

Construction of Life-Course Occupational Trajectories

Evidence for Work as a Mediator of Racial Disparities in Hypertension

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Objective: To determine whether a life-course model of work may explain racial or ethnic differentials in health. Occupational characteristics are relevant socioeconomic indicators of health disparities and essential determinants of health. **Methods:** Growth mixture modeling (GMM) was used to construct longitudinal trajectories of work characteristics from the ages of 20 to 32 years. Path analyses were used to evaluate the association of race, ethnicity, education, and work trajectory on incident hypertension. **Results:** Growth mixture modeling yielded three latent class trajectories. Black subjects with postsecondary education were 2.5 times more likely to be found in the lowest occupational trajectory. The three-class trajectory model mediated 43.6% of the direct effect of race on incident hypertension. **Conclusions:** Latent class trajectories of work demonstrated a stronger association with incident hypertension than did measures of current work, and clearly mediated the effects of race on hypertension.

Social and racial or ethnic inequalities in morbidity and mortality are a major public health concern. A response gradient in health, whereby socially, economically, and racially disadvantaged groups report higher rates of illness and death, is apparent.^{1,2} Evidence of health disparities is seen in both elevated risk for common chronic conditions and in structural factors such as quality and access to health care.^{3,4} Minorities, particularly African Americans, face increased risk of developing chronic conditions such as asthma, diabetes, and hypertension⁵ and of higher mortality for heart disease, stroke, and cancer, in comparison with their white counterparts.⁴ Farmer and Ferraro³ reported that African American adults who participated in the first National Health and Nutrition Examination Survey (NHANES I) study reported poorer health at baseline, were more likely to suffer from serious illness, and to rate their health poorly; this racial disparity in health did not diminish over 20 years of follow-up.

The hypothesis of diminishing returns, which posits that, paradoxically, racial disparity in health outcomes between African Americans and whites is greatest at high levels of socioeconomic status (SES), has been advanced to explain the interactive effect of race and education on health. African American adults report significantly poorer health with increasing education than their white counterparts.³ Diminishing returns are also evident in other health outcomes, such as low birth weight and preterm delivery, in which racial disparities in prevalence of adverse health outcomes

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Learning Objectives

- Discuss the authors' use of the lifecourse model to account for racial/ethnic differences in health.
- Summarize the findings on latent class trajectories, along with differences in relationships among race, education, and job trajectory.
- Discuss the ability of the class trajectories to explain the effects of race on incident hypertension, along with other implications.

increase with higher levels of educational attainment in African Americans.^{6–8}

Occupation is a relevant SES indicator of health disparities and is an essential determinant of health through hazards related to employment. Occupations differ in rewards (both financial and nonmonetary), societal prestige, authority, and independence, and also in level of physical application, stress, and exposure to harmful substances, factors that may cluster in particular occupations.⁹ Warren and Kuo¹⁰ point out that better-paying occupations are associated with reduced health risks as they are likely to be less physically demanding, hazardous, and stressful, whereas low occupational positions are associated with poorer health, independent of educational level. Although closely associated, occupation, income, and education are not interchangeable^{11,12}; therefore, changing one of these core dimensions will not reflexively alter the other two.

Our prior work indicates that low substantive complexity (SC) of work (independent of work demands) may be a better predictor of adverse outcomes than the overall demand-control model.^{13,14} When worker ethnicity is considered in separate analyses, a pattern emerges of stronger evidence for effects of low work SC in black subjects. In addition, our studies suggest that (1) within equivalent educational strata, there are differences in the proportions of blacks and whites working in low-SC occupations and (2) after control for educational attainment, Hispanics (but not blacks) are in work with higher SC, which may represent a protective factor. These results provide evidence that adverse outcomes may be associated with low SC work in blacks, whereas at the same time black subjects are overrepresented in these jobs, incommensurate with their educational attainment.

Pathways that lead from education or markers of early SES to work and the modifying effect of occupation on health outcomes may be particularly relevant to and may assist in developing a life-course model for occupation. Health effects associated with the social class standing of occupation were attenuated by job control, suggesting a mediating influence of work.¹⁵ Singh-Manoux and colleagues^{16,17} found a strong direct role of occupation, when contrasted with education, on psychological health in Whitehall II study participants, suggesting work's mediating role in the translation of the health effects of education. Also, they note a linear relationship between cumulative socioeconomic position (examining trajectories of parental-, early-, and mid-life occupational standing) with psychological health. The GAZEL study in France found similar associations of downward

mobility across adult life with noncardiovascular mortality.¹⁸ Karmakar and Breslin¹⁹ found that job characteristics partly explained education-associated gradients for work-related injury in younger Canadian workers. Germane is the previously cited evidence that African Americans experience diminishing returns on education, with poorer health in blacks at equivalent levels of education and occupational prestige.³ Also, perceptions of racial discrimination within work, and high-effort coping within work, termed “John Henryism,” appears to have selective health effects in blacks.²⁰

We hypothesized, based on the aforementioned and our prior studies, that a more dynamic component, better described as a trajectory rather than a separate factor, more adequately describes the translation of educational attainment and occupation into predictors of health status. In addition, we propose that the pathway we attempt to describe, which accounts for mutually reinforcing effects of education and occupation, in some fundamental respect differs for blacks and whites, a disparity that may be associated with the experience of discrimination or other forms of erosive social exposures. Our initial aim is to derive a set of occupational trajectories and determine their effects’ health, specifically hypertension. In doing so, we may also test the extent to which individuals’ work trajectories mediate racial and ethnic differentials in health.

