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ABSTRACT

The interrelationship between the health status and work activity of older men plays a central role in at least three current controversies about the direction of public policy: whether the average health levels of older men have deteriorated, remained the same, or improved over the past 25 years; whether retirement status influences health status; and whether recent improvements in mortality have selectively favored individuals at higher risk of disablement, thereby contributing to pre- and post-retirement health trends. Data from the National Longitudinal Survey Panel of Older Men covering the period from 1966 to 1981 were subjected to a Markovian analysis to cast further light on these policy issues. The results suggest that health levels of older men have deteriorated over the past two decades, partly as a consequence of improvements in life expectancy. These health trends have contributed to the observed decline in labor force particip_tion of this population subgroup. Little evidence was found, however, to support the claim that retirement harms health status. (MN)

HEALTH STATUS AND WORK ACTIVITY OF OLDER MEN: EVENTS-HISTORY ANALYSES OF SELECTED SOCIAL POLICY ISSUES

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ABSTRACT

The interrelationship between the health status and work activity of older men plays a central role in at least three current controversies about the direction of public policy. Whether the average health levels of older men have deteriorated, improved or remained roughly constant over the past 25 years and the extent to which below-average health leads to involuntary withdrawals from work are key considerations in appraising the effects of growing public transfers on the dramatic post-war decline in male labor force participation rates. Whether health levels of older men who retire from market work deteriorate as a result of the retirement is also a subject of controversy bearing on the evaluation of policies shaping early retirement trends. Whether recent improvements in mortality have selectively favored individuals at higher risk of disablement and thus contributed to pre- and post-retirement health trends is increasingly subject to debate as well.

In this paper, the interrelationship between health status and work activity in the National Longitudinal Survey (NLS) panel of Older Men is analyzed to cast further light on these controversies. A continuous-time, Markov model of health-related events encompassing death and disability states is constructed based on the longitudinal record of activity limitations and mortality experience of the NLS panel over the period 1966-1981. Several variants of the model are estimated for various subsamples of the panel, each emphasizing one of the three policy issues noted above.

The results suggest that health levels of older men have deteriorated over the past two decades, partly as a consequence of improvements in life expectancy. These health trends have contributed to the observed decline in labor force participation of this population subgroup. Little evidence is found, however, for the claim that retirement harms health status.

I. INTRODUCTION

The interrelationship between the health status and work activity of older men plays a central role in at least three current controversies about the direction or scope of public policy:

1. Whether the average health levels of older men have deteriorated, improved or remained roughly constant over the past 25 years and the extent to which below-average health leads to involuntary withdrawals from work are key considerations in appraising the effects of growing public transfers on the dramatic post-war decline in male labor force participation rates. Studies conducted over the past decade have concluded that inducements arising from social insurance and private pension plans are the primary cause of the declining labor supply of older men.[1] However, some of these studies have omitted health variables altogether from their statistical analyses and others have only used weak measures as control variables that probably bias health effects toward zero.[2] More important perhaps is that most of these studies use cross-sectional designs so inferences about the influence of poor health on involuntary withdrawals from work involve not only measured health effects at a point in time but also the extent to which average health has changed over time. Haveman and Wolfe's "replication" of Parsons' analysis disputing the magnitude of policy inducement effects on labor market withdrawal illustrates this point.[3] Haveman and Wolfe use a disability measure to control for health differences. Activity limitation or disability rates have historically risen at a rapid pace, so even marginal cross-sectional effects of disability on reduced labor supply are magnified greatly when the historical effect of health on nonparticipation is considered. In contrast, Parsons uses a mortality-related proxy to

control for health differences; mortality rates have declined over time, so health effects, even if they are substantial cross-sectionally, are minimized over time. Not surprisingly, the differences in estimated health effects between the two analyses and inferences about historical trends in labor force participation drawn from them are greatly confounded. These differences help rekindle the long standing controversy about the respective roles of health and pension factors in early retirement trends. Additional studies of the influence of health levels on work activity of older men, preferably using longitudinal data, thus appear warranted.

2. Whether health levels of older men who retire from market work deteriorate as a result of the retirement has also been the subject of considerable controversy. Some studies detect substantial retirement effects on health levels. Given the enormous increase in the number of retired persons in the recent past, the finding suggests either needed changes in policies that shape retirement patterns and/or needed interventions designed to improve adaptation to nonwork and the stress associated with anticipating this major "life event."[4] However, other studies such as a recent prospective investigation of participants in the VA Normative Aging project fail to detect adverse health consequences, and a few reports in the literature even conclude that the average health of retirees improves.[5] The recent review of this literature by Minkler[6] argues convincingly, however, that many of these studies are flawed methodologically. A critical concern is whether adequate measures for pre-retirement health status or post-retirement changes in such status are available and whether they can be interpreted unambiguously. A related concern is whether suitable controls for factors likely to moderate or

cushion the health effects of retirement are taken into account. Of special interest in this regard are recent reports by epidemiologists that social support networks influence (and hence confound) the relationship between the diminution of work activity and subsequent health status.[7] Additional analysis of the determinants of post-retirement health is thus also warranted.

3. Whether mortality and disability-morbidity trends are inversely related and, correspondingly, whether declining death rates raise the number of disabled individuals needing medical care and social services support is the subject of current debate in the health/medical literature.[8] Fries, for example, argues that in an age of fixed life spans and increasingly prevalent chronic disease, morbidity is being "compressed" and the need for many types of (acute) medical care interventions is accordingly being reduced.[9] Others dispute this claim, arguing that additional resources must be allocated to health and medical care services to satisfy the needs of a rapidly aging population.[10] This controversy may not seem highly relevant to the link between health and work unless one considers that disablement is most frequently gauged by the individual's ability to carry out major social roles and that the major role responsibility of adult men is to engage in market work.[11] If mortality improvements selectively favor those at higher risk of such disability, some portion of the observed historical decline in labor force participation rates may be attributable to improved life expectancy. Among others, Shepard and Zeckhauser (1980) theorize that the likelihood of such selectivity is high, although no estimate of its magnitude in the case of labor force participation trends has been prepared. Once selectivity factors in the relationship between mortality and disability

are admitted, new questions arise about the measured influence of other labor force determinants. For instance, do human capital characteristics such as formal schooling mediate the likelihood of disability and death differently and do the returns to such human capital investments differ when biases attributable to selective survival are included in the analysis? Additional analyses of the health and work interrelationship of men in a longitudinal framework incorporating morbidity and mortality outcomes and controlling for human capital differences are thus needed.

In this paper, the interrelationship between health status and work activity in the National Longitudinal Survey (NLS) panel of older men is analyzed to cast additional light on each of these policy controversies. A continuous-time, Markov model of health-related events encompassing death and functional disabilty or capability states is constructed based on the longitudinal record of activity (work) limitations and mortality experience of the NLS panel over the period 1966-1981. This model links the (instantaneous) probabilities of moving between (and among) these disability and death states to a set of baseline and time-varying characteristics of respondents, adjusted for censored observations attributable to uncompleted spells of functional capacity or incapacity, death or other loss to follow-up. Estimated parameters of the model are used to compute transitional probabilities between, and duration of stay in, health-related states associated with any specific set of these characteristics. Several variants of the model are estimated for various subsamples of the NLS panel, each emphasizing or isolating one of the three policy controversies noted above. One variant tests for the effects of pension eligibility, opportunity costs of time and physical-psychological impairments on subsequent history of disability in that portion of the NLS sample employed as wage and salary workers in 1966 to see the degree to which disability trends reflect deteriorating health status. The second tests for the effects of retirement status and of social (family) support mechanisms on subsequent health history of working men who had not retired prior to 1971 to see whether retirement has a deleterious effect on health. Other variants of the model test for the influence of human capital characteristics, especially schooling, on subsequent health history for the NLS panel as well as testing for the effects for different age cohorts and race subgroups of the entire panel.

The paper is organized as follows. Section II summarizes recent historical trends in various health status measures and mortality of older men. Key health indicators used later in the construction of the health-events model are emphasized in the discussion. Section III sets out the main characteristics of this model, including a description of all of the variables used in the statistical analysis. Sections IV-VI present the results of the several variants of the model testing for policy, retirement and human capital/cohort effects in turn. Section VII summarizes the empirical findings and discusses their implications for social policy.

II. HEALTH LEVELS OF OLDER MEN

Macro Trends

Figure 1 depicts trends in health-related characteristics of men 45 years of age and older over the past quarter-century in the United States. Age-specific mortality rates (from all causes) for men 45-64 years of age and 65 and older adjusted for changes in the age distribution within each category were calculated from Vital Statistics data.[12] Age-specific disability rates refer to the proportion of men in each age category reporting in the National Health Interview Survey that they are limited in major activities (or

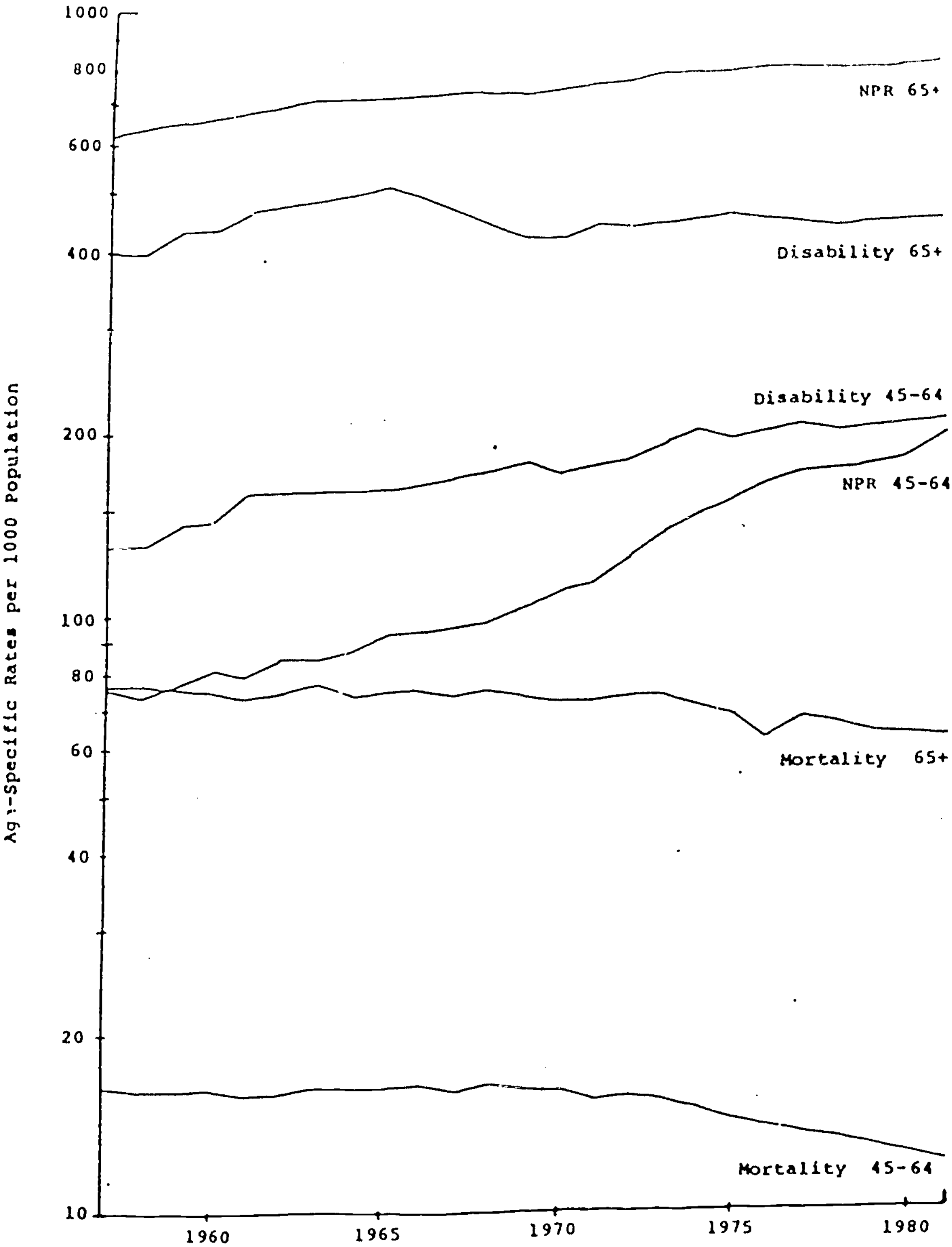

Figure 1. Age-Specific Mortality, Disability and Labor Force Nonparticipation (NPR) Rates for Men 45-64 Years of Age and 65 Years and Older, United States, 1957-1961.

SOURCE: See text.

prevented from performing major activities at all) because of a chronic health problem.[13] Age-specific participation rates refer to the percentage of men in each age category classified in the Current Population Survey as out of the labor force.[14]

As can be seen, each of these series has changed at a reasonably fast pace over the period for each age category. In the case of men over 65 years of age, mortality rates fell at almost one percent per year, from about 76 to 62 per 1000 men. Disability rates of men over 65 fluctuated during this period, but grew on average at about 0.5 percent per year, viz., from 397 to 447 per 1000. Nonparticipation in the labor force for these men also grew at one percent per annum, from 625 per 1000 in 1957 to about 815 in 1981. The changes for men 45-64 are dramatically greater. Mortality rates for this group fell at more than one percent per year from 16 to 12 per 1000 over the period; the pace was even more rapid over the decade of the seventies. In contrast, disability rates rose from about 130 to 210 per 1000 or roughly 1.9 percent per annum. Since these estimates are not adjusted for the change in the age distribution within the age category, some portion of this increase can be attributed to the growth of the oldest men in the category. Even with such adjustments, however, the overall increase in disability prevalence would doubtless continue to be high. The widely discussed change in nonparticipation of men 45-64 is reflected in the steep rise in the NPR curve, particularly during the 1970's. Overall, the nonparticipation rate for these men increased at 3.9 percent per year over the period 1957-1981.

