respondents classified as falling mortality were part of ICD groupings that experienced some decline in age-adjusted mortality in the United States over the recent past. Included are tuberculosis, arteriosclerosis, hypertensive disease, ischemic heart disease, stroke, stomach ulcer and other chronic stomach trouble, chronic kidney disease and diabetes, hernia, bladder, prostate or genitourinary problems. Conditions classified as *rising mortality* include chronic bronchitis, emphysema, asthma, any chronic lung trouble, cancer and other neoplasms, and chronic gallbladder and liver troubles. The residual third category (other) is comprised of conditions for which mortality trends are either ambiguous or irrelevant; included are mental illness, nervous or emotional problems, mental retardation or deficiency, alcohol or drug problems, epilepsy, allergy, anemia, lupus, varicose veins, hemorrhoids, chronic skin problems, colitis, ileitis, gout, and birth defects.

[d] Dummy variable taking the value of one if the respondent reported having smoked at least 100 cigarettes in his or her lifetime; zero otherwise.

[e] Dummy variable taking the value of one if the respondent's current or most recent job was in agriculture, mining, construction, manufacturing, transportation, communication, or public utilities; zero otherwise.

[f] Dummy variable taking the value of one if the respondent currently or most recently worked as a craftsman, operative or nonfarm laborer; zero otherwise.

[g] Respondent's age in 1978 measured continuously in years.

[h] Race dummy taking the value of one if the respondent is nonwhite; zero otherwise.

[i] Marital status variable taking the value of one if the respondent is married, spouse present; zero otherwise.

[j] Location variable taking the value of one if the respondent resided in a rural area in 1978; zero otherwise.

[k] This variable is constructed in two steps: First, the natural logarithm of hourly earnings, reported for 1977 by male or female respondents who worked during that year, was regressed by ordinary least squares against a (sex-stratified) vector of human capital characteristics likely to explain wage variation among working men or women. The vector of regressors included formal schooling completed, job tenure, job training, work experience, union membership, marital status, rural residence, race, and reported number of health conditions. Second, respondent values on each of the wage regressor variables are weighted by their respective vector of estimated (OLS) regression coefficients to compute expected (ln) hourly earnings for each respondent in each sex-stratified study population. These expected values are then used in the disability-status equations.

[l] A continuous dollar measure of all income available to the household in 1977, net of the respondent's labor market earnings.

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Acknowledgments: This study was completed while I was Professor of Preventive Medicine at Ohio State University. I wish to acknowledge the superb programming assistance of Jennie Nickel and John Paulson and the programming advice of Jill Williams of the Department of Preventive Medicine as well as the provision of computer time by the OSU Instruction and Research Computer Center. I also wish to acknowledge Carol Dowdell and Vickie Hundley for support services and J. McNeil of the U.S. Bureau of the Census for making some tabulations of work-disability prevalence from the 1980 census of population available to me. Without implicating him in the aims or results of the present study, I thank my colleague Gilbert Nestel for earlier helpful discussions on the topic of work-disability determinants.

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