METHODS

Data Sources

National Longitudinal Survey of Youth 1979

The National Longitudinal Survey of Youth 1979 (NLSY79) is a nationally representative sample of 12,686 participants (6403 male) that is initiated and maintained by the US Bureau of Labor Statistics. Its primary objective is to assess the labor market activities and significant life events of a cohort of adolescents and young adults across time. Initiated in 1979, the NLSY79 enrolled subjects residing in US households who were initially between the ages of 14 and 21 years on December 31, 1978, representing a birth cohort from 1957 to 1964. The NLSY79 is composed of three subsamples. The first was a cross-sectional sample of 6111 youth representative of the noninstitutionalized civilian segment of adolescents and young adults; with a second supplemental sample of 5295 youth intended to oversample civilian Hispanic, black, and underprivileged white youth. A third sample of 1280 represented participants aged 17 to 21 years as of January 1979 who were enlisted in the US military.

Distribution of the overall sample is 16% Hispanic, 25% black, and 59% non-black, non-Hispanic. Between 1979 and 1994, participants were interviewed annually, after which interviewing was conducted biennially. Retention rates for the survey are in excess of 80% across the 27 years (1979 to 2006) of the survey used here. Longitudinal data, annually or biennially, of occupation and education of the participating subjects are available in the NLSY79.

Occupational Information Resource Center

The successor to the Dictionary of Occupational Titles, the Occupational Information Resource Center (O*NET) was designed to refine, collect, and publish new measures of occupational descriptors, based on survey data from workers about skills, generalized work activities, work context, and knowledge.^{21,22} The O*NET supplants the Dictionary of Occupational Titles model that was based on expert opinion, and better aggregates similar jobs by the type of work tasks and their requisite education, skills or training. More than 1000 occupations are described in detail in the version (v 13.0, June 2008) of the O*NET used here, and can be used to classify nearly every job outside those in military service.

Variables of Interest

Independent Variables

The primary independent variables of interest were individual yearly subject scores for the SC of work, and educational attainment. To create a metric for the SC of work, a factor analysis that replicated the methods of Hadden and colleagues²² was performed as outlined previously.¹⁴ Briefly, a three-factor solution was obtained that composed factors describing *substantive complexity*, *people versus things*, and *physical demands*. Scales for these factors were created using regression methods to derive *z* scores (mean of 0 and standard deviation of ± 1), retaining variables with loadings greater than 0.7. O*NET variables with the highest loadings on the SC factor were deductive reasoning, inductive reasoning, critical thinking, analyzing data or information, and complex problem solving. Substantive complexity scores were linked by occupational-code crosswalks, via O*NET job codes, to census occupational codes for the NLSY79 subjects’ job data.^{14,23}

Annual data are provided for up to five occupations held for each participant in the NLSY79, coded by 1980, and subsequently 2000, census occupational codes. These job data were downloaded from the NLSY79 data set, and recoded by age, so that longitudinal patterns were uniform by age across subjects beginning at 20 years. Substantive complexity scores, linked by census occupational codes, were imputed to the job histories extracted from the NLSY79 data set, and the mean work SC score was calculated at each age point for each subject.

Educational attainment is measured at each survey in the NLSY79. For this study, the level of education recorded closest to the age of 30 years was recorded and used in analysis. Although some subjects may have undertaken additional schooling, the proportion is sufficiently low (<2%) so that we can consider educational level stable by the age of 30 years. Educational level was defined and recoded as an ordinal variable with four categories that correspond to discrete metrics of educational attainment: non-high school graduate, high school graduate, some college, and college graduate or professional degree holder.

Outcome Variable

NLSY79 subjects are given a supplemental health questionnaire after turning 40 years old. The health survey includes questions about the development and diagnosis of hypertension. Two questions were used to create the outcome variable: one asked whether the respondent had been diagnosed with hypertension by a physician; the second asked the date of diagnosis. A positive answer to the first question, with a diagnosis occurring after the age of 34 years, was considered an incident case of hypertension. Subjects diagnosed with hypertension before the age of 35 years were excluded from the analysis because—although the latency for causation is unknown—any temporal association drawn between hypertension and work SC mandates that the condition occur after the last age point (32–33 years old) used in the calculation of work trajectories in this study.

