THE ROLE OF EDUCATION IN EXPLAINING AND FORECASTING TRENDS IN FUNCTIONAL LIMITATIONS AMONG OLDER AMERICANS*

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Using the Survey of Income and Program Participation, we document the importance of education in accounting for declines in functional limitations among older Americans from 1984 to 1993. Of the eight demographic and socioeconomic variables considered, education is most important in accounting for recent trends. The relationship between educational attainment and functioning has not changed measurably, but educational attainment has increased greatly during this period. Our analysis suggests, all else being equal, that future changes in education will continue to contribute to improvements in functioning, although at a reduced rate.

Accurate forecasts of changes in older Americans' survival and health are critical for planning for the retirement of the baby boom and the future of Social Security and Medicare. Life expectancy at birth and at age 65 have increased substantially in recent decades, but there is considerable debate about whether we can expect those trends to continue (Wilmoth 1997). Also controversial is whether such improvements in survival at older ages are accompanied by improvements in the survivors' health (Agree and Freedman 1999).

Significant effort has been devoted to modeling and forecasting changes in mortality (see Stoto and Durch 1993). Work on broader health trends has been more limited because (1) substantial complexities are involved in measuring health status; (2) mathematical regularities in patterns of morbidity across countries and decades have not been identified; and (3) uncertainty persists about past health trends, even over the last few decades.

Accordingly, a particular focus of recent work has been to document trends in older Americans' functioning (Crimmins, Saito, and Reynolds 1997; Freedman and Martin 1998; Manton, Corder, and Stallard 1993, 1997). Crimmins and colleagues (1997), for example, examine trends in disability using two nationally representative data sources, and obtain mixed results. In contrast, Manton and colleagues (1993, 1997) and Freedman and Martin (1998) find strong evidence of declines in disability and in functional limitations, respectively, in the 1980s and early 1990s. Thus, although the results are not uniform, there is a growing consensus that disability among the elderly has recently declined.

Is it reasonable to expect declines to continue in the coming decades? One way to gain insight into the future is to understand more clearly the factors responsible for recent trends. In a separate study we found that large improvements from 1984 to 1993 in functional limitations—difficulties with bodily actions such as seeing, lifting, climbing, and walking—were explained in part by shifts in the demographic and socioeconomic composition of the older population (Freedman and Martin 1998). A lingering issue not addressed by that work is the relative importance of these demographic and socioeconomic factors in explaining past trends. Further, we did not attempt to formally decompose changes in functioning into changes in the *composition* of the population and changes in the *effect* of various factors on functioning.

The purpose of this paper is to understand more fully why functioning has improved in the recent past and whether declines will continue in the coming decades. We focus on the relative importance of education in explaining recent improvements in functioning.

We highlight the role of education for several reasons. First, education is strongly associated with many health-related behaviors over the life cycle, which frequently are not measured directly in nationally representative surveys. Further, unlike some other measures of socioeconomic status such as occupation and income, education is measured easily, and generally is fixed for each individual relatively early in life. As a result, health problems that emerge in late life are unlikely to influence educational attainment. Also, accurate forecasts of educational attainment (unlike those of wealth, for example) are possible several decades into the future. Finally, the educational attainment of the elderly has increased substantially in recent decades and is projected to continue increasing well into the next century. Thus a focus on education is useful for assessing future directions of functioning in the older population.

The aims of this paper are twofold. First, we investigate the importance of educational attainment, relative to other demographic and socioeconomic factors, in explaining recent improvements in older Americans' functioning. Second, we examine the potential for future improvements in functioning, given projected changes in educational composition and possible changes in the effects of education on functioning.

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BACKGROUND

Conceptual Framework

A large body of literature provides evidence of a strong positive cross-sectional relation between adult health and socioeconomic status, particularly as measured by education. For example, an association between education and well-being at adult ages was found in the classic study of differential mortality in 1960 by Kitagawa and Hauser (1973), in Elo and Preston's (1996) update on mortality differentials from 1979 to 1985, and in studies of broader measures of health (see, for example, House et al. 1990; Ross and Wu 1995, 1996). Nearly all of the cited studies show a substantial relationship between education and health for the oldest age groups, although the association diminishes with age in some (Elo and Preston 1996; House et al. 1990; Kitagawa and Hauser 1973) and increases in others (Ross and Wu 1996).

In this paper we focus on late-life functional limitations. By *functional limitations* we mean difficulty in performing basic physical actions such as seeing, bending, reaching, stooping, kneeling, lifting, carrying, climbing, and walking (Nagi 1965, 1991). Following Verbrugge (1990), we make a further conceptual distinction between two types of functional limitations: *intrinsic* and *actual*. The former refers to difficulty in performing a task without assistance from persons or devices; the latter refers to difficulty even with assistance.

As highlighted by the Institute on Medicine's (IOM's) model of the disablement process (Pope and Tarlov 1991), functioning in this context is conceptually distinct from disease, injury, and impairment, which involve abnormal function at the cellular or organic level rather than at the level of the organism. Functional limitations, however, are closer to underlying pathology than are measures of disability, such as activities of daily living (ADLs) and instrumental activities of daily living (IADLs). Compared with such measures of disability, which focus on an individual's ability to perform specific roles or activities, functional limitations are less susceptible to environmental and sociocultural influences.

The relationship between education and late-life functioning is complex, involving numerous indirect causal pathways. Drawing on the IOM model of the disablement process (Pope and Tarlov 1991) and the review by Preston and Taubman (1994), we sketch three main pathways in Figure 1. First, education, along with other socioeconomic, demographic, and cultural factors, operates on intrinsic functioning through its effects on more proximate determinants of disease, injury, and impairment. For example, education as a proxy for economic resources is probably related to access to health care throughout life, which in turn influences the onset of disease at both younger and older ages. Greater education also may reflect greater personal endowments obtained through more positive early life experiences, including early preventive care and fewer risky behaviors that influence health in later years.[1] Further, because more highly educated people can be expected to live longer than others, they may have a greater incentive to preserve health or to delay gratification by avoiding high-risk behaviors such as smoking and excessive drinking. Education is also related to occupational history and social standing; both of these are related to stress and environmental exposures, which in turn are related to health outcomes.