The extent to which there are connections between and among these historical trends is of central importance in the present paper. Visual inspection of Figure 1 suggests several interesting interrelationships in this regard. In the case of men over 65, for instance, nonparticipation rates increased steadily in the face of both fluctuating disability rates and mortality rates that were first steady and then declining. The degree to which poor health contributes to work withdrawal and/or the degree to which retirement causes adverse health consequences is thus not transparent in these trends, even though activity limitation measures have been used to proxy health status as both independent and dependent variables in the health-retirement literature.[15] In this respect, the link between disability and nonparticipation for men 45-64 is also noteworthy because the rise in disability prevalence is not only steadier but predates the dramatic increase in nonparticipation by a decade. This pattern fails to support not only the literature showing significant health effects on early retirement but also the results of recent (cross-sectional) studies concluding that labor force nonparticipation and such health "declarations" are simultaneously determined.[16] More striking perhaps is the timing of the upturn in nonparticipation of men 45-64 and the more rapid decline in their age-specific mortality rates. As with the other patterns in these data, however, it is difficult to conclude that these changes are necessarily correlated.

The interrelationships among the trends portrayed in Figure 1 might be more apparent if it were possible to superimpose concurrent trends in medically-relevant health conditions and indicators of choice (preference orderings) influencing the behavioral sequelae of those conditions. To illustrate substantively, the observed decline in all-cause mortality, particularly of men 45-64 years, stems to a considerable degree from the declining number of deaths attributable to ischemic heart disease--the major killer of men in this age group. There is presently some controversy in the medical literature about the factors that have contributed to this decline, including the issue of whether the incidence of ischemic disease has also been declining.[17] Unless the entire decline in mortality is attributable to a decline in incidence, prevalence must have increased as the average duration of cases lengthened. Prevalent cases of ischemic heart disease are quite likely to suffer shortness of breath, locomotor difficulties, etc. and thus be at risk of limitations in social role activities, including withdrawal from the work force. However, there is a large medical-epidemiologic literature suggesting that socioeconomic variables mediate this risk and, correspondingly, that variations in disability behavior cannot be explained fully by differences in underlying disease.[18] For example, a recent study suggests that the opportunity cost of time is inversely related to the probability that ischemic patients will be functionally disabled.[19] Disability and mortality trends shown in Figure 1 might be more easily interpreted if these underlying trends in incidence, prevalence and risk factors were also mapped.

Unfortunately, aggregate data on specific disease conditions and factors influencing behavioral consequences of disease are either unavailable or insufficiently detailed to allow us to analyze the linkage between disability, mortality and work. Even for major cases such as heart disease, reasonably detailed estimates of incidence and duration are missing. Prevalence data available, say, through the National Interview Survey refer only to individuals who previously reported limitations in role responsibility.[20] Furthermore, detailed correlates of such health problems (including work/retirement status) are not available in this data set. More generally, sufficiently detailed aggregate information needed to further our understanding of the interrelationships among national trends depicted in Figure 1 are unavailable. They can be analyzed effectively only by drawing on relevant micro-data sets of representative samples of older Americans.

Micro Dynamics: NLS Older Men

The NLS panel data on Older Men is clearly a valuable resource for more detailed study of the interrelated trends in health and work. Because the Survey of this cohort originally encompassed approximately 5000 men who were 45-59 years of age in 1966, a substantial proportion of them have withdrawn from market work or are otherwise categorized as retired over the past 18 years. By the tenth follow-up survey conducted in 1981, for example, substantially more than two-thirds of the interviewees could be categorized as retired. Health factors leading to these withdrawals or stemming from them can thus be analyzed. The panel has been reduced in size because of losses due to death, which is of course hardly unexpected in view of the ages of the initial cohort. About 15 percent of the 3518 whites and 22 percent of the 1420 blacks interviewed in 1966 died between 1966 and 1976; between 1976 and 1981, about 12 and 17 percent of the white and black men interviewed in 1976 had died. Even though the causes of these deaths are not known, the survey year when the death is first reported is known so that duration of survivorship for individuals with given health and socioeconomic characteristics at an earlier date can be analyzed in detail. Equally important perhaps is that ten NLS follow-ups have included questions on self-reported work limitations (whether the respondent was limited by a health or physical condition in the amount or kind of work he could do and, if so, whether he was prevented from working at all). These questions are virtually identical in format to those posed in the National Health Interview Survey, except that the NLS format does not include additional questions on the "chronic" conditions that are the primary cause(s) of the limitation. Prevalent cases are nonetheless identified in exactly the same form and are thus comparable to the macro disability data presented in the preceeding subsection. It is worth noting in this regard that age-specific prevalence rates for respondents interviewed in both 1976 and 1981 were roughly identical percentages to those observed in the macro data described above.

Although chronic medical conditions are not obtained in the NLS, three follow-ups have included a detailed battery of questions on physical and mental capacities that can be interpreted generally as the residual (chronic) effects of various organ-level pathologies or departures from normal physiological and psychological functioning. These capacities include the ability to walk, use stairs, stand, sit, stoop, lift heavy and light weights, handle, reach, see, hear, and deal with people by degree of severity. They also include whether men experience signs and symptoms such as shortness of breath, pain, tiring easily, aches, fainting spells, anxiety, or weakness. It is possible to use these "impairment" measures to gauge the underlying health or disease conditions influencing disability and mortality outcomes of NLS respondents. Since we have previously examined the level and changes of these items separately and in summary index form for the period 1971-1976, we focus in the remainder of this subsection on the impairment characteristics of NLS respondents for the period 1976-1981.[21] This descriptive analysis provides considerable evidence that impairment status changes over time and that these changes influence the behavioral consequences of disease.

To begin with, prevalence rates for these impairments are fairly high for men in this age group and rise rapidly as they grow older. To simplify the exposition, a subset of the 19 NLS impairment items selected in reference to the <u>International Classification of Impairment, Disabilities and Handicaps</u> for their representativeness and importance in understanding the consequences of disease are discussed.[22] Table 1 presents the prevalence rates for these thus comparable to the macro disability data presented in the preceeding subsection. It is worth noting in this regard that age-specific prevalence rates for respondents interviewed in both 1976 and 1981 were roughly identical percentages to those observed in the macro data described above.

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Table 1. Prevalence, Restoration and Incidence of Selected Impairments, NLS Survivor's Panel by Race, 1976-1981

Impairment[a]	Prevalence 1976		Restoration[b]		Incidence[c]		Prevalence 1981	
	White (%)	Black (%)	White (%)	Black (%)	White (%)	Black (%)	White (%)	Black (%)
Ambulation	16.8	25.8	5.7	7.2	13.2	17.1	24.3	35.7
Locomotor	8.1	15.8	3.7	8.1	8.5	14.7	12.9	22.4
Body Movement	10.4	13.1	6.7	7.3	7.5	11.9	11.2	17.7
Manual Activity	7.7	11.7	4.3	7.1	6.1	10.9	9.5	15.5
Sight	9.5	16.4	5.6	8.3	8.6	13.7	12.5	21.8

a. See text for definition.
b. Percentage of panel reporting impairment in 1976 but not in 1981.
c. Percentage of panel reporting impairment in 1981 but not in 1976.

selected items. The rates are calculated for 2014 white and 746 black men who were interviewed in 1976 and 1981 (labelled the survivors panel). As can be seen in the first two columns of Table 1, a substantial percentage of these men reported difficulty in performing (including the complete incapacity to perform) ambulatory, locomotor, body movement and manual activity functions, with the rates generally being a third higher for blacks than for whites. Equally high proportions of these men have sight or visual communication problems. In all cases, the prevalence rates for impairment rise with age so that each impairment item is higher in 1981 than in 1976. It is noteworthy that more than a third of the blacks and a quarter of the whites had some difficulty in ambulatory function.

The general rise in prevalence with age, however, is only the net effect of a set of highly dynamic changes in incidence and restoration of impaired function over time. To gauge these changes, two dummy variables were created by comparing responses to these items by members of the survivors panel between 1976 and 1981, viz, whether respondents reporting an impairment in 1976 also reported a similar problem in 1981 and whether respondents reporting an item in 1981 reported that condition in 1976. We refer arbitrarily to the first type of change as restoration of impaired capacity and the second type as the incidence of new impairments. The middle columns in Table 1 show that a considerable number of such changes occurred over the period. Specifically, the columns show that large percentages of initially impaired men experienced restored function, that the incidence of new impairments were greater than the differences in 1976 and 1981 prevalence rates and, by implication, that the duration of these problems average less than 5 years. Note that restoration rates as a percent of 1976 prevalence rates are quite high, and marginally higher for whites than blacks. They imply that duration of these items is on the order of 30 months. Such durations may be growing shorter because of increased access to medical care. Men also acquired new problems over the period. Judged against the proportion nonimpaired in given items in 1976, incidence rates of these functional difficulties range from about 9 percent for locomotor to 16 percent for ambulation.

The unexpectedly high rates of change in impairment observed over this five-year period suggest the possibility that the findings are artifactual. We turn briefly in Tables 2 and 3 to analyses of the relationships between restoration and incidence of selected impairments and several health/handicap outcomes available from the 1981 follow-up to appraise whether this explanation can be rejected. All outcome measures are dichotomous, measuring the ability to perform normal role functions (disabled in normal role activities by a health or physical condition), mobility (ability to go outside without help from another person), personal care (help needed in looking after such functions as dressing, bathing, eating, or other activites of daily living, ADL) and retrospective health appraisal (health improved versus other appraisals or deteriorated versus other appraisals over the past five years).[23] The dichotomous variables characterizing either the acquisition or recovery of impaired functions are cross-classified against these dichotomous outcome measures. The result is a set of 2x2 tables for each impairment item, outcome and race combination. Odds ratios are then calculated to test whether antecedent restorations in function lead to more favorable outcomes or whether incurring a new problem leads to less favorable ones. Since age can confound this relationship, we stratify the sample into three age subgroups in 1981: 60-64, 65-69 and 70-74 years. Methods developed by Mantel and Haenszel are then applied to test for possible interaction effects of age in the impairment-handicap association, with significant differences labelled age effects.[24]

Table 2 presents odds ratios that unfavorable outcomes (disabled, health worse, travel restricted or ADL help needed) are reported when a specific

Table 2. Odds Ratios[a] that Men Incurring Impairments Report Unfavorable Health-Related Outcomes by Type and Race

Impairment[b]	Disabled[b]		Health Worse[b]		Travel Restricted[b]		ADL Help[b]	
	White	Black	White	Black	White	Black	White	Black
Ambulation	8.2**#	8.8**	5.8**#	5.5**	c	7.7*	15.2**#	17.3**
Locomotor	20.5**	17.4**	4.2**	6.2**	33.3**	12.5**	7.3**#	9.8**
Body Movement	14.8**	7.4**	4.6**	4.6**	8.3*	9.1**	7.4**	6.0**
Manual Activity	7.5**	7.4**	3.3*	3.6**	4.3*	11.1**	8.1**#	7.7**
Sight	6.7**	5.7**#	3.7**	5.6**	7.3	8.3**	6.1**#	4.5*

a. Mantel - Haenszel statistics for age strata-specific odds ratios. See text.
b. See text for definition.
c. Only incident cases reported this outcome.
** = $p \leq .001$; * = $p \leq .10$; # = age effects, $p \leq .10$.

Table 3. Odds Ratios[a] that Men Restoring Impaired Functions Report Favorable Health Outcomes by Type and Race

Impairment[b]	Functional[b]		Health Better[b]		Travel Freely[b]		ADL Unassisted[b]	
	White	Black	White	Black	White	Black	White	Black
Ambulation	9.1**	9.1**	2.8*	0.3	8.4**	7.6*	4.0**	2.6*
Locomotor	c	4.3	3.1*	0.9	9.5**	11.8**	1.6	3.3**
Body Movement	c	c	2.4	1.0	5.2**	2.1	3.3**	2.4
Manual Activity	7.7**	2.9	c	0.9	5.3**	3.0	4.0**	1.4
Sight	2.4*	2.9**#	0.5	5.3	3.4	2.8	1.0	2.0

a. Mantel - Haenszel statistics for age strata - specific odds ratios. See text.
b. See text for definition.
c. Only restored cases reported this outcome.
** = $p \leq .05$; * = $p \leq .10$; # = age effects, $p \leq .10$.

impairment is incurred. As can be seen, these ratios are in most instances significantly greater than one at conventional confidence levels, suggesting that deteriorations in physical capacity are accompanied by changes in disability status and other functional handicaps. The similarity in magnitude of these ratios between whites and blacks, especially given the race differential in prevalence, is noteworthy. That there appear to be no interaction effects of age and impairment on those outcomes is also noteworthy. Table 3 shows that restored functional capacity in men impaired at the beginning of the period has the anticipated effect on reports of more favorable outcomes. While these effects are not generally as large or statistically significant as those detected in the analyses of incidence, the results seem encouraging enough to suggest that changes in Table 1 are not artifactual and, thereby, that dynamic intertemporal changes in impairments must be accounted for in any explanation of trends in disability and work. In interpreting these results, it is worth recalling that the comparison is between the odds of reporting a more favorable overall improvement in health on handicap status when only one previously impaired function has been restored. Calculated ratios that men reporting multiple impairments will report favorable outcomes are roughly similar to those for single items.

In view of these results, 1976 prevalence rates of these selected impairments for 453 nonsurvivors over the period 1976-1981 were computed. Odds ratios of mortality given the presence of these items for all men interviewed in 1976 (survivors plus nonsurvivors) stratified as before by age to see whether age exacerbates the impairment-death relationship were also computed. Table 4 shows that the 1976 prevalence rates for nonsurvivors were considerably higher than the corresponding rates for survivors only (Table 1). Not surprisingly, the high prevalence among nonsurvivors leads to odds ratios of mortality associated with reporting an item that are highly significant. The odds of dying over the period were generally 2.5 to 3 times

Table 4. Proportion of Nonsurvivor Panel[a] Reporting Selected Impairments in 1976 and Odds Ratios of Mortality 1976 - 1981 for All Men Reporting Impairments in 1976 by Type and Race.