Other Variables

Codes from the NLSY79 were used for self-identified race or ethnicity: non-Hispanic white, non-Hispanic black, and Hispanic. “Hispanics” in the NLSY79 classification were (1) participants who self-reported as Hispanic; (2) those who did not self-identify as Hispanic but who were Filipino or Portuguese, and (3) those who reported speaking Spanish at home as a child. In addition, those with family names on the census list of Spanish surnames were also classified as Hispanic by the NLSY79 interviewers. Body mass index (BMI), an additional risk factor for hypertension, was calculated as a mean from two self-reported measurements of height and weight in the 1996 and 2002 surveys. A smoking variable was constructed from questions about surveys in 1994 and 1998; subjects who indicated,

on either survey, that they smoked tobacco at the time of the survey were coded as current smokers.

Analyses

Longitudinal Modeling of Occupational Trajectories

Growth mixture modeling (GMM) was used to construct longitudinal trajectories of work characteristics across the time period of the multiple waves of the NLSY79, using the mean SC score for jobs held every 2 years. Growth mixture modeling allows for the estimation of growth trajectories on the basis of repeated measures across time, with the flexibility to handle subject data with differing numbers and timing of observations. This modeling assumes an overall survey population composed of a finite set of unobserved subpopulations that differ in their initial status and trajectory (slope).^{24,25} These subpopulations are hereafter referred to as *classes* in keeping with the standard terminology on the subject, but should be distinguished from implications of “social class.” Growth curve modeling estimates individual latent trajectories that are based on person-specific intercepts (initial value) and slopes (rate of change) that describe intraindividual patterns of change in the SC of work over time. The modeling procedure then reduces interindividual heterogeneity in growth patterns to describe a probable set of group trajectory classifications in the absence of a priori knowledge or assumptions as to how the data may be split. The purpose of GMM analysis is thus to (1) estimate the number and size of trajectory classes and (2) assign latent class membership to individuals in the population on the basis of the posterior probability of each subject’s growth trajectory fitting with one of the set of estimated classes.

A GMM using mean work SC in NLSY79 male subjects biennially from the ages of 20 to 32 years was constructed using the mixture modeling function in Mplus Version 6.11 (Muthen and Muthen, Los Angeles, CA). Our preliminary modeling results disclosed markedly differing trajectory patterns for men and women, a consequence of differences in education, career possibilities, and possibly time away from work for pregnancy and child-raising during the 1980s and 1990s. We therefore decided for these reasons, in addition to the larger number of incident hypertension cases in men, to limit the present investigation to male subjects only. Models from one to seven classes were constructed to test and contrast model fit. A quadratic growth model was specified for both substantive and statistical reasons. Examination of individual growth trajectories indicated that trajectory slopes were steeper in the subjects’ early- to mid-20s, following which a tendency to level off is observed, consistent with early advancement and later career equilibrium. Determination of the best-fitting trajectory class solution was based on three factors: examination of adjusted Bayesian Information Criterion (aBIC) scores for each model, use of the Vuong-Lo-Mendell-Rubin likelihood ratio test (VLMR), and examination of entropy, a measure of classification certainty. Adjusted Bayesian Information Criteria was used with a smaller-is-better indication of model fit, although with large sample sizes aBIC may exhibit continued small declines as the number of classes is increased. The VLMR statistic compares an estimated model with a model that has one fewer class; $P < 0.05$ indicates that the estimated model is an improvement from the preceding (fewer-class) model. Entropy, an estimation of classification precision ranging from 0 (completely random) to 1.0 (perfect classification) was also used to judge the appropriate number of classes.

Occupational trajectory class assignments for the NLSY79 subjects were matched with educational attainment, race or ethnicity, BMI, and history of hypertension and smoking. Path analyses were constructed in Mplus and used to evaluate the association of race or ethnicity, educational attainment, occupational trajectory class, and BMI on the outcome variable (incident hypertension after the age of 34 years). We assumed a priori that subjects’ self-identified race or

ethnicity preceded both educational attainment and work trajectory, which in turn preceded the development of hypertension, and that BMI (from 1996 and 2002, or in the age range from 32 to 45 years) and smoking were associated with hypertension. Aside from these fixed specifications, the model tested alternative direct and indirect pathways and associations of these variables with hypertension. Path models were tested by using (1) the root mean square error of approximation (RMSEA) as a guide to overall goodness-of-fit of the model, with a general criterion of a RMSEA value of 0.05 or less indicating good model fit; (2) $P \leq 0.1$ as a guide to the significance of individual paths within the model; and (3) the scaled χ^2 difference test (using the DIFFTEST procedure in Mplus) to examine whether inclusion or exclusion of specified pathways resulted in a statistically significant change in the model’s overall fit. Path model results are reported as standardized coefficients to facilitate comparisons of their magnitude.

Approval for this study was obtained from the Institutional Review Board of the University of Connecticut Health Center, which considered the investigation as exempt from human subjects review, as all data were previously de-identified and publicly available.

RESULTS

Construction of occupational histories and imputation of work SC scores across the ages of 20 to 32 years yielded 5947 men (93% of male NLSY79 subjects) with at least two data points, considered sufficient for trajectory construction. Information about educational attainment within 2 years of 30 years age was available for 5040 subjects, who formed the base for the path analyses for hypertension risk.

