Socioeconomic disadvantage in childhood and across the life course and all-cause mortality and physical function in adulthood: evidence from the Alameda County Study

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J. Epidemiol. Community Health 2007;61;723-730
doi:10.1136/jech.2006.050609

RESEARCH REPORT

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J Epidemiol Community Health 2007;**61**:723–730. doi: 10.1136/jech.2006.050609

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Accepted 30 October 2006

Objective: To measure the childhood and life course socioeconomic exposures of people born between 1871 and 1949, and then to estimate the probability of death between 1965 and 1994, the probability of functional limitation in 1994, and the combined probability of dying or experiencing functional limitation during this period.

Setting, participants and design: Data were from the Alameda County Study (California) and pertained to people aged 17–94 years (n = 6627) in 1965 (baseline). Socioeconomic position (SEP) in childhood was based on respondent's reports of their father's occupation, and life course disadvantage was measured by cross-classifying childhood SEP and the respondent's education and household income in 1965. The health outcomes were all-cause mortality (n = 2420) and functional limitation measured using the Nagi index (n = 453, 17.4% of those alive in 1994). Relationships were examined before and after adjustment for changed socioeconomic circumstances after 1965.

Results: Those from a low SEP in childhood, and those exposed to a greater number of episodes of disadvantage over the life course before 1965, were subsequently more likely to die, to report functional limitation and to experience the greatest health-related burden.

Conclusions: All-cause mortality, functional limitation and overall health-related burden in middle and late adulthood are shaped by socioeconomic conditions experienced during childhood and cumulative disadvantage over the life course. The contributions made to adult health by childhood SEP and accumulated disadvantage suggest that each constitutes a distinct socioeconomic influence that may require different policy responses and intervention options.

Socioeconomic variations in health in adulthood are partly the result of differential exposure to adverse social and economic conditions in early life and across the life course.[1 2] Prospective cohort studies demonstrate that poor socioeconomic circumstances in childhood are associated with higher rates of mortality from all causes, cardiovascular disease, stomach cancer[3–5] and lower self-rated health[6 7] in adulthood independent of adult socioeconomic position (SEP). Further, the highest rates of mortality and morbidity are exhibited by those who have experienced the greatest cumulative exposure to social and economic adversity over the life course.[8–10]

Many studies that investigate life course influences on adult health examine mortality. As mortality continues to fall and becomes a less sensitive indicator of population health,[11] assessments of health based solely on mortality overlook conditions such as functional limitation, which contribute significantly to the disease burden in society and result in substantial costs, suffering and disability, but do not necessarily lead directly to death.[12] As a consequence of such concerns, measures of population health monitoring emerged—such as the disability-adjusted life year—that combine information about mortality with certain aspects of morbidity, thereby allowing for a more complete picture of health.[12 13] Similar reasoning can be applied to the assessment of health in population-based surveys that take a life-course approach to socioeconomic health inequalities. The use of composite health indicators capturing both mortality and some aspects of morbidity would arguably add to our understanding of the total effect of cumulative disadvantage on overall health in adulthood.

In this study, we use data from the Alameda County Study (ACS) to measure the childhood and life-course socioeconomic exposures of people born between 1871 and 1949, and then estimate the probability of dying between 1965 and 1994, the probability of experiencing functional limitation in 1994 and the combined probability of one of these two adverse health events occurring.

METHODS

Study population

The ACS is a longitudinal population-based investigation of factors related to health and functioning: full details of the study have been reported elsewhere.[9 14] The first wave of data was collected in 1965, and the sample (n = 6928) was representative of the adult population of Alameda County, California, USA. Survivors were resurveyed in 1974, 1983 (a 50% sample) and 1994. Response rates for the four surveys were 86%, 85%, 87% and 93%, respectively.

Measurement of socioeconomic indicators

Table 1 gives details of the socioeconomic indicators of the study sample in 1965 and 1994.