Impairment[b]	% Nonsurvivors Impaired in 1976		Odds Ratio of Mortality	
	White	Black	White	Black
Ambulation	44.1	47.7	3.7**	1.9**#
Locomotor	26.0	32.2	2.7**	2.1**
Body Movement	21.9	21.8	2.3**	1.4
Manual Activity	14.2	20.7	2.0**	1.3
Sight	14.3	23.6	1.9**	1.5*

a. Men interviewed in 1976 but non-interviewed in 1981 because of death.
b. See text for definition.
** = $p \leqslant .001$; * = $p \leqslant .10$; # = age effects, $p \leqslant .10$

greater for whites reporting given items in 1976 than the odds for their nonimpaired counterparts. Although they are also highly significant, the odds ratios for blacks are somewhat lower than those for whites. This difference may stem from the higher prevalence rates of blacks in 1976. The absence of age-impairment interactions is also quite interesting. With only a few exceptions, differences across age-stratified tables are always insignificant. The failure to detect such effects here reinforces the general absence of these effects in the analysis of survivors presented earlier.

Because the entire set of 19 impairment items from which the subset above was selected is much too unwieldy to include separately in the statistical analyses, we construct summary indices of impairment status by means discussed at length in several earlier papers.[25] Although index values are used in continuous form in the following section, we conclude the present subsection by comparing the distribution of respondents by categories reflecting the severity level of impairment in 1976 and 1981 to see whether the dynamic character of single impairment items is also reflected in composite indexes of all items. Table 5 presents the distribution of the survivors panel by equivalent categories of severity at the beginning and end of this five-year period. It shows again the dynamic character of (composite) impairment status, with the average level of impairment growing more severe as the panel ages. For instance , only about one fifth of each subsample was unimpaired in both years and only about another fifth was in the same impairment category in each of the two years. Changes were generally in the direction of more severe problems, but it is also clear that many respondents enjoyed improvements or recovery of function during this period. We turn in the next sections to a multivariate analysis of the degree to which these changes contribute to the disability and mortality experience of the NLS panel.

Table 5. Percentage Distribution of Survivor Panel by Impairment Category[a] in 1976 and 1981 by Race

1976 Impairment Category and Race	1981 Impairment Category					
	None	Minor	Moderate	Substantial	Severe	All
White						
None	20.9	9.6	9.6	1.6	0.7	42.4
Minor	4.1	6.1	6.6	2.0	0.8	19.5
Moderate	1.6	3.9	9.4	4.9	1.6	21.5
Substantial	0.3	0.8	3.0	3.7	1.9	9.7
Severe	0.2	0.2	1.1	2.3	3.1	6.9
All Categories	27.1	20.6	29.7	14.5	8.1	100.0
Black						
None	20.1	9.0	6.1	3.4	0.6	39.2
Minor	3.3	3.6	6.2	2.7	2.3	18.1
Moderate	2.7	2.8	7.4	4.2	3.2	20.3
Substantial	0.4	0.8	3.0	3.9	4.0	12.1
Severe	0.1	0.0	2.2	3.4	4.6	10.3
All Categories	26.6	16.2	24.9	17.6	14.7	100.0

a. See text for definition

III. DYNAMIC MODEL OF HEALTH-RELATED EVENTS

Analytic Framework and Estimation Techniques

A literature has grown up in recent years on production functions or determinants of population health levels. Some studies have analyzed the correlates of mortality rates; others have investigated factors that account for variations in morbidity or disability rates.[26] Most of these latter studies have interpreted "health" as the ability to function or discharge social role responsibilities. They have shown that such abilities are not rigidly determined by demographic, biological or even medical care factors, but rather that socioeconomic (choice) differences play an equal if not more important role in their determination. Multivariate functions with various demographic, socioeconomic and medical or health-related arguments are thus assumed to be essential for accounting for forces shaping the ability to function, including the ability to function at all (mortality). The analyses in the present paper adopt the general conceptual framework suggested by the health production literature for investigating mortality and disability experiences of the NLS panel. In contrast to this earlier literature, however, the analyses here are longitudinal rather than cross-sectional, and they include survivors as well as nonsurvivors so that disability and mortality outcomes can be linked. They also use data on impairment status to control for underlying physical and psychological factors that may affect these outcomes and thereby allow the net influence of physical and socioeconomic factors on intertemporal variations in functional ability to be ascertained.

Events-history methods are used to estimate these models.[27] Longitudinal histories of the functional status of NLS respondents are used as the primary outcome measures. These histories portray the time or duration individuals under observation spend in different functional states or, conversely, the transitional probabilities of moving from one state to another over the period. Such movements or transitions over the observational period are considered "events" in the histories of functional status. In this paper, functional capacity is defined in terms of four mutually-exclusive outcomes: functionally capable (=1); functionally incapable or disabled (=2); death (=3); and loss to follow-up or attrition (=4). The first two states are transient; individuals may move into and out of them over time. In contrast, the third and fourth states are absorbing; individuals may enter them from either of the two transient states, but once entered, they cannot leave them. Let p_{ij} (0,t), (i, j=1, 2; $i \neq j$), represent the transitional probability that an individual in transient state i at time 0 will be in state j at time t and $q_{ik}(t)$, (i=1, 2;k=3,4;$i \neq k$), the probability of death or attrition for individuals in either of the two initial health states. The statistical analysis focuses on estimating the long-term values of these probabilities and the factors that affect their magnitude as a means of understanding more about the observed trends in work, disability and death over the past quarter century.

These event probabilities are assumed to be generated by a continuous-time, Markov process. One aspect of this assumption is that the analysis focuses on "instantaneous transition" or incidence rates. These instantaneous rates are represented for the two transient states as the probability $n_{ij}h$ that an individual in state i will move to state j during the instantaneous time period (t, t + h). Mortality and attrition rates are represented as the probability $m_{ik}h$ that an individual in transient state i dies or is lost to follow-up in the interval (t, t+h). In other words,

$$n_{ij} = \lim_{h \to 0} p_{ij}\ (t,\ t+h)/h \qquad (i,\ j=1,\ 2;\ i \neq j) \qquad (1a)$$

and

$$m_{ik} = \lim_{h \to 0} q_{ik}\ (t,\ t+h)/h \qquad (i=1,\ 2;\ k=3,4;\ i \neq k) \qquad (1b)$$

The n_{ij} and m_{ik} are the basic parameters of the events-history models and, as shown in the Appendix, all other elements can be derived from them. Another aspect of the Markovian assumption is that the waiting time between transitions has an exponential distribution so that, even though the incidence rates are constant over time, the probability of a change occurring increases as the length of the time interval increases. Substantively, this assumption embodies the idea that the aging process decreases the probability of remaining functionally capable (and alive) as the individual grows older.

The unobservable incidence rates are written as exponential functions of observable exogenous variables characterizing demographic, economic and health differences across sample members, and the parameters of these functions are estimated by maximum likelihood methods (see Appendix). Given the dynamic character of the model, values of some exogenous variables at different points in time are taken into account. These time-related measures characterize individuals during the year in which an event occurs. The parameter estimates reflect the influence of temporal changes of the explanatory variable on the instantaneous risk of changing functional states over the study period. Some time-invariant covariates are also included in various estimates of the model. Because in this paper the same vector of explanatory variables is used to estimate the n_{ij} and m_{ik}, we can represent the dynamic events model as:

$$\ln n_{ij}(t) = \underline{X}(t)\ \underline{a}_{ij} \qquad (2)$$

and

$$\ln m_{ik}(t) = \underline{X}(t)\ \underline{b}_{ik} \qquad (i,\ j=1,\ 2;\ k=3,4;\ i\neq j\neq k)$$

where $\underline{X}(t)$ is the vector of explanatory variables at the time t and $\underline{a}$ and $\underline{b}$ vectors of coefficients to be estimated by maximum likelihood methods. The estimated covariance matrix is used to derive asymptotic standard errors to test the statistical significance of each coefficient under the null hypothesis.

Construction of Outcome Variables

Functional status durations are constructed from responses to work limitation questions included in ten of the NLS follow-ups over the period 1966-1981; survivorship durations in each of the two states are computed from the survey year that death is first reported or the year in which the failure to be interviewed for any reason other than death is first noted. Work limitation responses proxy functional capability at various points in time by indicating whether respondents had health conditions that prevented working or limited the amount or kind of work they could do. The absence of a work-limiting health problem means that the individual is functional in that year, while its presence is used as evidence of functional incapacity or disablement. The functional capacity of respondents for the years in which no follow-up was conducted is assumed to be the same as his status in the subsequent survey year. Thus, each surviving respondent's functional capacity is coded for each year of the study period (or, for nonsurvivors, each year of the fraction of that period they were alive). It should be noted that the empirical analysis assumes arbitrarily that an individual categorized as, say, functionally capable in a given survey year is capable for that entire year. Events or transitions between states occur between years, and durations between events are measured in years. The period of time encompassed by the NLS follow-ups is of course sufficiently long to observe a variety of different patterns or profiles of events between functional capability and disability, between disablement and functional capacity and between either of these health-related states and death or loss to follow-up.

Explanatory Variables

The several variants of the health-events model estimated below draw on various combinations of measures reflecting the influence of aging, socioeconomic status, physical/psychological and genetic factors on functional capacity and length of life. The full set of these regressor or explanatory variables includes:

Age. A time-invariant, continuous measure of the age of respondents in 1966 in years.

Blue Collar. Dummy variable taking the value of one if the respondent worked as a craftsmen, operative or nonfarm laborer in 1966, zero otherwise.

Duncan Index. Continuous measure of the respondent's socioeconomic status in 1966 as characterized by the Duncan Socioeconomic Index of All Occupations of his 3-digit occupation code. The index assigns a two-digit status score to each 3-digit occupational category in the Census classification scheme. The Duncan scores range from 0 to 96, and reflect for each occupation (1) the proportion of male workers in 1950 with educational attainment of four years of high school or more and (2) the proportion of males with incomes of $3,500 or more in 1949.

Foreign Born. Dummy variable taking value of one if the respondent was not born in the United States, zero otherwise.

Geographic Immobility. Dummy variable taking the value of one if the respondent reported that his 1966 county of residence had been his residence "all of his life," zero otherwise.

Impairment Status. A time-varying, continuous index characterizing the degree of physical and emotional impairment of the respondent in year t. The impairment index was developed from responses to a battery of questions asked in the 1971, 1976 and 1981 follow-ups. The impairment indexes summarize whether respondents are functionally impaired (have difficulty in walking, using stairs, standing, sitting, stooping, lifting light and heavy weights, handling, reaching, seeing, hearing, and dealing with people) and the extent of the severity of each item; they also summarize whether respondents experience signs or symptoms of a health problem such as shortness of breath, pain, tiring easily, aches, fainting, anxiety, or weakness. Values of the impairment index for intervening years were interpolated linearly to gauge likely changes in impairment status for transitions occuring during the years when impairment data were not obtained.

Industry. Dummy variable equal to one if the industrial attachment of the respondent's 1966 job was agriculture, mining, construction, manufacturing, transportation-public utilities (SIC codes 017-499), zero otherwise.

Job satisfaction. Dummy variable taking the value of one if the respondent reported that he liked his 1966 job very much or fairly much, zero otherwise.

Marital Status. Dummy variable taking the value of one if the respondent was married, spouse present, zero otherwise.

Parents' Longevity. A measure of longevity of the respondent's parents to proxy for the influence of genetic inheritance on both health and length of life.[28] Respondents were asked in selected reinterviews whether either or both parents are still alive. A dummy variable is constructed taking the value of one if neither parent was living when the respondent was

55-59 years of age, zero otherwise. Roughly speaking, this measure divides individuals whose parent(s) failed to live into their eighth decade from those enjoying above average length of life. We anticipate that greater genetic health stock indicated by the longer life span of parents will reduce the risk both of functional disability and death.

Pension Eligibility. A dummy variable taking the value of one if the respondent was covered by Social Security and by private pension, zero otherwise. This variable tests whether functional incapacitation or restoration differs between eligible and ineligible respondents; it also tests whether the survival or attrition experiences of these two subpopulations are comparable.

Race. A dummy variable equal to one if the respondent is black, zero otherwise.

Retirement Status. A time-varying dummy variable taking the value of one if the respondent reports himself retired in year t, zero otherwise.

Schooling. Formal schooling completed in 1966 measured continuously in years.

Social Support. A vector of time-varying dummies taking the value of one if the respondent reports himself married spouse present or unmarried but living with persons other than a spouse in year t, zero otherwise. The referent (omitted) group for both variables are unmarried men living alone.

Wage. Hourly earnings of the respondent in 1966.

Specifications and Sample Universes

Various subsets of the above regressor variables referring to different subuniverses of the total NLS panel are used to estimate the relationships of interest. While the exact specifications and sample universes for each model are described fully in the following sections, two general points may be noted here. First, identical subsets of regressors are used to account for all six events or transitions for given subgroups of respondents. This strategy is adopted primarily to ensure that estimated coefficients on variables of special importance can be interpreted and/or that potential biases attributable to sample selectivity can be identified. The extent to which individuals with a given characteristic are more likely either to die or to be lost to follow-up and, thereby, less likely to be observed moving between (transient) states may influence the estimated coefficient on that characteristic with respect to a given incidence rate. Measuring the influence of that characteristic on death and loss to follow-up (on the simplifying assumption that the same probability distribution function applies) helps assess these findings.