Growth mixture modeling of work SC yielded a three-class solution as the best-fitting model. Graphical analysis of aBIC and entropy (Fig. 1) shows an inflection point at three classes, with a minimal (<1%) subsequent reduction in aBIC when additional classes were specified. Entropy, the degree to which class assignment was stable, showed an initial expected decline with increasing class specification, with subsequent stability (0.60) at a three-class solution and beyond. The P value for the VLMR likelihood test was also significant ($P = 0.0001$) for a three-class solution when contrasted with two classes, whereas the four-class solution was only of marginal significance ($P = 0.07$) contrasted with three classes. Growth mixture modeling using work SC for subjects older than 32 years did not result in appreciably different trajectory assignment (aside from increased negative values for the quadratic term, indicating a reduction in trajectory slope at later age, which would be expected) with

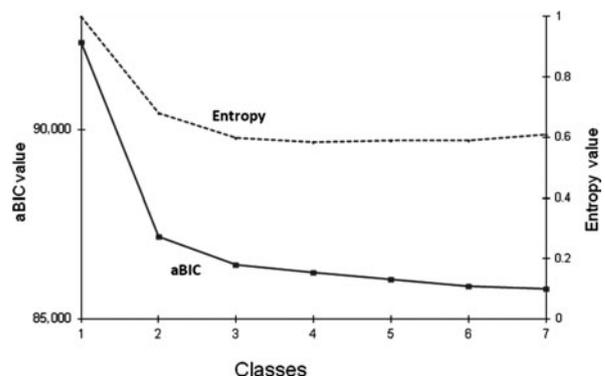


FIGURE 1. Goodness-of-fit characteristics for possible growth mixture models specifying one to seven classes. Solid line represents values for adjusted Bayesian Information Criterion (aBIC) on left axis, with entropy values (dotted line) on right.

minimal change in entropy and 95% to 98% of subjects remaining within the same trajectory class when SC scores at later ages were applied (results not shown).

The resultant three-class trajectories are shown in Fig. 2, with numbers, proportions, and relevant demographic variables in Table 1. The model effectively partitions the data into a low-intercept, flat-trajectory class comprising nearly one half (44.5%) of the subjects, one class (28.4% of subjects) with a moderate positive slope, and a third class with a higher intercept and a sharper upward trajectory. Black subjects were overrepresented in the flat-trajectory class 1, and underrepresented in class 3. Hispanic subjects were distributed evenly within the three classes. Educational attainment was unequally distributed by class; college-educated subjects were found primarily in class 3, whereas class 2 represented an intermediate class composed of subjects with educational attainment only modestly better than class 1 but who exhibited a progressive upward trajectory in work SC. An inverse trend for current smoking

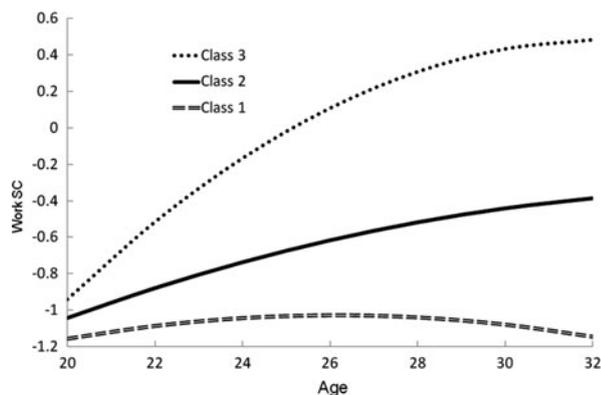


FIGURE 2. Graph of mean trajectories of work substantive complexity (SC) for three-class growth mixture modeling solution.

TABLE 1. Demographic Characteristics of Subjects by Occupational Trajectory Class

	Class			Overall
	1	2	3	
No. of subjects, %	2,644 (44.5)	1,688 (28.4)	1,615 (27.1)	5947
Intercept (at the age of 20 years)	-1.16	-1.04	-0.93	-1.06
Slope	0.09	0.20	0.45	0.22
Slope—quadratic term	-0.011	-0.014	-0.038	-0.019
Black, %	34.1	21.7	14.3	25.2
Hispanic, %	15.9	17.1	15.0	16.0
Educational attainment, years				
Mean	12	13	14	13
Median	12	12	14	12
BMI (median)	27.1	27.2	27.0	27.1
Current smokers 1994–1998, %	43.3	34.8	19.6	34.1
Hypertension after the age of 34 years, %	15.2	14.1	11.3	13.8

BMI, body mass index.

paralleled class trajectories. Body mass index values showed little evidence of differences across classes.