Second, education may influence more proximate determinants of the expression of disease as intrinsic functional limitations, namely behavioral risk factors and medical treatments. For example, more highly educated people might be expected to have greater knowledge about their health, including the risks associated with different behaviors, and to be more able to marshal resources to optimize their health outcomes. Indeed, education may directly influence an older person's ability to navigate the health care system, particularly in a managed care setting, where referrals are needed for specialty care. Third, education may affect actual functioning through its influence on personal care and use of assistive devices, including access to such assistance.

Thus the relation between education and functioning is complex, operating along these and other pathways. The potential complexity is even greater when one considers the stochastic nature of functional limitations. Prevalence of a functional limitation in a population at a given time reflects the processes of onset and recovery, as well as differential mortality associated with the limitation. In the cross-section, education could be associated with each of these processes in different ways.

Unfortunately, data are not available for a full model of the causal pathways and processes through which education affects functioning in late life. Instead, then, we focus on the *net* effect of changes in education in explaining past trends and on the consequences of these relationships for future trends in the prevalence of functional limitations. Education in this context is thus a proxy for a variety of behavioral and environmental risk factors, health-seeking and health-care utilization behaviors, and early-life experiences.

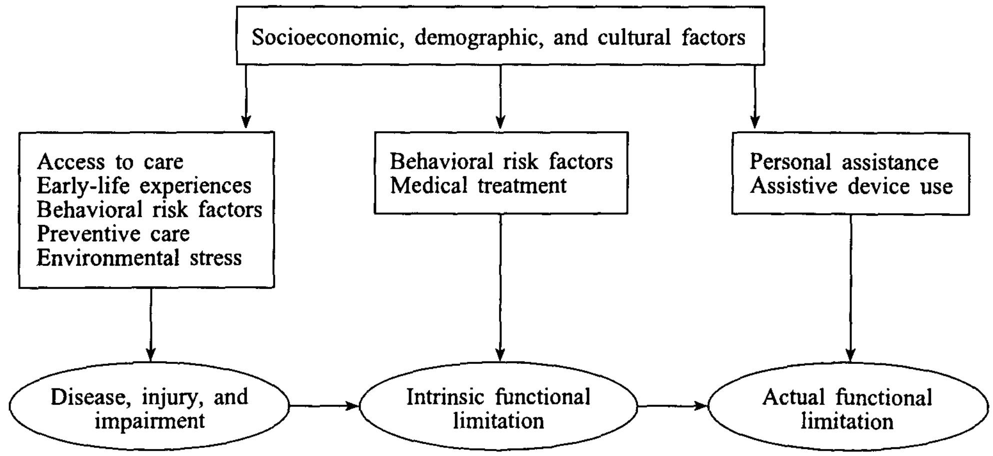
Trends in Educational Composition and Educational Effects on Health

Compositional changes in older Americans' educational attainment over the past decade are well documented. In 1980, for example, only 39% of older Americans had graduated from high school (U.S. Bureau of the Census 1984); a decade later, this figure had risen to over 50% (U.S. Bureau of the Census 1994).

In contrast, we have little evidence showing how the effects of education on health have changed over time. Preston and Taubman (1994) cite evidence for widening socioeconomic differentials in mortality in western countries

1. Of course, education may reflect childhood health environment, which directly affects adult health; thus the direct effects of education on adult health may be overestimated (Elo and Preston 1996:53).

FIGURE 1. POTENTIAL PATHWAYS FROM EDUCATION TO LATE-LIFE FUNCTIONING



in recent decades but do not present information on morbidity or disability patterns per se. Similarly, Clark (1997) shows widening racial disparities in disability among older Americans; this finding suggests that disparities also may have widened across socioeconomic strata. In contrast, 1982 and 1989 data on older disabled Americans, presented by Manton and Stallard (1997), show no discernible trend in education differentials.

Future shifts in older Americans' educational attainment are also relatively clear-cut. The proportion of the older population with high school diplomas is expected to reach 83% by 2030 (U.S. Bureau of the Census 1996). There is less certainty about the direction of future changes in the relationship between health benefits and additional years of education. It may be, for example, that as the high school graduate population becomes larger and more heterogeneous, the advantage conveyed by additional years of education will dissipate. Such a dissipation might occur because relative status—as opposed to absolute status—is important (Marmot 1998) or because the quality of education may have declined over time. Conversely, education may be even more important in determining positive health outcomes in the future, given the increasingly elaborate medical protocols for preventing and treating health conditions and for managing disability, and the increasingly complex utilization rules imposed by insurers paying for such care.

Given the importance of education in shaping late-life health and functioning, and the large shifts in educational attainment in the older population, it is reasonable to expect that education may be responsible in part for recent improvements in older Americans' functioning. Here we probe this issue further by addressing three specific questions about the role of education in recent and future trends in functioning:

How important is education relative to other demographic and socioeconomic factors in explaining past trends?

How much of the improvement in functioning is due to changes in the educational composition of the older population? How much is due to changes in the health advantages of greater education?

All else being equal, how will impending shifts in educational composition affect future trends? Could these effects be offset by changes in the health benefits of education?

METHODS

Data

We use data from the 1984 and 1993 panels of the Survey of Income and Program Participation (SIPP) (U.S. Bureau of the Census 1991). The SIPP is a nationally representative household-based survey of the U.S. noninstitutionalized population. Each year since 1984, a new panel has been selected and followed for more than two years with in-person interviews once every four months. In four of the panels (1984, 1990, 1991, and 1993), a detailed topical module on health and disability was administered at the third contact (LaPlante 1992; U.S. Bureau of the Census 1986).[2] Because changes in the prevalence of functioning over one- or two-year intervals are quite small, we decompose changes that occur over the full nine-year period, from

2. In a comparative study of disability questions, Wiener, Hanley, and Clark (1990) found that estimates based on the 1984 SIPP were similar to those from the 1984 Supplement on Aging despite differences in survey design and administration.

1984 to 1993.[3] We focus on the 65-and-over population, for which we have a sample of 5,898 in 1984 and 6,141 in 1993.

We analyzed several potential threats to the validity of our trend estimates that might stem from differential survey administration and coverage: loss to follow-up, imputation for functional limitation measures, proxy reporting, the relative size of the institutional population, and changes in question wording. In general, we found relatively small changes over time in the administration of the SIPP, and none that we believe would substantially affect the validity of our analysis.