Childhood SEP

SEP was assessed at baseline (1965) by respondents' reports of their father's usual occupation during the first 15 years of the respondent's life. Fathers' occupations were coded as white

Abbreviations: ACS, Alameda County Study; SEP, socioeconomic position

Table 1 Sample characteristics in 1965 (baseline) and 1994

	Men, n (%)	Women, n (%)	Total
Childhood socioeconomic position in 1965			
High	1418 (46.8)	1751 (48.7)	3169
Medium	991 (32.7)	1180 (32.8)	2171
Low	621 (20.5)	666 (18.5)	1287
Total	3030	3597	6627
Childhood socioeconomic position in 1994			
High	566 (50.1)	721 (48.8)	1287
Medium	369 (32.7)	523 (35.4)	892
Low	195 (17.3)	234 (15.8)	429
Total	1130	1478	2608
Cumulative socioeconomic disadvantage in 1965			
Least exposure	828 (28.5)	861 (25.6)	1689
Moderate exposure	1757 (60.4)	2113 (62.8)	3870
Greatest exposure	322 (11.1)	392 (11.6)	714
Total	2907	3366	6273
Cumulative socioeconomic disadvantage in 1994			
Least exposure	429 (39.1)	477 (33.2)	906
Moderate exposure	612 (55.7)	856 (59.7)	1468
Greatest exposure	57 (5.2)	102 (7.1)	159
Total	1098	1435	2533
Age in 1965 (years)			
17–35	1093 (36.1)	1298 (36.1)	2391
36–45	683 (22.5)	792 (22.0)	1475
⩾46	1254 (41.4)	1507 (41.9)	2761
Total	3030	3597	6627
Age in 1994 (years)			
46–64	572 (50.6)	779 (52.7)	1351
65–74	346 (30.6)	413 (27.9)	759
⩾75	212 (18.8)	286 (19.4)	498
Total	1130	1478	2608
Deaths from 1965 to 1994 by age in 1965 (years)			
17–35	103 (8.6)	67 (5.5)	170
36–45	178 (14.9)	163 (13.3)	341
⩾46	915 (76.5)	994 (81.2)	1909
Total	1196	1224	2420
Functional limitation in 1994 by age in 1994 (years)*			
46–64	38 (26.6)	109 (35.2)	147
65–74	49 (34.3)	92 (29.7)	141
⩾75	56 (39.2)	109 (35.2)	165
Total	143	310	453

*Reduced function was indicated if participants reported difficulties with ⩾5 items[9] on the Nagi scale.[15]

collar (high), skilled manual (middle) and unskilled manual (low).

Cumulative disadvantage

This was measured using childhood SEP and the respondent's education and household income in 1965. At baseline, participants of the ACS were aged 17–94 years, with the oldest and youngest person born in 1871 and 1949, respectively. Over this period, the social significance of the same education level would have changed markedly—for example, a high-school education attained in the early 1900s would be very different from an equivalent education in the 1950s. As in previous ACS papers,[3] we attempted to account for this by using a "cohort-sensitive" approach where respondents were assigned to an education category relative to their birth cohort. The resultant baseline education variable was distributed as follows: low (n = 1920, 27.8%), medium (n = 2508, 36.4%) and high (n = 2469, 35.8%). Household income was self-reported pre-tax total income from all sources received in the preceding year (1964), recorded using income categories. Respondents were classified as low (<US$6000, n = 1954, 29.8%), middle (⩾US$6000–10 000, n = 2461, 37.5%) and high income (>US$10 000, n = 2143, 32.7%). The cumulative disadvantage variable was created by cross-classifying the three socioeconomic indicators to derive different combinations of life course exposure as follows: high SEP at ⩾2 points before 1965 (least exposure), a mix of SEPs (moderate exposure) and low SEP at ⩾2 points (greatest exposure).