When educational attainment was stratified by work-trajectory class, marked disparities by ethnicity were evident. Although there were 50% more white subjects in class 1, the odds of black subjects with greater than postsecondary education (≥ 1 year of college) in class 1 were 2.5 times that of whites (Table 2). Similarly, the odds of a black or Hispanic subject with a postsecondary education in class 3 were reduced for both ethnicities (0.49 and 0.74, respectively) though college-attending Hispanic subjects had a 50% greater probability of membership in trajectory class 3 than did blacks.

The predictive validity of the trajectory classes was assessed through examination of their association with hypertension after the age of 35 years, accounting for the most probable pathway through which the association is expressed. Trajectory class was associated with hypertension in a Poisson regression model, adjusting for smoking and BMI, with the odds ratios for class 1 estimated at 1.34 (95% confidence interval, 1.03 to 1.75) and for class 2 at 1.22 (95% confidence interval, 0.93 to 1.61) using class 3 as the referent. The *P* value for trend across classes was 0.03. The resultant full path model for the association of trajectory class and hypertension is shown in Fig. 3A. The RMSEA value for this model, using trajectory classes as the measure for work, was less than 0.001 (upper 95% confidence bound for RMSEA = 0.035; probability RMSEA < 0.05 = 0.997) indicating a well-fitting model. Inclusion of a direct pathway from educational attainment to hypertension worsened model fit (RMSEA = 0.12) and was not supported by the scaled χ^2 difference test (*P* = 0.27) between the two models; also, the *P* value for the path coefficient from education to hypertension was not significant (*P* = 0.28), and therefore this direct path was omitted from the final model. In addition, BMI was associated with education and smoking, but not with trajectory class. Standardized path coefficients for the model are shown in Fig. 3A. The effects of covariates on the outcome, as well as the inverse association of BMI and smoking with educational level and, for smoking, occupation, were in the expected direction. Occupational trajectory class demonstrated a strong association with hypertension after the age of 35 years, roughly 40% greater than the effect of current smoking, even after control for smoking, BMI, and the indirect effects of education.

The model in Fig. 3A was used to examine whether the differences in trajectory membership may be associated with racial or ethnic differences in the incidence of hypertension. Figure 3B shows the path analytic model for the introduction of a variable contrasting black versus white (referent) subjects; we found no significant differences in the contrast between Hispanic and white subjects. Standardized path coefficients for the relevant pathways of the model in Fig. 3B are shown in Table 3. The strength of the three-class trajectory model as an occupational measure was also contrasted with several other possible measures of work, including (1) the subjects' mean SC level at ages 35 to 39 years, adjusted for baseline SC at the age of 20 years; (2) the subjects' overall mean SC score across early- and mid-adulthood (ages 20 to 39 years); and (3) the number of years spent in a low SC job across the ages of 20 to 39 years. All produced equivalently well-fitting models (RMSEA = 0.005 to 0.006) with the exception of mean SC at the ages 35 to 39 years. The three-class trajectory model demonstrated the largest proportion of mediation across the pathway from race through work to hypertension, accounting for more than two fifths (43.6%) of the reduction of the direct effect of race on the outcome, whereas the other measures mediated from one third to one fifth of this pathway. As most of the other pathway coefficients were stable across the range of occupational measures, the evidence of stronger mediation by a trajectory-based metric appears to be the result of a stronger association between race and trajectory class (standardized path coefficient, 0.24), which highlights the race-based disparities between education and occupational trajectory classes shown in Table 2.

TABLE 2. Differences in Educational Attainment by Race or Ethnicity Within Trajectory Class

Class	Educational Attainment						Odds Within Class of Having ≥1 Year Postsecondary Education				95% Confidence Interval		95% Confidence Interval	
	≥1 Year Postsecondary Education			High School Diploma or Less			White	Black	Hispanic	Black	Hispanic	Black	Hispanic	Black
1	137	80	27	769	751	342	0.153	0.376	0.152	2.46	1.80–3.37	0.99	0.64–1.55	
2	261	85	67	646	265	208	0.338	0.409	0.486	1.21	0.91–1.62	1.44	1.04–1.99	
3	636	128	111	341	76	110	1.598	0.776	1.181	0.49	0.37–0.63	0.74	0.55–1.00	

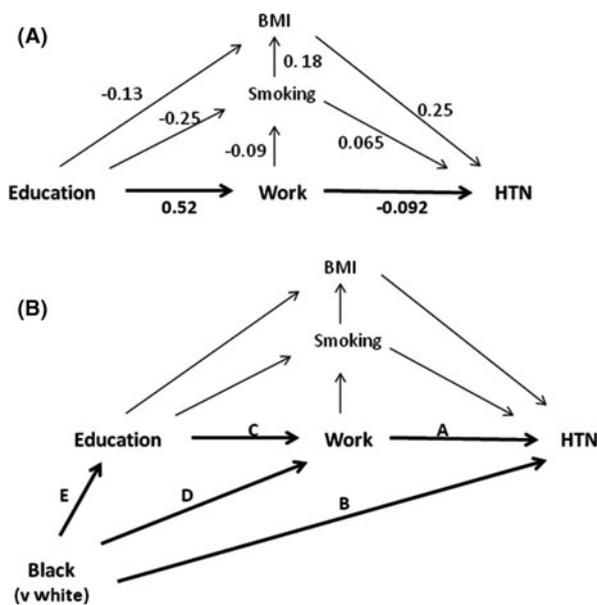


FIGURE 3. Path models for association of work substantive complexity and education with hypertension (HTN). (A) Pathway to HTN, controlled for effect of body mass index (BMI) and smoking. Numbers represent standardized path coefficients with “Work” denoting substantive complexity trajectory class. (B) Pathways with the inclusion of race (black contrasted with white) outlining the mediating effect of work and education. Letters are pathways with coefficients shown in Table 3.