Measures

Four self-assessed measures of functional limitations were obtained in the same way in the 1984 and the 1993 SIPP with the following questions: Does...have any difficulty

> Seeing the words and letters in ordinary newspaper print, even when wearing glasses or contact lenses if...usually wears them?
>
> Lifting and carrying something as heavy as ten pounds, such as a full bag of groceries?
>
> Climbing a flight of stairs without resting?
>
> Walking a quarter of a mile—about three city blocks?

The only important difference in question wording between the two years is that in 1984, before questions on difficulty lifting, climbing, and walking, if the reference person used special aids, interviewers were instructed parenthetically to ask about the person's ability to perform the activity while using the special aids. In 1993, no such instruction was included. Thus questions about lifting, climbing, and walking in 1984 directed the interviewer to ask about actual functioning. In contrast, the 1993 questions were ambiguous with respect to the distinction between intrinsic and actual functioning.[4] In both 1984 and 1993 the question about difficulty seeing referred explicitly to actual functioning.

The SIPP measured educational attainment in identical fashion in both years. Respondents were asked to name the highest grade of school attended, and then to state whether that grade had been completed. In analyses presented here, we distinguish three levels of completed education: less than high school graduation, high school graduation, and more than high school. Alternative codings did not increase our substantive understanding; we did not uncover important nonadditive effects.

The SIPP also provides consistent measures, over time, of seven additional demographic and socioeconomic characteristics of older people that we expect to be related to functioning: age, sex, race, ethnicity, marital status, financial assets, and region. We expect, all else being equal, that older females will have higher rates of limitations (Crimmins et al. 1997). We also expect to find an age gradient in difficulty functioning. For our analysis, we use five-year age groups: 65–69, 70–74, 75–79, and 80 and over.

There is also considerable evidence of health differentials according to older Americans' marital status, although the mechanisms by which marriage confers benefit (e.g., higher income, less risk taking, more social support) are subject to debate (Lillard and Waite 1995). Moreover, such differentials may reflect selection as well as protection effects (Goldman 1993). In this analysis, we classify individuals as married, widowed, separated or divorced, and never married.

The influences of race and ethnicity on health and disability are also complex, are intertwined with that of education, and are the subject of much debate (Manton and Stallard 1997; Markides et al. 1997; Smith and Kington 1997). Blacks and Hispanics tend to have poorer health, although the term *Hispanic* may mask considerable diversity. Health also varies considerably among Asians and Pacific Islanders in the United States. For the purposes of our analysis, we are able to distinguish only among whites, blacks, and others and between Hispanic and non-Hispanic.

We also include in our analysis an indicator of ownership of financial assets. Smith (1995a) observes that *amounts* of financial resources are reported poorly in the SIPP, but that the fact of *ownership* of a particular type of asset is reported fairly well. Moreover, ownership of liquid financial assets discriminates surprisingly well among older Americans. For example, Smith (1995b) found that in the 70-and-over population, more than 10% of whites and more than 50% of blacks and Hispanics have no financial assets. Accordingly, in our analysis we use a measure of ownership of liquid financial assets that refers to ownership of savings accounts, certificates of deposit, money market accounts, or interest-bearing checking accounts.

Finally, we control for residence in one of the four census regions: the Northeast, the Midwest, the South, and the West. Geographic differences in medical practice patterns have been well established, as have geographic differences in the health and functioning of the older population (Coroni-Huntley et al. 1990). Older persons living in the South are more likely than others to report chronic health problems (Adams and Marano 1995).

Statistical Approach

We draw on the standard decomposition framework (Kitagawa 1955) to assess the relative importance of the various demographic and socioeconomic characteristics in determin-

3. Analyses not shown here typically indicate larger declines in the six-year period from 1984 to 1990 than for the three-year period from 1990 to 1993. Also, in general, changes were statistically significant for the former period but not for the latter. We focus on the nine-year period to facilitate presentation and because we had no hypothesis about why a change should occur in the first period and not in the second, other than differences in interval length.

4. All things being equal, this difference potentially could lead to an underestimation of difficulty in 1984 relative to 1993, thereby reducing the estimated size of any improvement. Thus our estimates of trends in improvement would be conservative. Freedman and Martin's (1998) investigation of this difference in interviewers' instructions suggests that effects on estimates of difficulty walking are minimal because nearly all individuals using a mobility device (reported elsewhere in the survey for both years) also report difficulty walking.

ing past trends in functioning. This approach allows us to attribute changes in rates of functional limitations to changes in the composition of the population—"composition effects"—and to changes in the influences of those compositional factors on functioning—"rate effects."

For convenience, decomposition analysis involving multiple factors is most often conducted with a linear equation or linear regression. In the simplest case, let us suppose that there is only one factor of interest, education, and that we divide the population at a given time 1 into the proportion without (X_1) and with ($1 - X_1$) a high school education. Further, let us suppose that those with a high school education (the reference group) have no functional limitations but that the rate of functional limitations of those without a high school education is β_1. Then the overall rate of functional limitation at time 1, R_1, can be expressed as

$$R_1 = \beta_1 X_1. \tag{1}$$

As Kitagawa (1955) shows, the change in rate between time 1 and time 2 can be decomposed as

$$R_1 - R_2 = \beta_1 X_1 - \beta_2 X_2$$
$$= \frac{\beta_1 + \beta_2}{2}\left(X_1 - X_2\right) + \frac{X_1 + X_2}{2}\left(\beta_1 - \beta_2\right), \tag{2}$$

where the first term in the right-hand expression represents the composition effect and the second term represents the rate effect.

Das Gupta (1993) shows that the standard decomposition equation for two factors can be generalized to accommodate nonlinear specifications so that

$$R_1 - R_2 = \frac{\left(F\left(\beta_2, X_2\right) - F\left(\beta_1, X_2\right) + F\left(\beta_2, X_1\right) - F\left(\beta_1, X_1\right)\right)}{2}$$
$$+ \frac{\left(F\left(\beta_2, X_2\right) - F\left(\beta_2, X_1\right) + F\left(\beta_1, X_2\right) - F\left(\beta_1, X_1\right)\right)}{2}. \tag{3}$$

Further, Das Gupta (1993) shows that the decomposition approach can be generalized for any number of factors.