Second, Equation (2) takes into account uncompleted spells of functional capability or incapacity as well as unobserved or unrealized changes in functional status spells attributable to death and loss to follow-up (i.e., right-side censoring). That is one of the principal advantages of this modeling strategy. The data and period of the analysis, however, are also susceptible to left-side censoring or, what is sometimes called, the initialization problem. Simply put, it is unclear whether the same model or probability generating function is responsible for the health histories of respondents up to the point at which the interview started and, of course, the data set includes too little information to characterize earlier history. To help in interpreting the results of the estimated models, we restrict attention to outcomes occurring over the period 1971-1981. Time-invariant regressors, however, in most cases take their 1966 value so that selectivity effects of earlier history can be minimized. In the analysis of policy effects on disablement, for example, the subuniverse is restricted to men who were healthy enough to be working in 1966 and still alive at the beginning of the study period in 1971. Covariates are measured in 1966 values in the analysis, which further reduces selectivity effects. Thus, the analysis focuses on the death and disability experiences of men who were relatively healthy five years before those outcomes were observed. Their health histories after that point, as reflected in the incidence of disablement and death, is then tracked by the events-history model.

IV. IMPAIRMENT DIFFERENTIALS IN DISABILITY AND DEATH

Earlier cross-sectional estimates for NLS Older Men show that the labor force participation rates for respondents reporting a work disability is on average lower than their nondisabled counterparts by about 4 percent for whites and more than 17 percent for blacks.[29] These estimates imply that the rapid rise in disability prevalence depicted in Figure 1 above, especially for men 45-64 years of age, must be responsible for a considerable portion of the concommitant rise in male labor force nonparticipation. Whether this relationship means that health levels of these men have deteriorated and, correspondingly, that early withdrawals from the work force are involuntary responses to poor health, however, remains unclear. Cross-sectional analyses suggest that the probability of reporting disablement varies systematically with economic as well as health factors, and that perhaps only two-thirds of the measured disability effect on labor force participation can be attributed to health (impairment) differences between disabled and nondisabled individuals.[30] In this section, we use the dynamic model of health-related events to ascertain whether the longitudinal relationships between impairment, economic factors and disability are similar to these cross-sectional findings. The longitudinal analysis has the added advantage of testing the effect of these factors on survival and, thereby, of casting light on recent early retirement studies using mortality experience to proxy for health status.[31] A pension eligibility variable is introduced into the analysis to help appraise the results of these early retirement studies.

More particularly, the variant of the health-events model estimated in this section includes impairment, wage and pension eligibility variables, and controls for age, genetic factors, occupation and industry attachment. The model is estimated for a subsample of men who were employed as wage or salary earners in 1966 and thus reported an hourly wage rate for that year. Because the estimates are restricted to outcomes occurring over the period 1971-1981, potential sample selectivity bias arising from the use of observed (1966) wages should be minimized. Since men at work are comparatively healthy, this sample universe should not be biased in respect to health prognosis. The model is estimated separately by race, in part to offset the influence of oversampling of nonwhites in the NLS design, and in part to see whether the variations in prevalence between whites and blacks noted above in Section II continue to be detected in a multivariate framework.

Table 6 presents estimated coefficients on the three variables of primary interest for transitions between functionally capable and disabled states and between each of those states and death. The complete estimating equations for all events and all explanatory variables as well as summary statistics are set out in Appendix Tables A. 1 and A. 2. As expected, intertemporal changes in impairment status significantly raise the incidence of disability and impede the recovery from disability. These coefficients, which are remarkably similar for both white and black men, translate as roughly a 16 percent differential between the moderately impaired and unimpaired and 75 percent between substantially and moderately impaired for the transition between functional and disabled states. The larger, negative effect of impairment on the (instantaneous) likelihood of returning to functional capacity once having been disabled suggests of course that the more impaired are less likely to recover, but it does not rule out such changes. Calculated at the mean of the sample, for example, the expected duration (of that year) for whites in the disabled state is 0.23 months while their expectation for the functional state is 11.6 months. Given the changes in impairment status described in an earlier section, these durations doubtless reflect movements attributable to both

Table 6. Pension, Wage and Impairment Effects on Selected ln Incidence Rates by Race

Effects[a]	Estimated Coefficients[b]			
	Functional to Disabled	Disabled to Functional	Functional to Death	Disabled to Death
White				
Impairment	0.0001***	-0.0006***	0.0002***	0.0001**
Wage	-0.0006***	0.0003*	-0.0016**	-0.0014***
Pension Eligibility	-0.1431**	-0.0061	-0.6091***	0.1715
Black				
Impairment	0.0001***	-0.0005***	0.0002***	0.0001
Wage	-0.0006*	0.0005	-0.0006	0.0009
Pension Eligibility	-0.2682***	0.3015**	-0.6540***	-0.2294

a. See text for definitions.
b. See Appendix Tables A.1 and A.2 for complete estimating equation and summary statistics.
*** $p \leq .01$; ** $p \leq .05$; *$p \leq .10$; one-tailed test.

incidence and restoration. All things equal, more impaired individuals are likely to die, the force of mortality rising by 0.0002 for each unit change in impairment of those men last observed in the functional state. The impairment effect for those already disabled is not as great and is, in fact, insignificant at conventional levels for blacks. This relationship is discussed more fully below.

Table 6 shows, nonetheless, that impairment is not the only factor influencing these health-related outcomes. Of special interest from the viewpoint of the link between disability and nonparticipation trends are the influences of the economic variables, wages and pension eligibility. In the former case, wages have a significantly negative effect on the incidence of disability for both whites and blacks as predicted by the opportunity cost argument. Wages influence recovery and mortality, however, only for whites. These findings are consistent with Grossman's model that the demand for, and thereby investments in, health by individuals rises with their market wages and results in positive increases in "healthy time."[32] The absence of wage effects on recovery and mortality of black men suggests that they are less able to invest in health and their durations of time spent healthy (and alive) are affected as a result.

Pension eligibility has a significant effect on disablement; but, perhaps surprisingly, this effect is negative, with pension-eligible men of each race substantially less likely than those not eligible to be disabled. Pension-eligible blacks are also more likely to recover from disability than their pension-ineligible counterparts. Given the character of the disability (work limitation) outcomes, these findings suggest that pension-eligible men have different health behaviors leading to greater commitment to market work, perhaps as a means of maintaining their eligibility status. Whether this offsets the positive inducements of such status to reduce the overall length of work life by retiring early is unclear. Yet the interaction probably contributes to upwards bias in the estimated effects of pension eligibility on early retirement trends. The significant negative effect of pension eligibility on the risk of dying for functionally capable white and black men alike is equally noteworthy. The estimated coefficients strongly suggest that the pension-eligible subpopulation has different life table values than the noneligible. This possibility adds some weight to inferences about the influence of poor health on early retirement from some studies using the mortality experience of early pension claimants as a health status proxy.[33]

The evidence presented in Table 6 suggests generally that rising work disability prevalence rates of American men does not wholly reflect deterioration in underlying physical and psychlological capacities. National trends must be interpreted cautiously and the interpretation must account for economic preferences as well as health-related factors. The findings also suggest that estimated health effects on labor force nonparticipation using these disability measures are biased. Interestingly, inducements arising from pension eligibility may counter this bias to some extent because pension-eligible men have higher life expectancies and/or are induced to greater work effort (fewer periods of disablement) in order to maintain eligibility. These relationships make predicting the consequences of policy changes more difficult. On the one hand, changing the criteria of pension eligibility may not reduce the number of men seeking to retire early for reasons of poor health. On the other, such changes may well raise the likelihood of being disabled by poor health earlier in the work-life cycle. Permanent labor supply, in other words, may not differ between the two policy regimens, but policy changes may cause different time allocations over the life cycle.[34]

More analysis of this possibility seems warranted.

V. RETIREMENT EFFECTS ON DISABILITY AND DEATH

Previous research on the adverse health consequences of retirement has been confounded by the absence of suitable health status indicators, by the complications of modeling the direction of causality between health changes and retirement, and by the difficulty of disentangling pre-and post-retirement health changes and the "normal" changes in physical and psychological functioning attributable to the aging process. Many studies have used simple self-rated health measures, which are of course difficult to interpret. Recent investigations have restricted attention to more objective, easily measured health events, particularly death.[35] While mortality may occur after retirement, it cannot be directly attributable to retirement unless pre-retirement health is suitably controlled. Even under ideal circumstances, such control variables are not easily measured and/or separated from the forces shaping the decision to retire itself. Furthermore, some conceptual models, such as the life-change framework that links health conditions to retirement-related outcomes in terms of the stress created by dramatic shifts in life circumstances, cannot separate the effects occurring before and after retirement.[36] The inherent difficulty of deciding whether the stress occurs because of the "anticipation" of the event or the event itself is a case in point. Because retirement is a life event only for older individuals, distinguishing between health conditions, many chronic in character, that would have occurred as a normal effect of aging is also conceptually and methodologically difficult to handle. It is hardly surprising that conflicting findings about the health effects of retirement have been reported in the literature.

This section presents the results of a variant of the health-events model designed to test whether retirement has deleterious health effects. The model follows recent practice in using disability and mortality as the outcomes influenced by retirement.[37] Retirement is gauged as a time-varying self-report of the respondent's retirement status in any given year over the period 1971-1981. In contrast to earlier studies, however, retirement effects are separated into their influence on disability and, then, death or either of these outcomes alone. Moreover, the model controls for (time-varying) impairment status in each year of the study period but makes no attempt to distinguish pre-and post retirement differences in impairment status. Even though it might appear necessary or desirable to model the influence of retirement on impairment, the difficulty of identifying specific retirement effects as opposed, say, to the anticipation of retirement before the event and/or the effects of aging after the event argues against this analytic approach. Impairment changes represent a proxy for underlying health prognosis; the model tests whether outcomes, given that prognosis, are more severe for retirees. In contrast to the earlier literature, the model estimated here does not assume a unique relationship between impairment and disablement, but rather that various choice elements also influence such outcomes. Thus, the model tests whether retirement raises the risk of disability or death, controlling for the entire set of determinants of these outcomes.

In addition to age and genetic factors, the model includes several control variables suggested by findings in the earlier literature. Occupation, industry and education are incorporated to test for the influence of socioeconomic status detected in several studies. A vector of social support variables are also included to test whether the outcomes of married or unmarried individuals living with others differ from those living alone by virtue of socio-psychological support mechanisms provided by these social arrangements.[38] This retirement model is estimated for all NLS men who had not declared themselves retired by 1971. As before, the outcomes are restricted to the period 1971-1981 while the time-invariant control variables are measured in terms of their 1966 values to minimize selectivity effects.

Table 7 presents estimated coefficients for selected variables and transitions in this version of the health-events model. As before, the complete results for all explanatory variables and transitions are set out in the Appendix, Tables A.3 and A.4. Estimated coefficients on movements between transient states provide strong evidence that retirement is more likely to be a consequence than a cause of disablement for the (initially) nondisabled, but a factor contributing to longer durations of disability for those already disabled. The estimated force of mortality for retired men, however, does not differ significantly from those continuing to work. These findings provide little support for the stressful life-events paradigm except insofar as such stress might exacerbate conditions contributing to the length of disability spells. The absence of retirement differentials in mortality experience confirms the findings of other longitudinal investigations.[39]

The results of this model also fail to detect the potential mediating effects of social support as evidenced by the general absence of signficiant coefficients on the vector of marital status-household composition variables. Mortality experiences of men living with others or alone do not differ at conventional confidence levels. The only influence of these factors for white men is the comparatively shorter duration of disability observed for married individuals living with their spouses. This finding suggests that spouses make it possible to cut short disability spells and/or that the opportunity costs of disability are greater for men with spouses. In

Table 7. Retirement and Social Support Effects on Disability and Death by Race

Effects[a]	Estimated Coefficients[b]			
	Functional to Disabled	Disabled to Functional	Functional to Death	Disabled to Death
<u>White</u>				
Retired	-1.5230***	-1.4790***	9.6110	9.147
Social Support				
Married, Spouse Present	0.0868	0.3608**	0.1266	-0.1113
Unmarried, Living with Others	0.0809	0.2536	0.1519	0.0833
Impairment	0.0001**	-0.0005***	0.0001*	0.0002***
<u>Black</u>				
Retired	-1.2640***	-1.392***	9.190	9.2250
Social Support				
Married, Spouse Present	0.0939	-0.0414	-0.6294	-0.2209
Unmarried, Living with Others	0.3684**	-0.1486	-9.180	0.4575
Impairment	0.0001*	-0.0004***	0.0001	0.0001

a. See text for definitions.
b. See Appendix Tables A.3 and A.4 for complete estimating equation and summary statistics.
*** $p \leq .01$; ** $p \leq .05$; * $p \leq .10$; one-tailed test.

contrast, household differences appear to have greater influence on black men, as evidenced by the insignificant coefficients on all social support variables except disability incidence for the unmarried living with others. The factors contributing to this differential risk are unclear.

The findings presented in this section fail generally to confirm the claims that retirement is harmful to health and that social support networks mediate outcomes, especially after stressful life-events such as retirement. However, the inherent difficulty of testing any hypothesis about the effects of retirement on subsequent health status must be kept in mind in interpreting these findings. The health-events model has the advantage over other study designs of being able to control for physical and choice factors likely to influence adverse health outcomes at any point, thus enabling any rise in the likelihood of such risks in the post-retirement period to be isolated. Yet the possibility that the process of anticipating retirement and the typical "honeymoon" phase immediately following the event also influence these control variables cannot be completely ruled out; some coefficients may accordingly be biased. Yet the failure in earlier studies to recognize that disability status responds to economic preferences as well as underlying health conditions also created biases in their findings, and these biases may be greater than those arising in the health-events model. The possibility exists that bias also arises from measuring functional capacity as the absence or presence of limitations in role responsibilities because the perception of those responsibilities changes dramatically after retirement. Such a bias is a weakness of all behaviorial indicators of health status. Since survey questions about activity limitations allow the respondent individual flexibility in interpeting role responsibilities, the potential bias of using such measures is unlikely to be great. The fact that mortality experiences of disabled or functionally capable men does not differ by retirement status argues further against the likelihood that such measurement bias is great.