DISCUSSION

Our previous work found that occupational characteristics derived from O*NET variables, in particular using Kohn and Schooler’s^{26,27} construct of the SC of work, were predictive of incident hypertension in working subjects in two surveys across 10 years, and helped to establish the validity of using these metrics. Moreover, our prior work examining cross-sectional patterns of work characteristics from a birth data set¹³ suggested that longitudinal patterns of occupational psychosocial indicators may be associated with health outcomes as well as partly explanatory of gradients in health by race or ethnicity. Miech and colleagues²⁸ used measures of work stratification (occupational education and earnings) to derive similar graphics showing clear differences in occupational trajectories between whites and African Americans, with slope of the latter depressed and flattened. Extending their findings, we demonstrate that a set of distinct occupational trajectories can be described

within a mixture model framework, and that black subjects are disproportionately found within the lower or reduced-slope trajectory class across early- and mid-adult working life. We find that equivalent educational attainment, particularly having attended college or obtained a postsecondary degree, is insufficient to lift many black subjects out of the low-trajectory class. Although we do not, in this current project, describe the causes or antecedents of this finding, other investigations find a pattern of discrimination at both individual and structural levels that inhibits members of racial and ethnic minorities from obtaining work commensurate with occupational qualifications.^{3,28} One advantage of the latent trajectory approach for future work in this area is that antecedents can be tested in the model for significance of their influence, or capacity to alter individual subjects’ trajectory class.

In addition, we demonstrate here that trajectory classes may be used as metrics of exposure to working conditions, with additional evidence of association of occupational trajectory class membership with the onset of hypertension. The path models that we demonstrate leading to hypertension and incorporating race or ethnicity and education are noteworthy in several respects. Consistent with other investigations, we show that the effect of education is primarily mediated through work, at least for the male subjects in these analyses.^{16,29} The lack of a significant direct pathway from education to health outcome indicates support for a position that views education as important not for its direct effects on health, but for the opportunities or life chances that it creates.²⁹ Second, the latent class trajectories of work SC demonstrate a stronger association with incident hypertension than either current work SC, or cumulative metrics of work characteristics, including early- to mid-adulthood mean SC, or cumulative years spent in a low SC job. More noteworthy is that incorporation of race or ethnicity into the model demonstrates clear mediation of the effects of race (contrasting black subjects with white) on hypertension by occupation, whereas this is true of all metrics used for work SC here, the three-class trajectory model proved a much stronger mediator, with nearly half of the association of race with hypertension mediated by pathways through work. The stronger (more negative) coefficient for the pathway from race to work suggests a direct effect of race in placement into work trajectory, rather than an effect that is principally driven by education, a pathway that is roughly equivalent in all the models shown, other than the much weaker model for the effect of current SC on hypertension. This provides evidence for Farmer and Ferraro’s³ assertion that African Americans experience “diminishing returns” on education, with poorer health in blacks at equivalent levels of education and occupational prestige. It also suggests a potential quantitative and work-based explanation for the “weathering hypothesis” whereby African Americans are subject to the erosive effects of stressors over the long term, and the consequences for health of these incremental but prolonged exposures.^{30,31}

TABLE 3. Standardized Path Coefficients for the Model in Figure 3B, by Measure of Work SC

Path	Model			
	3 Trajectory Classes	Mean SC (Ages 35–39 years)	Mean SC (Ages 20–39 years)	Years in Low SC Work
A (Work → HTN)	– 0.140	– 0.120	– 0.116	0.114
B (Race → HTN)	0.044	0.053	0.058	0.061
C (Education → Work)	0.50	0.41	0.48	– 0.50
D (Race → Work)	– 0.24	– 0.22	– 0.17	0.15
E (Race → Education)	– 0.19	– 0.16	– 0.18	– 0.18
RMSEA value for model	0.006	0.045	0.005	0.005
Indirect pathway (Race → HTN via paths through work)	0.034	0.026	0.020	0.018
% of Race → HTN pathway mediated by work characteristic	43.6	32.9	25.6	22.8

Letters refer to paths denoted in Figure 3B. SC, substantive complexity; RMSEA, root mean square error of approximation; HTN, hypertension.