In this application we define $F(\beta_i, X_i)$ as a logistic regression function so that the probability of having difficulty with a specific function at time i is equal to $\exp(X_i'\beta_i)/(1 + \exp(X_i'\beta_i))$. We expand Eq. (3) to accommodate composition and rate effects for eight demographic and socioeconomic factors plus a residual (intercept) rate effect. Estimates of X_i are obtained from weighted tabulations of each of the variables of interest by year. We obtain estimates of β_i from weighted logistic regression models estimated separately for each of the functional limitation outcomes by year. Total effects for each variable of interest are calculated by summing composition and rate effects.

Although we did not conduct statistical tests for the decomposition analysis, we calculated p values for chi-square tests for differences in composition and changes in logistic regression coefficients over time. All statistical tests reported here have been corrected to take into account the complex sample design of the SIPP.

Projection Methodology

To illustrate the effects of future educational shifts on functioning, we calculate predicted rates of functional limitations based on our logistic model coefficients for 1993, on covariate distributions for 1993, and on our calculations of the educational distribution of future cohorts of older Americans for 2010, 2020, and 2030. These predicted rates assume no changes in other demographic and socioeconomic characteristics and assume static relationships between functioning and those factors. Thus we answer the question: All else being equal, what would be the effect of impending educational shifts on the rate of functional limitations in the older population?

Our projections of the future educational composition of the older population are based on data on age and education from the 1990 census. We project that the proportion of those 65 and older with less than a high school education will decline from 39.3% in 1993 to 18.0% in 2030, the proportion that are graduates will remain stable at about 30%, and the proportion with more than a high school education will almost double from 27.5% to 51.7%. In making these projections, we assume that the educational composition of the population age 45 to 79 in 1990 reflects the educational composition of the population age 65 to 99 in 2010. Similarly, we use the education of persons age 35 to 69 in 1990 to estimate the educational composition of the 65-to-99 group in 2020, and so on. Implicit in these projections is the assumption of nondifferential survival by educational level. If more highly educated people live longer than others (as is likely, given historic patterns), then the changes in the educational composition of the elderly population between 1990 and 2030 are likely to be even greater than those presented here. Had we based our projections on (say) the 25-to-54 population in 1990 (and thus on the 65-to-94 group in 2030), the change would have been even greater: The younger the population, generally the greater the educational attainment.

These illustrative predicted rates also assume no change in the future relationship between education and functioning. In an attempt to relax this assumption, we provide sensitivity analyses for a range of potential changes in education's effects on functioning. In analyzing potential future directions, a subtle but important distinction must be made between changes in the *disadvantage* associated with *lower* educational achievement and changes in the *advantage* associated with *greater* education. Because we use a nonlinear model, these effects are asymmetric. Changes in the former might include, for example, improvements in functioning in the less well-educated groups as the result of universal access to drugs or emulating healthier personal habits of the better-educated group. Changes in the advantage of higher education might involve, for example, further improvements in the diet and exercise habits of the better-educated group.

Unlike future educational composition, which is somewhat predictable, the direction and size of future education effects are unclear. Given this uncertainty, we provide a range of possible scenarios, changing education's effect on functioning by as much as ±100%. We selected our range of hypothetical values on the basis of changes observed for the period 1984 to 1993 and on the assumption that educational disparities could disappear but not reverse course.[5] (That is, having less than a high school education would not become protective against disability, and having more than a high school education would not become a liability.)

As our point of departure we use the calculations based on the projected educational composition for 2030 and the education coefficients from our logistic regression model for 1993. We then assume 10%, 25%, 50%, and 100% increases and decreases in the education advantage, calculated first by inflating and then by deflating the coefficients of the two lower education categories in models with more than high school as the reference category. We then inflate and deflate coefficients on the higher education categories from models with less than high school graduation as the reference category.[6] Although we cannot calculate the probability that future changes in educational effects will fall within this range, and although we do not provide statistically based confidence intervals, our illustrations are useful for understanding how large a change in educational effects will be necessary to offset impending compositional changes, and for assessing the potential influence of education on future trends in functioning.

RESULTS

Trends in Functioning

Overall rates of functional limitations are presented in Table 1 for the 65-and-older population in 1984 and 1993. A large and significant improvement was evident in all four functions. The greatest absolute change occurred for difficulty lifting and carrying a 10-pound weight, with a decline of 7.2 percentage points from 33.8% to 26.6%. Improvements in climbing stairs showed the smallest absolute change (4.0 percentage points) but still were substantial for a nine-year period.

Trends in Educational Composition

We also observe large changes in the educational composition of the older population over the nine-year period (see

TABLE 1. PREVALENCE OF FUNCTIONAL LIMITATIONS AMONG THE 65-AND-OVER POPULATION, 1984–1993, SURVEY OF INCOME AND PROGRAM PARTICIPATION

	Percentage With Difficulty			
Function	1984 (n = 5,898)	1993 (n = 6,141)	Change	p Value[a]
Seeing	21.7	16.8	–4.9	.000
Lifting and Carrying	33.8	26.6	–7.2	.001
Climbing Stairs	34.9	31.0	–4.0	.000
Walking 1/4 Mile	37.6	31.5	–6.1	.000

[a]The p values shown are for chi-square tests for differences in functional limitations across years. They have been adjusted to take into account the complex sample design of the SIPP.

Table 2). From 1984 to 1993, the proportion of older Americans with less than a high school education declined 15.2 percentage points from 54.5% to 39.3%. This decline was offset by gains of 8.3 and 6.9 percentage points, respectively, in the proportion of high school graduates and in the proportion with education beyond high school. The composition of the population also showed statistically significant shifts with respect to Hispanic origin, marital status, and the ownership of liquid financial assets. In absolute terms, however, these shifts are much smaller than those observed for educational attainment.

Trends in Educational Effects on Functioning

Logistic regression coefficients, shown in Table 3, consistently show strong effects of education on functioning across years and specific limitations. In all the regressions, being less than a high school graduate is significantly associated with difficulty functioning relative to the reference category (having more than a high school education). With the exception of seeing in 1993, the sizes of the coefficients across years and functions are remarkably similar, ranging from 0.695 to 0.790 in 1984 and from 0.666 to 0.741 in 1993. This consistency suggests that having less than a high school education is associated with approximately twice the odds of having a functional limitation in late life (e.g., exp(0.695) = 2.00), in comparison with someone who has more than a high school education. The effects on functioning of having graduated from high school (compared with the omitted group) are small, however, and not statistically significant. This finding implies that being a high school graduate is indistinguishable from having more than a high school education in terms of its relation to functioning.