VI. HUMAN CAPITAL AND DEMOGRAPHIC DIFFERENTIALS IN DISABILITY AND DEATH

Human Capital Effects

The results presented thus far show that health-related outcomes are influenced by economic characteristics, but they do not necessarily account for the kinds of causal mechanisms or pathways by which these factors exert such influence. In this subsection, we test whether men with more human capital are better producers of healthy time as suggested by Grossman's household production model.[40] More particularly, Grossman's empirical analysis of health demand is based on a reduced form equation implied by a production function for "healthy time" and an investment function with inputs of individual time and market goods. For adults, Grossman finds a significant cross-sectional effect of schooling on self-rated health, controlling for wages and other socioeconomic characteristics including job satisfaction. He also finds a significant (negative) schooling effect on mortality experience in a separate analysis. He interprets these findings as evidence that individuals with more human capital produce health more efficiently. His results are quite important in the context of the present paper because they suggest that men forced out of the work force by poor health are unlikely to have substitutable human capital attributes--indeed, that health status will compound their already disadvantaged position in the labor market.

Grossman's schooling hypothesis is tested in the continuous-time, Markov framework using schooling, wage, job satisfaction and other socioeconomic covariates. Although our model imposes a slightly different functional form on the underlying healthy-time production function assumed by Grossman and models "health capital" explicitly, the general specifications of the vector of covariates in each model are quite similar. Because wages are included, the model is estimated for the restricted subuniverse of wage and salary earners reporting hourly earnings in 1966. As in the models presented previously, other time-invariant regressor variables take their 1966 value to reduce selectivity bias. Table 8 sets out selected findings (and Appendix Tables A.5 and A.6 present the complete results) of this human capital version of the health-events model.

Two findings warrant comment. The first is that individuals with more schooling spend longer periods of time functionally capable as evidenced by the significantly negative coefficients on the functional to disabled transition. Whites are marginally more likely than blacks to stay nondisabled, but the absolute effect is not great. In contrast to the Grossman's general findings, however, there is no evidence that schooling experiences influence length of life. Equally important is that schooling has no influence, controlling for impairment, on the ability of men to return to functional capacity once they are disabled. Although the use of medical care and rehabilitation services is unobserved in the model, the expectation is that more efficient health "producers" might be better able to recover, all things equal. It is possible, although unlikely, that the absence of schooling effects on these transitions stems from the use of a linearly continuous measure of years of formal schooling completed. It is also possible that these men are too old for the influence of their schooling to be detected, i.e., that schooling plays a more prominent role in health decisions at younger ages.

Second, Table 8 shows that job satisfaction also has a significantly

Table 8. Schooling, Job Satisfaction and Impairment Effects on Disability and Death by Race

Effects[a]	Estimated Coefficients[b]			
	Functional to Disabled	Disabled to Functional	Functional to Death	Disabled to Death
White				
Schooling	-0.0321***	0.0085	0.0029	-0.0242
Job Satisfaction	-0.1449*	-0.1076	0.0342	0.0762
Impairment	0.0001***	-0.0006***	0.0002***	0.0001*
Black				
Schooling	-0.0260**	0.0093	0.0147	0.0299
Job Satisfaction	-0.3241**	0.0133	-0.7108**	-0.7175
Impairment	0.0001***	-0.0005***	0.0002***	0.0000

a. See text for definitions.
b. See Appendix Tables A.5 and A.6 for complete estimating equation and summary statistics.
*** $p \leq .01$; ** $p \leq .05$; * $p \leq .10$; one-tailed test.

negative effect on the incidence of disability for both white and black men; the net effect for white and black men indicating in 1966 that they liked their job very much or fairly much were 13 and 28 percent, respectively, less likely to have become disabled over this period than men who did not like their job. Since the opportunity cost of time and impairment status are controlled for, this difference suggests that motivations influenced by situational factors play some role in health-related outcomes. Perhaps most interesting in this respect is that job-satisfied, functionally capable black men are less likely to die than their counterparts who are dissatisfied with work. This effect is not, however, observed for white men.

The estimates for the human capital version of the health-events model confirm the general predictions of Grossman's household production model that human capital formation through schooling can have a positive effect on health status and, thereby, that policy interventions designed to augment human capital can have an important secondary impact on functional capacity. We find, however, that this schooling effect occurs by preventing departures from functional capacity rather than by fostering the recovery of already disabled men. We speculate the reason for this one-way effect is that schooling influences lifestyle and preventive health behavior more than the ability to use (curative) medical care once functional capacity is impaired. That schooling has no influence on life expectancy appears quite surprising and contradicts the findings of other studies.[41] Many of these studies, however, were cross-sectional designs unable to control for dynamic changes in impairment status and other socioeconomic control variables.

Race and Age Cohort Effects

The possibility that life expectancy improvements leading to rising disability prevalence rates differs among demographic subgroups is examined in this subsection. Ideally, the connection between these outcomes might be gauged by first identifying the factors that influence recent increases in life expectancy and then appraising the net effects of those factors on the risks of disablement. Unfortunately, little is presently known about which subgroups have been favored by changes in mortality trends over the recent past. It is unclear, for example, whether mortality rates have declined more rapidly for high or low income individuals and thus whether these improvements have served to lower or raise disability prevalence for these persons. Detailed studies of decendent characteristics at different points in time must be conducted before such trends can be identified. Some preliminary inferences may be developed, however, by appraising the effects of demographic factors known to differ in terms of mortality experience. The influence of race and age cohort effects on death and disablement are analyzed here with this goal in mind.

Race differentials in mortality are quite large, with age-adjusted rates for black men at present about 44 percent higher than white men. While both white and black death rates have declined over the past quarter-century, the decline has been marginally greater for whites so that the mortality gap has not narrowed significantly. Insufficient aggregate data are available to trace the influence of these changes on disability trends by race.[42] The common assumption, however, is that black men are also more likely to be disabled. We analyze race differentials in the framework of the health-events model to provide a preliminary view of the connection, if any, in these dynamics. This variant of the model is designed to include as many members of the NLS panel as possible so the sample restriction that respondents must be wage and salary earners in 1966 is removed. Given this change, we use Duncan Index scores to proxy for economic status; impairment, age, marital status and several other control variables are also included. In one version, a race variable (taking the value of one if the respondent is black, zero otherwise) is incorporated in a model estimated for the larger universe of respondents to gauge the main effects of race on health-related outcomes. The model is then re-estimated for each race separately to measure possible interaction effects. Selected findings of these models are presented in Table 9; Appendix Tables A.7-A.9 present the complete results.

The first row in Table 9 confirms that black men indeed have higher risks of death than white men. It is noteworthy, however, that race effects are more pronounced for the transition between functionally capable and death than for the transition between disability and death. While there is a race effect on the risk of disablement, it is accordingly much smaller in magnitude than the differential in the risk of death. We interpret these findings as generally consistent with the view that improving mortality experience is associated with rising disability prevalence. The considerably higher mortality risk of blacks than whites of comparable age while functionally capable suggests that fewer blacks enter the pool of persons at potential risk of disability. The comparative smaller differential between whites and blacks in the risk of death once disabled implies that mortality improvements are more likely to influence the risks of death from the functionally capable state. When mortality falls, the pool of disabled persons is increased. The interaction or joint effects of race and other key variables also support this interpretation. The influence of age is similar for both races, even though the gradient effect of age is greater for blacks by virtue of their shorter

Table 9. Main and Selected Interaction Effects of Race on Death and Disability

Effects[a]	Estimated Coefficients[b]		
	Functional to Death	Disabled to Death	Functional to Disabled
Main Race Effect	0.4175***	0.2286**	0.0906**
Interaction Effects, White			
Age	0.0805***	0.0480***	0.0522**
Impairment	0.0002**	0.0001**	0.0001***
Duncan Index	-0.0096***	-0.0019	-0.0091***
Parents' Longevity	-0.1055	0.0808	0.0939*
Interaction Effects, Black			
Age	0.1098***	0.0675***	0.0606***
Impairment	0.0002***	-0.0000	0.0001***
Duncan Index	-0.0035	0.0017	-0.0086***
Parents' Longevity	-0.3756*	0.3956**	0.0707*

a. See text for definitions.

b. See Appendix Tables A.7-A.9 for complete estimating equations and summary statistics.

$^{***}p \leq .01$, $^{**}p \leq .05$, $^{*}p \leq .10$, one-tailed test.

expected length of life. Impairment effects are also similar. Race differences do not appear to stem from genetic inheritance as evidenced by the mixed results on the parents' longevity variable. Only the coefficient for whites on the incidence of disability and the coefficient for blacks on the mortality risk while functionally capable are noteworthy. The differences in the effects of socioeconomic status are more interesting. The Duncan Index is significantly negative for the mortality of functional whites but statistically insignificant for blacks. This finding may reflect that mortality reductions for white men favored those at lower levels of socioeconomic status. Similar effect for blacks may also be detected when their mortality risks are reduced.

In view of the steady historical decline in male mortality rates during the 1970s, it is also possible to use the effects of different age-cohorts on health-related events as a means of drawing inferences about the connection between declining mortality and rising disability prevalence. Even though the time span and age range of the NLS panel is not ideally suited for such a test, we estimate a variant of the health-events model in which the pattern of outcomes over two five-year periods was linked to two five-year age cohorts. More specifically, subsamples of outcomes over the periods 1971-1976 and 1976-1981 for men aged 60-64 at the beginning of each of these two periods were combined (with a dummy cohort variable taking a value of one if the respondent was a member of the first cohort, zero otherwise) to test whether individuals entering their seventh decade earlier or later in the decade of the 1970s differed in their health-related outcomes. Similarly, cohorts of men aged 55-59 either at the beginning of the period 1971-1976 or the beginning of the period 1976-81 were selected, again with a dummy variable indicating whether they were a member of the first of these two cohorts.

Table 10 summarizes selected findings from these estimates; Appendix Tables A.10-A.11 present the full results. Given the comparatively short span of time over which we attempt to measure cohort efforts, it is perhaps noteworthy that any significant differences are found. Yet Table 10 shows that the cohorts differ significantly in terms of the incidence of disablement. Men in each age group were less likely to have been disabled if they were part of the earlier cohort. Furthermore, for men 55-59, this early cohort was more likely to die when disabled than the later group; this effect was not found, however, for older men 60-64 years of age. The cohort effects that are detected, nonetheless suggest responses associated with a changing environment, including continuing declines in age-specific mortality rates.

Weak evidence of a connection between improving mortality and rising disability prevalence has been found in this section. Race differences in mortality reflect differential risks of death and disability under different life table expectations. Age cohort effects also suggest that men with more favorable life table expectations have less favorable disability experiences, all things equal. These findings may, of course, be explained by some unidentified "third" factor that accounts simultaneously both for declining mortality and rising disability. (The possibility that medical care is such a factor cannot be easily discounted; unfortunately, it cannot be tested with the data at hand.) The findings are nonetheless suggestive enough to warrant more detailed analysis. Since earlier studies show disablement to have adverse effects on work activity, the relationship between improving mortality and the projected labor force of older persons would be an especially fruitful focal point for such analyses.

Table 10. Cohort and Race Effects on Death and Disability by Age Group

Effects[a]	Estimated Coefficients[b]		
	Functional to Death	Disabled to Death	Functional to Disabled
Men Age 55-59			
Cohort	0.1247	0.4293***	-0.1278**
Race	0.3634*	0.1858	0.0694
Men Age 60-64			
Cohort	-0.1511	-0.0278	-0.1513**
Race	0.1414	0.2000	0.1293*

a. See text for definitions.

b. See Appendix Tables A.10 and A.11 for complete estimating equations and summary statistics.

***$p \leq .01$; **$p \leq .05$; *$p \leq .10$, one-tailed text.

VII. DISCUSSION

Considered jointly, the results of the preceeding events-history analyses suggest a complex and perhaps unexpected set of interrelationships among recent historical trends in work activity, disability and mortality. The rapid rise in prevalence rates of functional disablement reflects deteriorations in the physical and psychological capacities of older American men that, in turn, appear to stem from recent improvements in longevity. Labor force participation rates of these men have declined as a direct consequence of these impairment factors and indirectly from extended length of life. Although labor force behavior has clearly been influenced by inducements arising from more generous benefits of social insurance and private pension programs, health (disability) behavior is also shown to vary by whether men are eligible for such benefits. This interaction effect confounds attempts to gauge the extent to which declining work activity can be attributed to health or pension factors and, thereby, the extent to which the labor supply of older men might respond to modified program parameters. While early withdrawal from work may be caused by health problems, there is little evidence to support the claim that retirement harms health. This result adds further weight to the conclusion that declining work activities of older men is an outcome shaped by dynamics changes in the risk of functional incapacity and life expectancy.

At least two aspects of these general findings warrant closer attention by social policymakers and planners. First, even though functional disability status is determined by a variety of factors, the rising risk of disablement reflects a population subgroup growing on averag less "healthy" over time. Demands for social/medical care services and income maintenance will continue to expand rapidly; reallocations of resources away from acute-curative care towards long-term care aimed at achieving greater functional independence will also continue, the pace governed perhaps by the extent to which mortality rates continue to fail. Yet, the dynamic character of underlying impairment characteristics of older men must also be kept in mind. Evidence that individuals acquire new problems and recover from old ones over time suggests that health-related disabilities are not always permanent or irreversible. It follows that disability prevalence data are not precise indicators of the number of men in continuing poor health who cannot be expected to work. It also follows that social policies should accord priority to interventions aimed at reducing the duration of disability spells. Factors identified in the social estimates of the health-events model as serving to shorten such durations should be considered in designing these interventions.