Some limitations of the present work should be acknowledged. The NLSY79 preferentially enrolled low-income subjects and over-recruited minority subjects; thus, the findings may not fully represent the career trajectories of those beginning their education or careers from more privileged socioeconomic strata. These subjects' early educational and job experiences are also becoming more distant in time and may not be reflective of current labor market conditions for the young, especially as service and information jobs supplant those in manufacturing. As noted earlier, this work included only male subjects, because women's education, career possibilities, and trajectories in the 1970s and 1980s differed markedly from those of men, and make the two sets of trajectories noncomparable (M. Mutambudzi, unpublished doctoral dissertation). We hope to describe these in a subsequent article.

In addition, imputed job characteristics from databases remain proxy and "average" measures of exposure. Such imputed job scores may not reflect individual work circumstances, differential job tasks for minorities or women within the same occupation, or changes in occupational stressors that may occur as jobs change across time. Nevertheless, as we have previously noted, despite these limitations, the magnitude and direction of risks attributable to the risk factors derived from our administrative data set were consistent with those from other studies.^{7,14,32,33} Imputation also may help to avoid problems associated with common-instrument bias, whereby workers' evaluation of their jobs is influenced by health problems or negative emotions.^{34,35} Similarly, use of a dichotomous, and self-reported, measure for hypertension may obscure subtle but important distinctions in the association between work and cardiovascular disorder. Techniques such as ambulatory monitoring of blood pressure have proven useful in the assessment of early elevations in blood pressure not yet noted in the clinical setting^{36,37} and the outcome measure here may reflect only the most overt of cases. Finally, we did not incorporate a measure of unemployment or account for periods when the subjects were not working. It is unclear as to what the most suitable metric for unemployment (on an equivalent scale to work SC or job control) might be, although the deleterious effects on health are well-described.^{38,39} Prolonged unemployment would, however, almost certainly flatten subjects' occupational trajectories as they fail to advance in their careers; however, we are not, as yet, able to quantify the overall effect of this on the construction of trajectory classes. Further work would require detailed work histories accounting for the length of employed and nonemployed periods, which would also increase the complexity of the analyses performed here.

CONCLUSIONS

The construction of validated latent class trajectories for occupation suggests useful avenues for future research. Antecedents and predictors of trajectory classes can be examined for both their predictive value in latent class assignment, in addition to the determination of their capacity to modify individual trajectories or shift subjects from one trajectory class to another. By a similar process, subjects who are found to shift occupational trajectory during the course of working life may be sensitive indicators for the effect of influential factors such as alcohol, drugs, education, or training opportunities on work and health. The ability to follow work and its relevant characteristics longitudinally may improve our capacity to integrate occupation into a life-course model that examines both its antecedents and consequences for health.

REFERENCES

- Phelan JC, Link BG, Diez-Roux A, Kawachi I, Levin B. "Fundamental Causes" of social inequalities in mortality: a test of the theory. *J Health Soc Behav.* 2004;45:265–285.
- Niedhammer I, Chastang JF, David S, Kelleher C. The contribution of occupational factors to social inequalities in health: findings from the national French SUMER survey. *Soc Sci Med.* 2008;67:1870–1881.
- Farmer MM, Ferraro KF. Are racial disparities in health conditional on socioeconomic status? *Soc Sci Med.* 2005;60:191–204.
- Keppel KG, Percy JN, Wagener DK. Trends in racial and ethnic-specific rates for the health status indicators: United States, 1990–98. *Healthy People 2000 Stat Notes.* January 2002;1–16.
- Young CJ, Kew C. Health disparities in transplantation: focus on the complexity and challenge of renal transplantation in African Americans. *Med Clin North Am* 2005;89:1003–1031.
- Schoendorf KC, Hogue CJ, Kleinman JC, Rowley D. Mortality among infants of black as compared with white college-educated parents. *N Engl J Med.* 1992;326:1522–1526.
- Meyer JD, Warren N, Reisine S. Job control, substantive complexity, and risk for low birth weight and preterm delivery: an analysis from a state birth registry. *Am J Ind Med.* 2007;50:664–675.
- Collins JW Jr, Butler AG. Racial differences in the prevalence of small-for-dates infants among college-educated women. *Epidemiology.* 1997;8:315–317.
- MacDonald LA, Karasek RA, Punnett L, Scharf T. Covariation between workplace physical and psychosocial stressors: evidence and implications for occupational health research and prevention. *Ergonomics.* 2001;44:696–718.
- Warren JR, Kuo HH. How to measure "what people do for a living" in research on the socioeconomic correlates of health. *Ann Epidemiol.* 2003;13:325–334.