Comparing the coefficients for less than high school education across years, we find only small changes in the effect of education on all four functions. The disadvantage of having less than a high school education, for example, appears to decrease for seeing and for lifting and carrying, but to increase slightly for climbing and for walking. However, tests (not shown for the sake of brevity) indicate that

5. This range brackets historical experience well: Calculations (not shown) suggest that 10 of the 12 unique education contrasts (three contrasts × four activities) observed for the 1984–1993 period fall within the specified range.

6. Coefficients in these models are identical to those presented in Table 3, except for the intercept and education effects. Suppose β_0*, β_2*, and β_3* are coefficients for the intercept, high school graduate, and more than high school graduate in models with less than high school graduate as the reference group. If β_0, β_1, and β_2 are the corresponding parameters for the intercept, less than high school, and high school graduate from Table 3, then $\beta_0^* = \beta_0 + \beta_1$; $\beta_2^* = \beta_2 - \beta_1$; and $\beta_3^* = -\beta_1$.

TABLE 2. CHANGE IN THE DEMOGRAPHIC AND SOCIOECONOMIC COMPOSITION OF THE 65-AND-OVER POPULATION, 1984–1993

Function	Percentage With Characteristic 1984 (n = 5,898)	1993 (n = 6,141)	Change	p Value[a]
Education				0.000
Less than high school	54.5	39.3	−15.2	
High school graduate	25.0	33.3	8.3	
More than high school	20.6	27.5	6.9	
Age				0.287
65–69	33.8	32.0	−1.8	
70–74	27.9	27.4	-0.5	
75–79	19.0	19.8	0.8	
80+	19.3	20.8	1.5	
Race				0.100
White	90.5	89.3	−1.2	
Black	8.3	8.3	0.1	
Other races	1.2	2.3	1.1	
Hispanic Origin				0.000
No	97.4	95.3	−2.1	
Yes	2.6	4.7	2.1	
Sex				0.491
Male	40.8	41.7	0.9	
Female	59.2	58.3	−0.9	
Marital Status				0.000
Married	53.2	55.6	2.4	
Widowed	35.1	33.0	−2.2	
Separated/divorced	5.6	7.2	1.6	
Never married	6.1	4.2	−1.9	
Liquid Asset Ownership				0.000
Yes	74.3	70.2	−4.1	
No	25.7	29.8	4.1	
Region				0.100
Northeast	22.9	22.3	−0.6	
South	34.9	32.4	−2.5	
Midwest	24.3	25.9	1.6	
West	17.9	19.3	1.5	

[a]The p values shown are for chi-square tests for differences in composition across years. They have been corrected to take into account the complex sample design of the SIPP.

these differences are not statistically significant even at the 0.10 level.

Other demographic and socioeconomic characteristics frequently associated with difficulty functioning are age, race, sex, being widowed, ownership of assets, and residence in the South. The disadvantages associated with being female, possessing no liquid assets, and living in the South appear to decrease over time for all four functions; the disadvantage of older age decreases for all limitations except difficulty in seeing. As before, however, these changes are not statistically significant even at the 0.10 level.

Decomposition Results

Table 4 displays the effects on changes in functioning of each of the eight demographic and socioeconomic factors included in our analysis. We present the *combined* effects of changes in composition and changes in rate effects for each variable of interest, ranking them from largest to smallest. The combined effects sum to the total change from 1984 to 1993 in overall rates of functioning.[7] In our rankings we include an intercept term, which captures changes in residual effects.

Clearly, education has a large effect on the changes in seeing and in lifting and carrying over the nine-year period. Education accounts respectively for 3.6 (out of 4.6) and 3.8 (out of 7.3) percentage point changes in seeing and in lifting. Education also ranks second (after sex) as a factor accounting for changes in walking and third (after region and sex) for changes in climbing. When expressed as a percentage of the change in overall rates of functioning, as shown in the last row of Table 4, educational effects account for more than three-fourths of the improvement in seeing, about half of the changes in lifting and climbing, and about one-quarter of the improvement in walking.

How much of the improvement in functioning is due to changes in the educational composition of the older population, as opposed to changes in the health advantage of greater education? The first and second columns of Table 5 show the effects of education decomposed into composition effects and rate effects. For seeing and for lifting and carrying, compositional changes account respectively for one-third and one-half of the educational effects. For climbing stairs and walking a quarter-mile, compositional changes explain all the declines in difficulty and even offset decreases in the advantage of education.

Education and Future Trends in Functioning

Table 6 shows the implications, for future functioning of the elderly, of impending shifts in that population's educational composition. For each of the functions in question, all else being equal, changes in educational composition will contribute to further declines in the percentage of older Americans with difficulty functioning. The size of the decline over the 37-year period ranges from 1.3 to 3.2 percentage points, depending on the function in question. As shown in Figure 2, these estimates are only slightly larger than the compositional effects of education for just nine years, from 1984 to 1993. Except for climbing, however, estimates based only on changes in future educational composition do not begin to approach the overall change from 1984 to 1993.

Changes in the relationship between education and functioning over the 37-year period may be expected as well.

7. Because we used a nonlinear specification, the total estimated changes in the bottom line of Table 4 are not identical to crude changes reported in Table 1. They are reasonably close, however: within three-tenths of a percentage point for all four functions.