Second, policymakers should also give more attention to selectivity effects on target populations of older men. The analyses above showed clearly, for example, that economic status plays a prominent role in determining the likelihood of being disabled. The analyses also showed significant differences in mortality experiences by income level. Of special interest in this regard were the mixed results of education on functional disablement. Contrary to expectations, schooling does not significantly influence mortality or the ability of men to recover from a disability. Yet schooling is associated with longer durations in the functionally capable state. Given the greater likelihood of work activity for men in that state, human capital investments yield porportionately higher (discounted) yields over the life cycle than is even commonly reflected in standard cross-sectional rate of return computations. Men with low levels of schooling, then, will be more likely to have health problems as well as lower permanent earnings potential. This compounding of disadvantages contrasts sharply with the selective subpopulation of men who are eligible for public and private pensions and who, thereby, are less likely to have a health-related problem by virture of their longer life expectancy and longer durations as functionally able. These selective advantages and disadvantages should be weighed carefully in appraising alternative policies that cushion the adverse economic consequences of poor health while reducing the disincentives to continued attachment to the work place.

FOOTNOTES

1. See, for example, Boskin (1977); Burkhauser (1980); Burtless and Moffit (1984); Diamond and Hausman (1984); Hanoch and Honig (1983); Mitchell and Fields (1984); Parsons (1980); Quinn (1977); and Slade (1984).

2. Cf., Danziger, Haveman and Plotnick (1981); Also see Chirikos and Nestel (1981 and 1984); Haveman, Wolfe and Warlick (1984); Parnes (1983); and the literature cited in footnote 1 above.

3. See Haveman and Wolfe (1984); Parsons (1984) and the original analysis in Parsons (1980).

4. See, for example, Wan (1983) and the literature cited therein.

5. Ekerdt, et al. (1983).

6. Minkler (1981).

7. See Asher (1984) and Broadhead, et al. (1983).

8. Cf., Manton (1982).

9. Fries (1980 and 1983).

10. Schneider and Brody (1983). Also see Feldman (1983) and Verbrugge (1984).

11. See, for example, Nagi (1976). Also see Wilson and Drury (1981).

12. Various issues of Vital Statistics of the United States were used for this purpose. See, for example, U.S. Public Health Service, National Center for Health Statistics (1984).

13. Various issues of Vital and Health Statistics, Series 10 were used for this purpose. See, for example, U.S. Public Health Service, National Center for Health Statistics (1981).

14. Various issues of Handbook of Labor Statistics were used for this purpose. See, for example, U.S. Bureau of Labor Statistics (1980).

15. See Chirikos and Nestel (1981); Lambrinos (1981); Haynes et al. (1978); and Minkler (1981).

16. Parsons (1982).

17. Cf., Elneback et al. (1981).

18. Croog and Levine (1982) and Doehrman (1977).

19. Chirikos and Nickel (1984).

20. See, for example, U.S. Public Health Service (1973).

21. Chirikos and Nestel (1981 and 1982).

22. World Health Organization (1980). Our analysis uses the ability to walk, lift light weights, reach and handle as indicators of ambulation, locomotor, body movement and manual activity, respectively. See also Branch and Jette (1981) and Jette and Branch (1981).

23. CHRR (1981).

24. Fleiss (1981).

25. Chirikos and Nestel (1981 and 1982).

26. See, for example, Hadley (1982), Grossman (1983) Nagi (1976), and Chirikos and Nestel (1984) and the literature cited therein.

27. Tuma, Hannan and Groenveld (1979).

28. Cf., Vanderbrouche et al. (1984). Also see Hamermesh and Hamermesh (1983).

29. Chirikos and Nestel (1984 and 1985).

30. Chirikos and Nestel (1984).

31. See, for example, Hamermesh (1982), Kingson (1982), Myers (1982), Parsons (1980), Program Analysis Staff (1982), and Wolfe (1983).

32. Grossman (1972 and 1975).

33. Cf., Meyers (1982).

34. Cf., Burkhauser and Turner (1978).

35. See Minkler (1981) for a review of the literature.

36. Wan (1983).

37. Haynes, et al. (1978).

38. Broadhead, et al. (1983).

39. Haynes, et al. (1978).

40. Grossman (1972 and 1975). Also see Leigh (1983) and Fuchs (1982).

41. Cf., Hadley (1982) and the literature cited therein.

42. Published estimates from the National Health Interview Survey, for example, lack detailed racial characteristics by age. Among other things, this explains why national trends in disability discussed in Section II above were not divided by race.

43. The exposition here closely follows Chiang (1968).

44. We use the computer program developed by Professor Tuma of Stanford University to obtain these results. See Tuma (1980).

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Appendix

Transitional Probabilities and Expected Duration[43]

Transitional probabilities between transient states (p_{ij}) and into absorbing states (q_{ik}) as well as expected duration in a given state (Et_{ij}) may be computed from the incidence rates, n_{ij} and m_{ik}. The relationship between these values can be seen by first noting that transitional probabilities in some time interval (0, t) satisfy linear homogeneous differential equations of the following sort:

$$\frac{\partial p_{ij}}{\partial t}(0, t) = \Sigma_h p_{ih}(0, t) n_{hj} \qquad \text{(A.1)}$$

where n_{hj} are instantaneous transition rates defined in text equations (1a) and (1b), and the initial conditions are taken as $p_{ij}(0, 0) = 0$; $p_{ii}(0, 0) = 1$; $q_i(0, 0) = 0$. The solution of equations such as A.1 take the general form,

$$p_{ij}(0, t) = c_{ij} \exp(\lambda t) \qquad \text{(A.2)}$$

Solving for c_{ij} and λ in A.2 involves introducing a matrix of incidence rates. In our case,

$$N = \begin{bmatrix} n_{ii} & n_{ij} \\ n_{ji} & n_{jj} \end{bmatrix} \qquad (i \neq j) \qquad \text{(A.3)}$$

and the corresponding characteristic matrix,

$$N(\lambda) = [(\lambda I - N)]$$

$$= \begin{bmatrix} \lambda - n_{ii} & -n_{ij} \\ -n_{ji} & \lambda - n_{jj} \end{bmatrix} \qquad \text{(A.4)}$$

where I is the identity matrix. The determinant value of $N(\lambda)$, $N(\lambda)$ expanded fully appears as a second degree polynominal in λ, the coefficients being obtained from the n's. Equating this polynominal to zero yields a second degree equation, the so-called characteristic equation of $N(\lambda)$, with roots (eigenvalues) λ_1 and λ_2. That is:

$$|N(\lambda)| = 0 \qquad (A.5)$$

$$\lambda^2 - (n_{ii} + n_{jj})\lambda + (n_{ii}n_{jj} - n_{ij}n_{ji}) = 0$$

so that $\lambda_1 = n_{ii} + n_{jj} + (n_{ii} - n_{jj})^2 + 4n_{ij}n_{ji} /2$

$$\lambda_2 = n_{ii} + n_{jj} - (n_{ii} - n_{jj})^2 + 4n_{ij}n_{ji} /2$$

Because the term under the radical in A.5 cannot be negative, λ_1 and λ_2 are real and, assuming $n_{ij} > 0$ and $n_{ji} > 0$, distinct. If so, substitution of A.2 into A.1 can be used to solve for the p_{ij} (0, t), viz.,

$$p_{ij}(0, t) = \sum_{\alpha=1}^{2} \frac{n_{ij}\exp(\lambda_\alpha t)}{(\lambda_\alpha - \lambda_\beta)} \qquad (\alpha \neq \beta) \qquad (A.6)$$

and

$$p_{ii}(0, t) = \sum_{\alpha=1}^{2} \frac{(\lambda_\alpha + n_{jj}) \exp(\lambda_\alpha t)}{(\lambda_\alpha - \lambda_\beta)} \qquad (\alpha \neq \beta)$$

The probability of death or other loss to follow-up q_{ik} (0, t) may now be written as the influence of the force of mortality or follow-up loss on individuals who either stay in the i^{th} state or move between states in the time interval (0, t). Since these movements can occur anytime before t, consider the time interval t* (t*, t* + Δ) where $0 < t^* \leq t$.

Then:

$$q(t) = \int_0^t p_{ii}(t^*)\, m_{ik}dt^* + \int_0^t p_{ji}(t^*)\, m_{ik}dt^* \qquad (A.7)$$

So by substitution

$$q(t) = \sum_{\alpha=1}^{2} \frac{\exp(\lambda_\alpha t) - 1}{\lambda_\alpha(\lambda_\alpha - \lambda_\beta)} \left[(\lambda_\alpha - n_{jj})\, m_{ik} + n_{ij}m_{jk}\right] \qquad (A.8)$$

Given the transitional probabilities , it is also possible to compute the expected durations in each state for individuals. Specifically, the expectation that an individual in state i at time 0 is in state j at time t* and remaining there for the duration (t^*, $t^* + dt^*$) is simply the sum over all values of t^* in the interval (0, t), i.e., the expected duration in state j is:

$$Et_{ij}\ (0,\ t) = \int_{o}^{t} p_{ij}\ (0,\ t^*)\ dt^* \qquad \text{(A.9)}$$

Substituting Equation A.6 into A.9 yields the following explicit formula for duration:

$$Et_{ij}\ (0,\ t) = \sum_{\alpha=1}^{2} \frac{n_{ij}}{\lambda_{\alpha}(\lambda_{\alpha} - \lambda_{\beta})}\left[\exp\ (\lambda_{\alpha} t) - 1\right] \qquad \text{(A.10)}$$

Likelihood Function and Predicted Incidence Rates[44]

Maximum likelihood methods are used to estimate the parameters on the log-linear relationship between the instantaneous transition rates, n_{ij} and m_{ik}, and the vector of explanatory variables, $\underline{X}$. The likelihood function for the constant rate Markovian model described above is simply the product of the exponential survivorship function and the incidence rates. For each sample member, let t_i represent the time an individual spends in state i; ν_{ij} the number of transitions from state i to state j; and μ_i an indicator variable equal to one if the individual dies or is lost to follow-up while in state i, and let S equal total sample size, the likelihood function may be very generally represented as

$$\mathcal{L} = \prod^{S} \prod_{i=1}^{2} \prod_{j=1}^{2} \exp - \left[(t_i)\ n_{ii}\ \underline{X}\right]\left[\ n_{ij}\ \underline{X}\right]^{\nu_{ij}}\left[\ m_{ij}\ \underline{X}\right]^{\mu_i} \qquad \text{(A.11)}$$

In evaluating the expected durations in the text, the incidence rates were predicted by multiplying the vector of estimated coefficients $\hat{\underline{a}}_{ij}$ to specific values of the explanatory variables. Recall that some explanatory variables changed over the study period so the assumed values of these specific values of the explanatory variables. Recall that some explanatory variables changed over the study period so the assumed values of these variables refer either to fixed characteristics or time varying characteristics. Letting $\underline{X}^*$ represent the assumed values of the vector of independent variables, predicted incidence rates, say, $\hat{n}_{ij}$, are calculated as:

$$n_{ij}(t) = \exp\left[\underline{\hat{a}}_{ij}\ \underline{X}^*\right] \qquad (A.12)$$

Then by definition,

$$n_{ii}(t) = -\left[\sum_j n_{ij} + \sum_k m_{ik}\right] .$$

Table A.1 Determinants of ln Incidence Rates in Policy Model, 1971-1981: White Wage and Salary Earners

Determinant	Means (Standard deviations)	Estimated coefficients (asymptotic t-ratios)					
		Functional to disabled	Functional to death	Functional to follow-up loss	Disabled to functional	Disabled to death	Disabled to follow-up loss
Age	51.47 (4.26)	0.04631 (6.74)	0.05767 (2.30)	0.05777 (2.72)	-0.02654 (-3.09)	0.06209 (3.78)	-0.01825 (-0.68)
Impairment	2850 (1505)	0.00011 (5.02)	0.00020 (3.28)	0.00015 (2.66)	-0.00057 (-15.86)	0.00006 (1.79)	-0.00018 (-2.37)
Parents' longevity	0.7659 (0.42)	0.15400 (2.26)	-0.14080 (-0.61)	0.04707 (0.23)	-0.01277 (-0.14)	-0.00963 (-0.05)	0.26020 (0.88)
Blue collar	0.5581 (0.50)	0.17370 (2.65)	-0.35430 (-1.55)	0.27900 (1.35)	-0.10040 (-1.22)	-0.18080 (-1.19)	0.23290 (0.87)
Industry	0.6387 (0.48)	0.03463 (0.53)	0.64450 (2.59)	0.05070 (0.25)	-0.06285 (-0.76)	0.05959 (0.38)	0.19870 (0.72)
Wage	346.7 (185.1)	-0.00063 (-3.49)	-0.00161 (-2.23)	-0.00004 (-0.08)	0.00026 (1.44)	-0.00135 (-2.60)	-0.00036 (-0.46)
Pension	0.8290 (0.38)	-0.14310 (-1.85)	-0.60910 (-2.47)	-0.25470 (-1.10)	-0.00611 (-0.06)	0.17150 (1.00)	0.42240 (1.26)
Constant	-	-4.57600 (-12.35)	-7.18800 (-5.36)	-7.65200 (-6.68)	1.10200 (2.34)	-6.49000 (-6.96)	-3.50700 (-2.34)
-2 ln likelihood	-	125.51	33.49	19.07	424.65	27.49	12.45
Events	-	1253	95	130	763	218	80

Table A.2 Determinants of ln Incidence Rates in Policy Model, 1971-1981: Black Wage and Salary Earners