Ascertainment of mortality

Deaths occurring between 1965 and 1994 were ascertained by computer linkage to the California Master Death Index supplemented by searches of the National Death Index, and extensive in-state and out-of-state tracing. Approximately 95% of deaths that occurred between 1965 and 1994 were successfully (and correctly) ascertained. As at December 1994, 2560 participants in the 1965 cohort had died from all causes.

Assessment of functional limitation in 1994

We used the physical performance scale developed by Nagi,[15] which is based on Likert-type self-reports of the difficulty involved in performing seven activities: stooping, crouching or kneeling; lifting or carrying weights >10 pounds (>45 kg), such as a heavy bag of groceries; reaching or extending your arms above your shoulders; getting up from a stooping, kneeling or crouching position; standing up after sitting in a chair; pulling or pushing a large object, such as a living room chair; and writing or handling small objects. Self-reported measures of functional limitation have acceptable test–retest reliability[16 17] and validity when examined against the observed performance of tasks.[18] Despite earlier concerns about sex reporting bias,[19 20] recent work indicates that men and women report their limitation and disability levels accurately and in accordance with their actual performance ability.[18 21] Consistent with an earlier ACS,[9] participants were classified as having reduced physical functioning if they reported difficulties with ⩾5 items (453/2608, 17.4%).

Analysis

We undertook an age-stratified analysis for men and women aged 17–35, 36–45 and ⩾46 years in 1965, who were aged 46–64, 65–74 and ⩾75 years, respectively, in 1994. Those aged 46–64 years corresponded to a working age group, thus allowing us to investigate the socioeconomic patterning of premature mortality and function, whereas the latter two age groups are typically defined in gerontological research as "older persons",[22 23] among whom we would expect to see a flatter socioeconomic gradient in health vis-à-vis their younger counterparts.[24]

The analyses (performed in SAS V.8.2) were conducted separately for childhood SEP and cumulative disadvantage; hence, sample sizes differed slightly for each socioeconomic indicator. The 1965 baseline sample of the ACS comprised 6928 participants. Of these, 301 were excluded because of missing data on childhood SEP, and 354 additional cases because of missing data on either education or income, which in combination with childhood SEP, formed the cumulative disadvantage variable. In 1994, the follow-up sample comprised 2729 participants. For the analysis of childhood SEP, this was reduced to 2608 participants, with the exclusion of missing data for father's occupation (n = 82), the Nagi index (n = 37) or both (n = 2). Analyses involving the cumulative disadvantage variable necessitated that 75 additional cases be excluded because of missing data on education or income, resulting in a final sample of 2533.

The probability of dying between 1965 and 1994, and of reduced physical function in 1994, was modelled using Poisson

and logistic regression, respectively. The probability of death or functional limitation in 1994 was estimated by the addition law of probability for independent events using the expression: Pr(death U functional limitation) = Pr(death)+Pr(functional limitation)×[1−Pr(death)]. In words, the probability of death or limitation was a function of the probability of death plus the probability of experiencing functional limitation, multiplied by the probability of being alive (which is equivalent to 1 minus the probability of death). The probabilities for the middle and low socioeconomic groups relative to the most advantaged were expressed as risk ratios. For each ratio, we estimated a 95% confidence interval (CI) using a bootstrap procedure.[25]

To assess the ''independent'' effect of pre-1965 life course SEP on mortality and functional limitation, it was necessary to adjust for changes in SEP between 1965 and 1994. This was undertaken by deriving an estimate of income change over the reference period and then including this estimate as an ''adjustment factor'' in subsequent life course modelling. Across the four waves of the ACS, income data were collected using a question that had different income categories at each wave (reflecting changing population income distributions over time): thus, the income categories for each survey year were not directly comparable. To account for this, and to allow comparability over time, we estimated an actual income for each participant in 1965, 1974, 1983 and 1994 using information on each participant's reported age, sex, race, marital status, employment, education and occupation from the equivalent groups in the US Current Population Survey. The Current Population Survey is a monthly nationally representative survey of households conducted by the Bureau of the Census and is the primary source of information on the labour force characteristics of the US population. The estimated income for each participant was bounded within what they reported categorically in the survey. The result of this process when applied to the total ACS sample was a continuous income distribution for each survey year. We subsequently used autoregressive statistical models to estimate income changes for each participant—where ''change'' was reflected in the direction and magnitude of the income slope coefficient—and this coefficient was then used to adjust for changes in SEP between 1965 and 1994.