TABLE 3. LOGISTIC REGRESSION COEFFICIENTS FOR MODELS OF FUNCTIONAL LIMITATIONS, 65-AND-OVER POPULATION, 1984 AND 1993

	Seeing		Lifting		Climbing		Walking	
	1984	1993	1984	1993	1984	1993	1984	1993
Intercept	–3.030[a]	–2.974[a]	–2.581[a]	–2.569[a]	–2.215[a]	–2.158[a]	–1.986[a]	–2.043[a]
Education Less Than High School	0.717[a]	0.528[a]	0.790[a]	0.666[a]	0.695[a]	0.711[a]	0.716[a]	0.741[a]
High School Graduate	0.214	–0.057	0.247	0.124	0.073	0.095	0.084	0.140
Age 70–74	0.183	0.304[a]	0.250[a]	0.215	0.123	0.165	0.152	0.220
Age 75–79	0.550[a]	0.676[a]	0.529[a]	0.361[a]	0.361[a]	0.324[a]	0.536[a]	0.372[a]
Age 80 and Older	1.189[a]	1.186[a]	1.187[a]	1.022[a]	1.013[a]	0.849[a]	1.111[a]	1.080[a]
Black	0.265	0.355[a]	0.394[a]	0.349[a]	0.352[a]	0.322[a]	0.217	0.270
Other Races	–0.008	–0.221	–0.214	0.037	–0.236	–0.088	–0.590	–0.372
Hispanic	0.223	0.289	–0.049	0.113	–0.240	0.177	–0.359	–0.197
Female	0.118	–0.008	0.775[a]	0.600[a]	0.465[a]	0.311[a]	0.374[a]	0.171
Widowed	0.277[a]	0.321[a]	0.214	0.329[a]	0.106	0.224[a]	0.162	0.267[a]
Separated/Divorced	0.318	0.428[a]	0.271	0.494[a]	0.308	0.536[a]	0.247	0.344[a]
Never Married	0.221	0.229	0.012	0.171	–0.044	0.075	0.087	–0.069
No Liquid Assets	0.554[a]	0.498[a]	0.564[a]	0.460[a]	0.619[a]	0.455[a]	0.583[a]	0.462[a]
South	0.576[a]	0.417[a]	0.287[a]	0.233[a]	0.541[a]	0.441[a]	0.337[a]	0.259[a]
Midwest	0.481[a]	0.255	0.225	–0.004	0.295[a]	0.105	0.223	0.116
West	0.442[a]	0.130	0.190	0.172	0.329[a]	0.237	0.182	0.129
Chi-Square, 16 *df*	277.4	249.9	422.1	327.4	351.5	288.8	350.4	304.0

[a]$p < .05$ for null hypotheses ($\beta = 0$). Chi-square measures for these tests and for those shown in the last row of the table have been corrected to take into account the complex sample design of the SIPP.

Depending on the size and the direction of the change, the effects of educational composition could be further strengthened or offset entirely. As shown in the upper panel of Table 7, increasing the risk of limitations for lower educational groups yields higher estimates of functional limitations than does the 2030 scenario with no change in the education ef-

TABLE 4. COMBINED EFFECTS OF CHANGES IN COMPOSITION AND CHANGES IN RATE EFFECTS OF DEMOGRAPHIC AND SOCIOECONOMIC FACTORS ON ESTIMATED CHANGES IN PREVALENCE OF FUNCTIONAL LIMITATIONS, 65-AND-OVER POPULATION, 1984–1993

		Percentage-Point Change							
		Seeing		Lifting		Climbing		Walking	
	Overall Rank	Effect	Rank	Effect	Rank	Effect	Rank	Effect	Rank
Change Due to:									
Education high school or less	1	–3.6	1	–3.8	1	–1.8	3	–1.6	2
Region other than Northeast	2.5	–2.4	2	–1.6	3	–2.2	1	–1.4	3
Female	2.5	–1.0	4	–2.2	2	–2.0	2	–2.7	1
Marital status other than married	4	0.3	6	1.2	4	1.4	4	0.7	5
Intercept	5	0.8	5	0.2	6.5	1.2	5	–1.2	4
Age 70 and over	6	1.1	3	–1.1	5	–0.3	7.5	0.0	8.5
No liquid assets	7	0.1	7.5	–0.2	6.5	–0.5	6	–0.3	6
Hispanic	8	0.1	7.5	0.1	8	0.3	7.5	0.0	8.5
Black and other races	9	0.0	9	0.0	9	0.0	9	0.1	7
Total Estimated Change (1984–1993)		–4.6		–7.3		–4.0		–6.4	
% of Total Estimated Change Due to Education High School or Less		78.3		52.1		45.0		25.0	

TABLE 5. ESTIMATED CHANGES IN PREVALENCE OF FUNCTIONAL LIMITATIONS DUE TO EDUCATIONAL CHANGES, 65-AND-OVER POPULATION, 1984–1993

	Percentage-Point Change in Prevalence Due to:		
	Changes in Educational Composition	Changes in Effect of Education on Functioning	Total Education Effect
Seeing	–1.2	–2.3	–3.6
Lifting	–1.9	–1.9	–3.8
Climbing	–2.1	0.3	–1.8
Walking	–2.2	0.6	–1.6

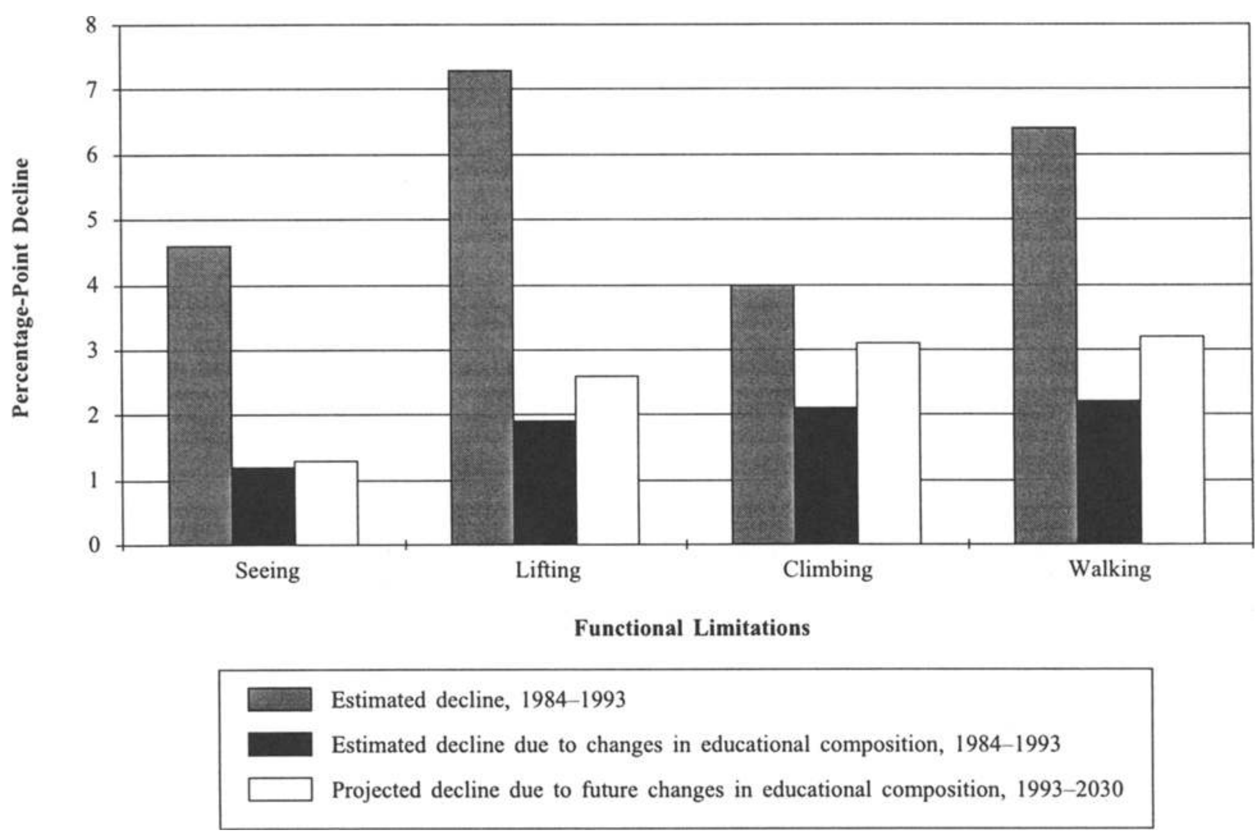
TABLE 6. PROJECTED PREVALENCE OF FUNCTIONAL LIMITATIONS, 65-AND-OVER POPULATION, 1993–2030, ASSUMING FUTURE CHANGES IN EDUCATIONAL COMPOSITION