Determinant	Means (Standard deviations)	Estimated coefficients (asymptotic t-ratios)					
		Functional to disabled	Functional to death	Functional to follow-up loss	Disabled to functional	Disabled to death	Disabled to follow-up loss
Age	51.67 (4.09)	0.05726 (5.67)	0.10500 (3.45)	-0.00077 (-0.00)	-0.01162 (-0.86)	0.03664 (1.63)	-0.03619 (-0.58)
Impairment	2948 (1749)	0.00008 (2.67)	0.00022 (3.64)	-0.00050 (-1.40)	-0.00050 (-10.64)	0.00001 (0.38)	-0.00009 (-0.72)
Parents' longevity	0.8171 (0.39)	0.04024 (0.38)	-0.37340 (-1.29)	-0.64910 (-1.50)	0.05680 (0.40)	0.35890 (1.38)	-0.78710 (-1.55)
Blue collar	0.7244 (0.45)	-0.13400 (-1.36)	0.00713 (0.03)	-0.16390 (-0.34)	0.15700 (1.16)	-0.07037 (-0.34)	0.54010 (0.95)
Industry	0.6927 (0.46)	0.38230 (3.97)	-0.21560 (-0.81)	0.43020 (0.88)	-0.12960 (-0.97)	-0.38310 (-1.90)	-1.72000 (-3.26)
Wage	227.6 (97.81)	-0.00059 (-1.29)	-0.00061 (-0.43)	0.00131 (0.64)	0.00053 (0.91)	0.00091 (0.95)	0.00105 (0.42)
Pension	0.7194 (0.45)	-0.26820 (-2.76)	-0.65400 (-2.36)	0.44930 (0.71)	0.30150 (2.23)	-0.22940 (-1.13)	0.23220 (0.38)
Constant	-	-4.74700 (-8.55)	-8.95000 (-5.25)	-4.22600 (-1.46)	-0.26620 (-0.36)	-5.10800 (-4.03)	-2.04900 (-0.59)
-2 ln likelihood	-	72.82	37.12	7.28	198.75	11.91	15.02
Events	-	605	66	25	354	132	18

Table A.3 Determinants of ln Incidence Rates in Retirement Model, 1971-1976: White Men

Determinant	Means (Standard deviations)	Estimated coefficients (asymptotic t-ratios)					
		Functional to disabled	Functional to death	Functional to follow-up loss	Disabled to functional	Disabled to death	Disabled to follow-up loss
Age	52.24 (3.90)	0.07411 (9.08)	0.11500 (2.33)	0.08867 (2.14)	0.03499 (3.36)	0.06533 (2.65)	0.01599 (0.38)
Impairment	2872 (1560)	0.00005 (1.94)	0.00015 (1.35)	0.00019 (2.35)	-0.00046 (-11.36)	0.00020 (5.59)	-0.00011 (-1.18)
Parents' longevity	0.7738 (0.42)	0.03850 (0.53)	1.12900 (1.86)	0.47690 (1.15)	0.04158 (0.44)	0.08766 (3.65)	0.92900 (1.75)
Blue collar	0.5000 (0.50)	0.04284 (0.64)	-0.44440 (-1.16)	-0.11510 (-0.34)	0.00494 (0.05)	-0.02944 (-0.14)	1.11200 (2.68)
Industry	0.6373 (0.48)	-0.02043 (-0.31)	0.84050 (2.06)	0.39610 (1.18)	0.00339 (0.04)	-0.11070 (-0.52)	0.14870 (0.38)
Schooling	10.31 (3.27)	-0.03276 (-3.33)	-0.03901 (-0.67)	-0.05084 (-1.00)	0.01789 (1.36)	0.01242 (0.41)	0.05533 (0.99)
Married, spouse present	0.8888 (0.31)	0.08684 (0.67)	0.12660 (0.17)	0.47470 (0.66)	0.36080 (2.20)	-0.11130 (-0.38)	0.69570 (0.95)
Unmarried, living with others	0.0399 (0.20)	0.08096 (0.42)	0.15190 (0.12)	0.23950 (0.19)	0.25360 (1.00)	0.08330 (0.18)	-0.02576 (-0.00)
Retirement status	0.6430 (0.48)	-1.52300 (-24.08)	9.61100 (0.29)	9.69700 (0.33)	-1.47900 (-17.42)	9.14700 (0.30)	9.57100 (0.19)
Constant	-	-4.82000 (-10.28)	-22.15000 (-0.66)	-20.08000 (-0.67)	-2.03200 (-3.36)	-17.31000 (-0.56)	-17.62000 (-0.35)
-2 ln likelihood	-	689.18	44.05	48.52	724.52	61.73	27.53
Events	-	1161	35	47	667	113	39

Table A.4 Determinants of ln Incidence Rates in Retirement Model, 1971-1981: Black Men

Determinant	Means (Standard deviations)	Estimated coefficients (asymptotic t-ratios)					
		Functional to disabled	Functional to death	Functional to follow-up loss	Disabled to functional	Disabled to death	Disabled to follow-up loss
Age	52.24 (3.72)	0.07158 (5.36)	0.43140 (3.62)	0.87120 (0.08)	0.03576 (1.96)	0.09470 (2.64)	-0.19480 (-1.68)
Impairment	3065 (1801)	0.00006 (1.54)	0.00012 (0.71)	-0.01051 (-0.14)	-0.00042 (-7.45)	0.00005 (0.95)	0.00001 (0.06)
Parents' longevity	0.8209 (0.38)	0.14440 (1.20)	-0.00426 (-0.00)	-10.84000 (-0.18)	0.15820 (0.95)	0.48080 (1.25)	-0.57300 (-0.61)
Blue collar	0.6652 (0.47)	-0.19980 (-1.93)	0.34610 (0.48)	-3.97500 (-0.03)	0.18910 (1.28)	0.07503 (0.29)	1.66800 (1.44)
Industry	0.7070 (0.46)	0.30710 (2.76)	0.62470 (0.81)	0.16020 (0.00)	-0.13390 (-0.84)	-0.48070 (-1.76)	-2.16200 (-2.39)
Schooling	6.774 (3.77)	-0.02370 (-1.85)	-0.06768 (-0.80)	0.61090 (0.04)	0.01109 (0.62)	0.03273 (0.95)	0.00895 (0.08)
Married, spouse present	0.7296 (0.44)	0.09239 (0.77)	-0.62940 (-0.99)	3.43200 (0.03)	-0.04141 (-0.25)	-0.22090 (-0.76)	9.14400 (0.09)
Unmarried, living with others	0.0887 (0.28)	0.36840 (1.95)	-9.18000 (-0.00)	5.68500 (0.03)	-0.14860 (-0.60)	-0.45950 (-0.81)	9.00100 (0.09)
Retirement status	0.6017 (0.49)	-1.26400 (-12.40)	9.19000 (0.23)	7.72600 (0.10)	-1.39200 (-9.91)	9.22500 (0.23)	9.59500 (0.08)
Constant	-	-5.01600 (-6.69)	-37.44000 (0.91)	-53.30300 (0.08)	-1.86600 (-1.85)	-18.14000 (-0.45)	-14.15000 (-0.09)
-2 ln likelihood	-	220.94	39.88	11.94	265.07	32.55	14.85
Events	-	487	13	1	256	67	6

Table A.5 Determinants of ln Incidence Rates in Human Capital Model, 1971-1981: White Wage and Salary Earners

Determinant	Means (Standard deviations)	Estimated coefficients (asymptotic t-ratios) Functional to disabled	Functional to death	Functional to follow-up loss	Disabled to functional	Disabled to death	Disabled to follow-up loss
Age	51.48 (4.25)	0.04599 (6.63)	0.06286 (2.51)	0.05917 (2.77)	-0.02622 (-3.02)	0.05768 (3.50)	-0.01845 (-0.68)
Impairment	2849 (1498)	0.00011 (5.08)	0.00020 (3.42)	0.00016 (2.71)	-0.00058 (-15.80)	0.00005 (1.55)	-0.00018 (-2.45)
Parents' longevity	0.7674 (0.42)	0.13830 (2.00)	-0.15960 (-0.69)	0.02599 (0.13)	-0.03075 (-0.03)	-0.02733 (-0.16)	0.25550 (0.86)
Blue collar	0.5583 (0.50)	0.11150 (1.62)	-0.30850 (-1.30)	0.25780 (1.18)	-0.07831 (-0.89)	-0.21040 (1.35)	0.27910 (0.99)
Industry	0.6386 (0.48)	-0.00014 (-0.00)	0.62220 (2.47)	0.02370 (0.11)	-0.05700 (-0.68)	0.02833 (0.18)	0.25640 (0.92)
Schooling	10.45 (3.33)	-0.03207 (-3.04)	0.00288 (0.08)	-0.01503 (-0.46)	0.00859 (0.63)	-0.02418 (-1.00)	0.03348 (0.79)
Wage	346.7 (18.56)	-0.00044 (-2.32)	-0.00186 (-2.28)	-0.00002 (-0.03)	0.00021 (1.08)	-0.00099 (-1.83)	-0.00038 (-0.47)
Marital status	0.9364 (0.24)	0.07646 (0.63)	-0.28270 (-0.75)	0.11160 (0.28)	0.06944 (0.45)	-0.06602 (-0.27)	0.38610 (0.74)
Job satisfaction	0.9220 (0.27)	-0.14490 (-1.36)	0.34240 (0.74)	-0.00150 (0.00)	-0.10760 (-0.82)	0.07622 (0.31)	-0.63150 (-2.00)
Constant	-	-4.28200 (-10.34)	-7.95100 (-5.31)	-7.84400 (-6.08)	1.01900 (1.90)	-5.93000 (-5.75)	-3.31400 (-1.97)
-2 ln likelihood	-	135.77	29.18	18.54	424.58	27.70	15.51
Events	-	1244	95	130	757	217	80

Table A.6 Determinants of ln Incidence Rates in Human Capital Model, 1971-1981: Black Wage and Salary Earners

Determinant	Means (Standard deviations)	Estimated coefficients (asymptotic t-ratios) Functional to disabled	Functional to death	Functional to follow-up loss	Disabled to functional	Disabled to death	Disabled to follow-up loss
Age	51.65 (4.08)	0.05550 (5.33)	0.12630 (4.04)	-0.00385 (-0.07)	-0.01664 (-1.24)	0.04397 (1.93)	-0.04574 (-0.73)
Impairment	2954 (1757)	0.00008 (2.62)	0.00022 (3.77)	-0.00044 (-1.28)	-0.00050 (-10.62)	0.00002 (0.58)	-0.00008 (-0.65)
Parents' longevity	0.8171 (0.39)	0.03528 (0.33)	-0.37180 (-1.29)	-0.58440 (-1.34)	0.02963 (0.21)	0.28110 (1.07)	-0.66580 (-1.20)
Blue collar	0.7231 (0.45)	-0.17570 (-1.72)	0.09863 (0.33)	-0.06653 (-0.13)	0.15930 (1.16)	-0.00272 (-0.00)	0.42400 (0.73)
Industry	0.6896 (0.46)	0.34250 (3.46)	-0.19210 (-0.69)	0.48480 (0.98)	-0.11800 (-0.86)	-0.33110 (-1.56)	-1.93300 (-3.38)
Schooling	7.146 (3.78)	-0.02602 (-2.23)	0.01473 (0.42)	0.03359 (0.57)	0.00933 (0.56)	0.02988 (1.11)	-0.04031 (-0.53)
Wage	227.6 (97.78)	-0.00068 (-1.48)	-0.00189 (-1.26)	0.00116 (0.57)	0.00089 (1.53)	0.00045 (0.46)	0.00243 (0.92)
Marital status	0.8480 (0.36)	-0.10720 (-0.95)	-0.20420 (-0.63)	-0.35210 (-0.70)	-0.08571 (-0.56)	-0.33770 (-1.48)	-0.43090 (-0.66)
Job satisfaction	0.9350 (0.25)	-0.32410 (-2.01)	-0.71080 (-1.64)	9.74900 (0.08)	0.13330 (0.57)	-0.71750 (-2.79)	0.16790 (0.16)
Constant	-	-4.18800 (-6.92)	-9.60300 (-5.33)	-1.35900 (-0.11)	0.03368 (0.04)	-4.84900 (-3.63)	-1.19700 (-0.33)
-2 ln likelihood	-	72.27	36.53	9.65	194.17	19.34	15.33
Events	-	596	65	25	349	131	17

Table A.7 Determinants of ln Incidence Rates in Demographic Model, 1971-1981: White and Black Men

Determinant	Means (Standard deviations)	Estimated coefficients (asymptotic t-ratios)					
		Functional to disabled	Functional to death	Functional to follow-up loss	Disabled to functional	Disabled to death	Disabled to follow-up loss
Age	51.72 (4.23)	0.05450 (10.99)	0.09088 (5.26)	0.02650 (1.53)	-0.02628 (-4.22)	0.05425 (5.04)	-0.01567 (-0.77)
Impairment	2936 (1626)	0.00007 (4.77)	0.00021 (6.06)	0.00005 (0.75)	-0.00059 (-23.77)	0.00002 (0.89)	-0.00021 (-3.70)
Parents' longevity	0.7788 (0.42)	0.08618 (1.71)	-0.19960 (-1.19)	0.01212 (0.07)	0.00105 (0.00)	0.17510 (1.51)	0.11080 (0.51)
Race	0.2838 (0.45)	0.09060 (1.86)	0.41750 (2.56)	-0.53660 (-2.55)	0.11300 (1.80)	0.22860 (2.30)	-.57550 (-2.43)
Marital status	0.8943 (0.31)	-0.02107 (-0.31)	-0.34940 (-1.68)	-0.13980 (-0.56)	0.09770 (1.10)	-0.28520 (-2.33)	-0.02051 (-0.07)
Duncan index	31.37 (23.27)	-0.00895 (-9.35)	-0.00875 (-2.55)	-0.00008 (-0.03)	0.00259 (2.07)	-0.00117 (-0.50)	0.00229 (0.56)
Geographic immobility	0.2450 (0.43)	0.00696 (0.14)	-0.07119 (-0.41)	-0.20230 (-1.10)	-0.09591 (-1.53)	-0.18060 (-1.72)	0.05885 (0.30)
Foreign born	0.0441 (0.21)	0.11120 (1.10)	-0.26500 (-0.68)	0.55410 (2.23)	0.17340 (1.37)	-0.14550 (-0.55)	-0.05175 (-0.11)
Constant	-	-4.65400 (-17.34)	-9.00800 (-9.66)	-5.64200 (-6.10)	0.88070 (2.58)	-6.09500 (-10.06)	-3.03400 (-2.70)
-2 ln likelihood	-	297.73	85.84	19.50	954.29	50.83	29.12
Events	-	2395	196	197	1461	515	134