11. Braveman PA, Cubbin C, Egerter S, et al. Socioeconomic status in health research: one size does not fit all. *JAMA*. 2005;294:2879–2888.
12. Volkers AC, Westert GP, Schellevis FG. Health disparities by occupation, modified by education: a cross-sectional population study. *BMC Public Health*. 2007;7:196.
13. Meyer JD, Warren N, Reisine S. Racial and ethnic disparities in low birth weight delivery associated with maternal occupational characteristics. *Am J Ind Med*. 2010;53:153–162.
14. Meyer JD, Cifuentes M, Warren N. Association of self-rated physical health and incident hypertension with O*NET factors: validation using a representative national survey. *J Occup Environ Med*. 2011;53:139–145.
15. Rahkonen O, Laaksonen M, Martikainen P, Roos E, Lahelma E. Job control, job demands, or social class? The impact of working conditions on the relation between social class and health. *J Epidemiol Community Health*. 2006;60:50–54.
16. Singh-Manoux A, Clarke P, Marmot M. Multiple measures of socio-economic position and psychosocial health: proximal and distal measures. *Int J Epidemiol*. 2002;31:1192–1199.
17. Singh-Manoux A, Ferrie JE, Chandola T, Marmot M. Socioeconomic trajectories across the life course and health outcomes in midlife: evidence for the accumulation hypothesis? *Int J Epidemiol*. 2004;33:1072–1079.
18. Melchior M, Berkman LF, Kawachi I, et al. Lifelong socioeconomic trajectory and premature mortality (35–65 years) in France: findings from the GAZEL Cohort Study. *J Epidemiol Community Health*. 2006;60:937–944.
19. Karmakar SD, Breslin FC. The role of educational level and job characteristics on the health of young adults. *Soc Sci Med*. 2008;66:2011–2022.
20. James SA, LaCroix AZ, Kleinbaum DG, Strogatz DS. John Henryism and blood pressure differences among black men. II. The role of occupational stressors. *J Behav Med*. 1984;7:259–275.
21. Peterson N, Mumford M, Borman W, et al. Understanding work using the occupational information network (O*NET): implications for practice and research. *Personnel Psychol*. 2001;54:451–492.
22. Hadden W, Kravetz N, Muntaner C. The dimensions of work organization using the O*NET. *Soc Sci Res*. 2004;58:1869–1887.
23. LaPolice CC, Carter GW, Johnson JW. Linking O*NET descriptors to occupational literacy requirements using job component validation. *Personnel Psychol*. 2008;61:405–441.
24. Muthen B, Muthen LK. Integrating person-centered and variable-centered analyses: growth mixture modeling with latent trajectory classes. *Alcohol Clin Exp Res*. 2000;24:882–891.
25. Sturgis P, Sullivan L. Exploring social mobility with latent trajectory groups. *J Royal Statist Soc: Series A*. 2008;171:65–88.
26. Kohn ML, Schooler C. The reciprocal effects of the substantive complexity of work and intellectual flexibility: a longitudinal assessment. *Am J Sociol*. 1978;84:24–52.
27. Schooler C, Mulatu MS, Oates G. The continuing effects of substantively complex work on the intellectual functioning of older workers. *Psychol Aging*. 1999;14:483–506.
28. Miech RA, Eaton W, Liang KY. Occupational stratification over the life course: a comparison of occupational trajectories across race and gender during the 1980s and 1990s. *Work Occup*. 2003;30:440–473.
29. Davey Smith G, Hart C, Hole D, et al. Education and occupational social class: which is the more important indicator of mortality risk? *J Epidemiol Community Health*. 1998;52:153–160.
30. Geronimus AT. Understanding and eliminating racial inequalities in women's health in the United States: the role of the weathering conceptual framework. *J Am Med Womens Assoc*. 2001;56:133–136, 149–150.
31. O'Rand AM, Hamil-Luker J. Processes of cumulative adversity: childhood disadvantage and increased risk of heart attack across the life course. *J Gerontol B Psychol Sci Soc Sci*. 2005;60(suppl):S117–S124.
32. Meyer JD, Nichols GH, Warren N, Reisine S. Maternal occupation and risk for low birth weight delivery: assessment using state birth registry data. *J Occup Environ Med*. 2008;50:306–315.
33. Messing K, Dumais L, Courville J, Seifert AM, Boucher M. Evaluation of exposure data from men and women with the same job title. *J Occup Med*. 1994;36:913–917.
34. Schwartz JE, Pieper CF, Karasek RA. A procedure for linking psychosocial job characteristics data to health surveys. *Am J Public Health*. 1988;78:904–909.
35. Brandt LP, Nielsen CV. Job stress and adverse outcome of pregnancy: a causal link or recall bias? *Am J Epidemiol*. 1992;135:302–311.
36. Landsbergis PA, Schnall PL, Pickering TG, Warren K, Schwartz JE. Life-course exposure to job strain and ambulatory blood pressure in men. *Am J Epidemiol*. 2003;157:998–1006.
37. Landsbergis PA, Schnall PL, Warren K, Pickering TG, Schwartz JE. Association between ambulatory blood pressure and alternative formulations of job strain. *Scand J Work Environ Health*. 1994;20:349–363.
38. Steenland K. Epidemiology of occupation and coronary heart disease: research agenda. *Am J Ind Med*. 1996;30:495–499.
39. Breslin FC, Mustard C. Factors influencing the impact of unemployment on mental health among young and older adults in a longitudinal, population-based survey. *Scand J Work Environ Health*. 2003;29:5–14.