	Percentage With Difficulty			
	Seeing	Lifting	Climbing	Walking
Assuming Educational Composition in:				
1993 (Estimated)	14.6	24.2	29.3	29.8
2010	14.2	23.3	28.3	28.7
2020	13.6	22.2	26.9	27.3
2030	13.3	21.6	26.2	26.6
Change (1993–2030)	–1.3	–2.6	–3.1	–3.3

fect. Only very large increases in the disadvantage of lower education—on the order of 100%—would completely offset the effect of expected changes in educational composition. Not surprisingly, decreasing the disadvantage of low education would further enhance projected declines in limitations.

The lower panel of Table 7 shows the effects of changing the *advantage* of having more education. Two points are worth noting. Increasing the advantage of higher education yields even lower prevalence estimates than do similar-sized decreases in the disadvantage of low education. Decreasing the advantage more than 25%, however, completely offsets gains from shifting composition, yielding prevalence estimates as large as those for 1993, or larger.

FIGURE 2. PROJECTED DECLINES IN PREVALENCE OF FUNCTIONAL LIMITATIONS DUE TO FUTURE CHANGES IN EDUCATIONAL COMPOSITION, 1993–2030



How do these projections compare with the experience over the past decade? Table 8 summarizes the total and average annual changes in functional limitations due to changes in both educational composition and educational rate effects from 1984 to 1993 and from 1993 to 2030. For the latter period, we present differences for the entire range of scenarios presented in Table 7. For comparison we include both total changes and changes in functional limitations due to educational changes for the earlier period.

In regard to total decline, only increases of 50% or more in the advantage of greater education, combined with impending compositional shifts, would yield percentage-point declines in seeing greater than those associated with educational change for the period 1984 to 1993. For lifting and carrying, decreases in the disadvantage of less education approaching 50% or increases in the advantage of more education greater than 10% would be needed to match declines associated with education for the earlier period. For climbing and walking, however, future declines associated with education will exceed those of the earlier period if the disadvantage of lower education does not increase by more than 50% and if the advantage of higher education does not decline by more than 10%.

When these figures are annualized, however, educational effects in the coming decades are unlikely to reach those of the past decade for difficulty seeing and lifting (see the right-hand side of Table 8). For example, the average annual percentage-point decline in difficulty seeing due to changes in educational composition and effects was 0.40 from 1984 to 1993; even under optimistic assumptions of 100% increases in the advantage of higher education, average annual improvements would reach only 0.15 percentage points between 1993 and 2030. For climbing and walking, only elimination of the disadvantage of lower education (–100%) or increases as large as 50% or more in the advantage of higher education would produce average annual declines on a par with those due to educational changes for the earlier period.

TABLE 7. PROJECTED PREVALENCE OF FUNCTIONAL LIMITATIONS, 65-AND-OVER POPULATION, ASSUMING PROJECTED EDUCATIONAL COMPOSITION IN 2030 AND FUTURE CHANGES IN EDUCATIONAL EFFECTS

	Percentage With Difficulty			
	Seeing	Lifting	Climbing	Walking
1993 (Estimated)	14.6	24.2	29.3	29.8
Disadvantage of Lower Education Changes From 1993 by				
+100%	14.6	24.4	29.4	30.1
+50%	13.9	23.0	27.8	28.3
+25%	13.6	22.3	27.0	27.4
+10%	13.4	21.9	26.5	26.9
No change	13.3	21.6	26.2	26.6
–10%	13.1	21.4	25.9	26.2
–25%	12.9	21.0	25.5	25.7
–50%	12.6	20.3	23.5	24.7
–100%	12.0	19.1	22.1	23.1
Advantage of Higher Education Changes From 1993 by				
+100%	8.9	14.2	16.0	16.9
+50%	10.9	17.6	21.2	21.4
+25%	12.0	19.6	23.6	23.9
+10%	12.8	20.8	25.2	25.5
No change	13.3	21.6	26.2	26.6
–10%	13.8	22.5	27.3	27.7
–25%	14.6	23.9	29.0	29.4
–50%	16.1	26.3	30.5	32.2
–100%	19.3	31.5	36.7	38.7

CONCLUSIONS

The remarkable improvements in older Americans' functioning from 1984 to 1993 have been accompanied by large increases in educational attainment. The relationship of educational attainment to functioning, however, has not changed measurably over the last decade. Persons who are not high school graduates are consistently at twice the risk of high school graduates for functional limitation in late life, both across years and across functions. Our decomposition analysis suggests that, among the demographic and socioeconomic factors considered here, education is the most important factor associated with improvements. Together, changes in composition and changes in effects of education account for more than three-fourths of the improvement in seeing, half of the changes in lifting and in climbing, and about one-quarter of the improvement in walking.