Table A.8 Determinants of ln Incidence Rates in Demographic Model, 1971-1981: White Men

Determinant	Means (Standard deviations)	Estimated coefficients (asymptotic t-ratios) Functional to disabled	Functional to death	Functional to follow-up loss	Disabled to functional	Disabled to death	Disabled to follow-up loss
Age	51.65 (4.26)	0.05219 (8.86)	0.08048 (3.70)	0.03753 (2.01)	-0.02695 (-3.69)	0.04798 (3.64)	-0.01712 (-0.76)
Impairment	2865 (1515)	0.00007 (3.88)	0.00021 (4.65)	0.00009 (1.61)	-0.00063 (-19.93)	0.00005 (1.84)	-0.00021 (-3.24)
Parents' longevity	0.7635 (0.43)	0.09388 (1.60)	-0.10550 (-0.50)	0.09367 (0.51)	-0.02174 (-0.30)	0.08078 (0.59)	0.27980 (1.13)
Marital status	0.9183 (0.27)	0.00629 (0.07)	-0.14760 (-0.46)	0.06069 (0.19)	0.09045 (0.78)	-0.12850 (-0.72)	0.37600 (0.96)
Duncan index	36.55 (23.79)	-0.00909 (-8.75)	-0.00958 (-2.48)	-0.00182 (-0.58)	0.00302 (2.22)	-0.00190 (-0.73)	0.00039 (0.09)
Geographic immobility	0.2413 (0.43)	-0.03749 (-0.65)	0.10890 (0.52)	-0.21640 (-1.08)	-0.01614 (-0.22)	-0.29630 (-2.12)	0.11150 (0.51)
Foreign born	0.0593 (0.24)	-0.12890 (-1.25)	-0.16090 (-0.41)	0.48620 (1.90)	0.18150 (1.39)	-0.24580 (-0.86)	-0.02757 (-0.06)
Constant	-	-4.55000 (-14.26)	-8.73800 (-7.40)	-6.49100 (-6.43)	1.00300 (2.50)	-5.90000 (-7.97)	-3.41000 (-2.71)
-2 ln likelihood	-	187.10	36.41	13.40	676.32	25.20	16.45
Events	-	1687	122	167	1046	326	110

Table A.9 Determinants of ln Incidence Rates in Demographic Model, 1971-1981: Black Men

Determinant	Means (Standard deviations)	Estimated coefficients (asymptotic t-ratios) Functional to disabled	Functional to death	Functional to follow-up loss	Disabled to functional	Disabled to death	Disabled to follow-up loss
Age	51.89 (4.14)	0.06064 (6.52)	0.10980 (3.83)	-0.01922 (-0.41)	-0.02438 (-2.03)	0.06752 (3.58)	-0.00916 (-0.18)
Impairment	3117 (1865)	0.00007 (2.69)	0.00021 (3.78)	-0.00054 (-1.62)	-0.00053 (-13.04)	-0.00002 (-0.66)	-0.00020 (-1.72)
Parents' longevity	0.8174 (0.39)	0.07074 (0.71)	-0.37560 (-1.38)	-0.54310 (-1.34)	0.05264 (0.41)	0.39560 (1.81)	-0.57380 (-1.27)
Marital	0.8336 (0.37)	-0.06533 (-0.63)	-0.49140 (-1.78)	-0.63470 (-1.46)	0.09559 (0.69)	-0.45380 (-2.65)	-0.75750 (-1.67)
Duncan index	18.32 (15.55)	-0.00864 (-3.38)	-0.00348 (-0.45)	0.01044 (1.16)	-0.00000[a] (-0.00)	0.00173 (0.33)	0.01660 (1.39)
Geographic immobility	0.2546 (0.44)	0.11870 (1.36)	-0.43710 (-1.33)	-0.14170 (-0.31)	-0.29770 (-2.52)	-0.01680 (-0.10)	-0.17670 (-0.37)
Foreign born	0.0057 (0.08)	0.09235 (0.18)	-9.73400 (-0.04)	1.86400 (1.69)	0.32990 (0.56)	0.72660 (1.00)	-9.90500 (-0.03)
Constant	-	-4.85800 (-9.69)	-9.35200 (-6.00)	-2.02800 (-0.83)	0.76860 (1.18)	-6.55800 (-6.16)	-3.10400 (-1.12)
-2 ln likelihood	-	75.06	36.33	12.87	285.01	25.69	10.22
Events	-	708	74	30	415	189	24

[a]Less than 0.000005.

Table A.10 Determinants of ln Incidence Rates in Demographic Model, 1971-1981: White and Black Men Age 55-59 in 1971 and 1976

		Estimated coefficients (asymptotic t-ratios)					
Determinant	Means (Standard deviations)	Functional to disabled	Functional to death	Functional to follow-up loss	Disabled to functional	Disabled to death	Disabled to follow-up loss
Impairment	2872 (1579)	0.00011 (4.42)	0.00029 (5.34)	-0.00009 (-0.69)	-0.00066 (-14.93)	-0.00010 (-2.24)	-0.00018 (-2.06)
Parents' longetivy	0.7556 (0.43)	0.17870 (2.24)	-0.23290 (-0.87)	-0.20590 (-0.89)	0.10280 (0.95)	-0.23870 (-1.28)	-0.12590 (-0.40)
Race	0.2761 (0.45)	0.06941 (0.89)	0.36340 (1.37)	-0.19320 (-0.68)	-0.01892 (-0.18)	0.18580 (1.03)	-0.09254 (-0.27)
Marital status	0.8963 (0.31)	-0.14800 (-1.35)	-0.60710 (-1.83)	-0.51080 (-1.56)	0.09704 (0.64)	-0.49530 (-2.38)	0.08809 (0.18)
Duncan index	31.80 (23.35)	-0.00864 (-5.41)	-0.00944 (-1.55)	0.00159 (0.35)	0.00330 (1.59)	0.00059 (0.14)	0.00770 (1.23)
Geographic immobility	.2514 (0.43)	0.01474 (0.19)	0.09828 (0.36)	-0.50690 (-1.71)	-0.01659 (-0.16)	0.06549 (0.36)	-0.13150 (-0.39)
Foreign born	0.0389 (0.19)	-0.15230 (-.84)	-0.88370 (-0.87)	0.58740 (1.54)	0.09928 (0.45)	0.74440 (2.11)	0.17440 (0.24)
1971 cohort	0.5542 (0.50)	-0.12780 (-1.91)	0.12470 (0.51)	-0.00127 (-0.00)	0.13270 (1.47)	0.42930 (2.55)	-0.16230 (-0.57)
Constant	-	-1.90700 (-12.34)	-4.46000 (-9.08)	-3.46100 (-6.75)	-0.42230 (-1.83)	-2.72400 (-7.96)	-3.86800 (-5.78)
-2 ln likelihood	-	77.83	32.50	10.67	369.56	25.45	9.42
Events	-	922	72	90	518	157	53

Table A.11 Determinants of ln Incidence Rates in Demographic Model, 1971-1981: White and Black Men Age 60-64 in 1971 and 1976

Determinant	Means (Standard deviations)	Estimated coefficients (asymptotic t-ratios)					
		Functional to disabled	Functional to death	Functional to follow-up loss	Disabled to functional	Disabled to death	Disabled to follow-up loss
Impairment	3130 (1827)	0.00007 (2.65)	0.00025 (4.56)	0.00005 (0.40)	-0.00063 (-14.37)	0.00006 (2.08)	-0.00025 (-2.69)
Parents' longevity	0.8179 (0.39)	0.09913 (1.07)	0.11790 (0.37)	0.18720 (0.56)	-0.16600 (-1.50)	0.30910 (1.52)	1.08300 (2.08)
Race	0.2996 (0.46)	0.12930 (1.58)	0.14140 (0.49)	-0.94530 (-2.24)	0.22500 (2.09)	0.20000 (1.28)	-0.93350 (-2.44)
Marital status	0.8845 (0.32)	-0.00311 (-0.03)	0.12230 (0.30)	1.02400 (1.41)	0.13760 (0.96)	-0.08508 (-0.42)	-0.12160 (-0.30)
Duncan index	30.33 (23.15)	-0.01067 (-6.46)	-0.00694 (-1.26)	-0.00312 (-0.59)	0.00307 (1.39)	-0.00205 (-0.52)	-0.00759 (-1.04)
Geographic immobility	0.2416 (0.43)	-0.00954 (-0.12)	-0.31210 (-0.99)	-0.00453 (-0.00)	-0.09643 (-0.88)	-0.17120 (-1.03)	0.34570 (1.18)
Foreign born	0.0493 (0.22)	-0.02223 (-0.14)	0.27520 (0.58)	0.61310 (1.57)	0.19550 (0.95)	-0.62700 (-1.23)	-0.19390 (-0.26)
1971 cohort	0.4972 (0.50)	-0.15130 (-2.17)	-0.15110 (-0.63)	-0.08670 (-0.35)	0.01084 (0.12)	-0.02778 (-0.20)	0.22150 (0.81)
Constant	-	-1.53000 (-9.33)	-4.68800 (-8.45)	-5.19700 (-6.15)	-0.44280 (-2.03)	-3.64000 (-11.13)	-4.29200 (-5.87)
-2 ln likelihood	-	85.71	20.01	14.07	346.26	14.62	23.44
Events	-	834	70	64	492	204	54

The Center has also been active in manpower planning both in the U.S. and in the developing countries. A project for the Ohio Advisory Council for Vocational Education identified the highly fragmented institutions and agencies which supply vocational and technical training in Ohio. Subsequent projects for the Ohio Occupational Information Coordinating Committee have followed graduates of these programs. These data and information on occupational distributions of employers collected for the Occupational Employment Statistics Program are being integrated into a comprehensive planning model which will be accessible to trainees and employers and linked to a national network.

Another focus of the Center's research is industrial relations and collective bargaining. In a project for the U.S. Department of Labor, staff members are working with unions and management in a variety of industries to evaluate several current experiments for expedited grievance procedures. The procedural adequacies, safeguards for due process, and cost and timing of the new procedure are being weighed against traditional arbitration techniques.

Senior staff also serve as consultants to many boards and commissions at the national and state level. Recently the Center's staff have produced papers and prepared testimony for the Department of Labor, the Vice President's Task Force on Youth Unemployment, the Joint Economic Committee of Congress, the National Commission for Employment and Unemployment Statistics, the National Commission for Employment Policy, the White House Conference on the Family, the Ohio Department of Corrections, the Ohio Board of Regents, the Ohio Governor's Task Force on Health, and the Ohio Governor's Task Force on Welfare.

The Center maintains a working library of approximately 10,000 titles, including a wide range of reference works and current periodicals, as well as an extensive microfilm and microfiche collection. Through their facilities linked to the University computer, the Center's data processing staff provide statistical, technical, and programming support both for in-house researchers and the over 250 users of the National Longitudinal Surveys data tapes. They maintain the NLS tapes, data base, documentation, and associated software.

For information on specific Center activities, write: Director, Center for Human Resource Research, 5701 North High Street, Worthington, Ohio 43085.

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The Ohio State University

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Center for Human Resource Research

The Center for Human Resource Research is a policy-oriented multidisciplinary research organization affiliated with The Ohio State University. Established in 1965, the Center is concerned with a wide range of contemporary problems related to developing and conserving human resources. Its more than thirty senior staff members come from disciplines including economics, education, English, health sciences, industrial relations, management science, psychology, public administration, social work, and sociology. This multidisciplinary team is supported by approximately 70 graduate research associates, full-time research assistants, computer programmers, and other personnel.

The Center has become preeminent in the fields of labor market research and manpower planning. With continuing support from the United States Department of Labor, the Center has been responsible since 1965 for the National Longitudinal Surveys of Labor Market Experience. Staff have assisted in population and human resource planning throughout the world, having conducted major studies in Bolivia, Ecuador, Kenya, Sierra Leone, Venezuela, and Zaire. At the request of the National Science Foundation, a review of the state of the art in human resource planning was conducted. Other studies have assessed the impact of labor and education policy on labor supply and evaluated employment statistics collection methods. Senior personnel are also engaged in several other areas of research—collective bargaining and labor relations, evaluation and monitoring of the operation of government employment and training programs, and the projection of health education and facility needs.

The Center for Human Resource Research has received over two million dollars annually from government agencies and private foundations to support its research in recent years. Providing support have been the U.S. Departments of Labor, State, Defense, Education, Health and Human Services; Ohio's Health and Education Departments and Bureau of Employment Services; the Ohio cities of Columbus and Springfield; the Ohio AFL-CIO; the George Gund Foundation; the Rockefeller Foundation; and the Ford Foundation. The breadth of the Center's research interests is best illustrated by a brief review of a few of its current projects.

The Center's largest project is the National Longitudinal Surveys of Labor Market Experience. This project has involved repeated interviews over a fifteen-year period with four groups of the United States population: older men, middle-aged women, and young men and women. The data are collected for 20,000 individuals by the U.S. Bureau of the Census, and the center is responsible for data analysis. Since 1979, the NLS has followed an additional cohort of 13,000 young men and women between the ages of 14 and 21. This cohort includes for the first time those serving in the armed forces at the time of the initial interview. In addition to being the definitive U.S. national data set on the labor market activities of young adults, this continuing survey includes unique batteries of questions on such socially important issues as delinquency, alcohol and drug use, fertility, and prenatal care. For this cohort, field work is handled by the National Opinion Research Center. To date the Center's staff have prepared dozens of research monographs, special reports, and books on the NLS, and they also prepare and distribute data tapes for public use.

The Quality of Work Life Project, another ongoing study, began in 1975 as an attempt to improve the productivity and the meaningfulness of work for public employees in the cities of Springfield and Columbus. Center staff also served as third party advisers and researchers exploring new techniques for attainment of management-worker cooperation and worker health in a number of central Ohio private sector industries.

(Continued on inside back cover)