Given that further increases in the older population's educational attainment are quite predictable and large, we explored how these gains might be translated into further improvements in functioning by 2030. All else being equal, future changes in educational composition will contribute to further declines in the percentage of older Americans with difficulty functioning. These additional declines are unlikely to be offset completely by potentially widening disparities in functioning across education levels.

The absolute size of the decline from 1993 to 2030 due to educational changes could be as large as those observed for the period 1984 to 1993, or larger, but the average annual rates of decline due to educational changes are unlikely to approach those of the last decade. Projected annual increases in functioning due to education would surpass those reported for 1984 to 1993 only under highly optimistic scenarios—elimination of the disadvantage of lower education or increases of 50% or more in the advantage of higher education—and then for only two functions: climbing stairs and walking.

We admit that our exercise is limited by our inability to model directly the pathways through which education influences late-life functioning. Existing research, however, pro-

TABLE 8. TOTAL AND AVERAGE ANNUAL PROJECTED DECLINES IN PREVALENCE OF FUNCTIONAL LIMITATIONS DUE TO FUTURE CHANGES IN EDUCATIONAL COMPOSITION AND EDUCATIONAL EFFECTS, 1993–2030

	Total Decline in Percentage With Difficulty				Average Annual Decline in Percentage With Difficulty			
	Seeing	Lifting	Climbing	Walking	Seeing	Lifting	Climbing	Walking
1984–1993	4.6	7.3	4.0	6.4	0.51	0.81	0.44	0.71
1984–1993, Due to Change in Educational Composition and Effects	3.6	3.8	1.8	1.6	0.40	0.42	0.20	0.18
1993–2030, Due to Change in Educational Composition and Change in Disadvantage by								
+100%	–0.0	–0.2	–0.1	–0.3	–0.00	–0.01	–0.00	–0.01
+50%	0.7	1.2	1.5	1.5	0.02	0.03	0.04	0.04
+25%	1.0	1.9	2.3	2.4	0.03	0.05	0.06	0.06
+10%	1.2	2.3	2.8	2.9	0.03	0.06	0.08	0.08
No change	1.3	2.6	3.1	3.3	0.04	0.07	0.08	0.09
–10%	1.5	2.8	3.4	3.6	0.04	0.08	0.09	0.10
–25%	1.6	3.2	3.8	4.1	0.04	0.09	0.10	0.11
–50%	2.0	3.9	5.8	5.1	0.05	0.10	0.16	0.14
–100%	2.6	5.1	7.2	6.7	0.07	0.14	0.19	0.18
1993–2030, Due to Change in Educational Composition and Change in Advantage by								
+100%	5.7	10.0	13.3	12.9	0.15	0.27	0.36	0.35
+50%	3.7	6.6	8.1	8.4	0.10	0.18	0.22	0.23
+25%	2.6	4.6	5.7	5.9	0.07	0.13	0.15	0.16
+10%	1.8	3.4	4.1	4.4	0.05	0.09	0.11	0.12
No change	1.3	2.6	3.1	3.3	0.04	0.07	0.08	0.09
–10%	0.8	1.7	2.0	2.2	0.02	0.05	0.05	0.06
–25%	–0.0	0.3	0.3	0.4	–0.00	0.01	0.01	0.01
–50%	–1.5	–2.1	–1.2	–2.4	–0.04	–0.06	–0.03	–0.07
–100%	–4.8	–7.3	–7.3	–8.9	–0.13	–0.20	–0.20	–0.24

vides some insight into the possible mechanisms by which education affects specific limitations. In the case of difficulty seeing ordinary newspaper print, for example, not smoking and vitamin supplementation have been identified as potentially protective against cataracts and macular degeneration, the two most important causes of visual impairment in the elderly (Christen, Glynn, and Hennekens 1996; Christen, Glynn, Manson et al. 1996; Christen et al. 1992; Seddon et al. 1996); these and other behaviors promoting health, in turn, have been linked to educational attainment (Antonucci, Akiyama, and Adelmann 1990; Houston et al. 1998; Pierce et al. 1989; Wister 1996). Treatment differentials by education level also may be at issue, as reflected in differences in cataract surgery by type of insurance plan (Goldzweig et al. 1997).

The pathways from education to lower-body limitations are likely to be even more complex because a variety of chronic conditions—for example, arthritis, cerebrovascular disease, and osteoporotic hip fractures—are associated with increased risk of mobility impairment (Boult, Kane, and Louis 1994; Wolinsky, Fitzgerald, and Stump 1997). A number of studies have linked behavioral risk factors for these diseases—such as inactivity, smoking, and obesity—to low education (Antonucci et al. 1990; Pierce et al. 1989; Winkleby, Fortmann, and Barrett 1990; Wister 1996). Other studies have shown important treatment differentials among the elderly by education status, both in use of prescription drugs (Rogowski, Lillard, and Kington 1997) and in physical or occupational therapy (Mayer-Oakes et al. 1992). A fruitful focus for further research would be to illuminate the various pathways through which education affects specific limitations in late-life functioning.

In addition, our analysis is limited by its focus solely on demographic and socioeconomic characteristics. Moreover, our projections do not take into account future changes in the distribution of demographic and socioeconomic factors other than education; many of these are less predictable. Further, we do not allow for changes over time in the effects, on functioning, of other demographic and socioeconomic factors. Thus we cannot say with certainty whether overall trends in functioning will continue in the same direction, or at the same speed, as in the recent past. We know, however, that future changes in education, one of the most important factors related to functioning, will continue to contribute to improvements, although probably not at the same rate as witnessed over the past decade.

Despite these limitations, our analysis suggests that complacency is not in order with respect to future improvements in older Americans' health. The apparently extraordinary improvements of the last decade may not be repeated, even with further gains in the educational attainment of these future cohorts of older Americans. Optimism must be tempered further when we consider the impending growth in the sheer number of older persons. Interventions need to be designed to prevent functioning deficits and to rehabilitate those who develop difficulties in performing basic activities. Such interventions should be designed with the expressed goal of reducing the disadvantage of those with less education, while we continue to raise even higher the standards for all older Americans' quality of life.

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