RESULTS

Table 2 presents associations between childhood SEP and the probability of dying between 1965 and 1994. The probability of death was higher among those who experienced a socioeconomically disadvantaged position in childhood; this pattern was evident irrespective of sex or age, and both before and after adjustment for SEP post baseline. Table 2 also shows a graded association between cumulative disadvantage and mortality, with the probability of death being highest among those who experienced the greatest number of exposures to adverse socioeconomic circumstances across the life course before 1965.

Table 3 examines the association between childhood SEP, cumulative disadvantage and the probability of experiencing functional limitation in 1994. Before adjustment for changed socioeconomic circumstances after baseline, the risk of functional limitation tended to be highest among those from disadvantaged backgrounds. These relationships were attenuated after adjustment for SEP after 1965, although increased risks of functional limitation remained for a number of age–sex subgroups.

Table 4 shows associations between childhood SEP, cumulative disadvantage and the combined probability of dying between 1965 and 1994 or experiencing functional limitation in 1994. The likelihood of either of these adverse health events occurring was typically higher among those from disadvantaged backgrounds; moreover, the relationships were found for both men and women before and after adjustment for post-baseline SEP.

DISCUSSION

The likelihood of dying between 1965 and 1994 was significantly higher for respondents who experienced a socioeconomically disadvantaged position in childhood and those who were exposed to a greater number of disadvantaged circumstances in the years preceding baseline. These findings are consistent with other prospective life course studies that have examined all-cause mortality.[3–5] Childhood SEP and cumulative disadvantage were also (suggestively) associated with functional limitation for women, although for men, too few cases precluded any reliable assessment. Of women who survived to 1994, those who experienced disadvantage in childhood, and those exposed to greater accumulated disadvantage, were more likely to report limited function. These results extend earlier work showing associations between adult SEP and functional limitation[26–28]; however, we also demonstrated a relationship between childhood SEP and functional limitation in adulthood.

Our use of an outcome that combined the probability of dying between 1965 and 1994 with the probability of experiencing functional limitation in 1994 further contributes to life-course research. Summary measures that link mortality with non-fatal morbidity or impairment are increasingly being used for population health monitoring purposes as a means of assessing health and well-being in both its quantitative and its qualitative aspects.[12 13] Our adaptation of this approach for use with a population-based survey showed that the greatest health burden in adulthood was borne by those from the most disadvantaged group in childhood and those who experienced more episodes of accumulated disadvantage.

Many of the associations between childhood SEP and accumulated disadvantage with mortality, functional limitation and the combined measure of health burden were observed before and after adjustment for changes in SEP over the 29-year period between baseline and 1994, although the associations were often attenuated as a result of adjustment. The fact that adjustment for changed socioeconomic circumstances often attenuated (but did not eliminate) the relationship between SEP and health suggests that childhood and life-course disadvantage are important for health in later life, and that adult SEP makes an additional contribution.[29] Also, significant associations after adjustment suggest that disadvantages in earlier life affect health in later life, which is to some extent immutable to intervening factors.[30 31]

Socioeconomic difference by sex

Until recently, evidence about the links between childhood SEP, accumulated disadvantage and health in adulthood were based on studies of men.[3 5] During the last few years, researchers have begun to redress this imbalance by conducting studies which show that childhood and life-course socioeconomic processes are also important for the health of adult women[3 32] and these findings are now further supported by the results of this study. Irrespective of socioeconomic indicator and age cohort, the probability of death was greater for men, whereas the likelihood of experiencing functional limitation was higher for women. These results are consistent with evidence showing that men have a lower life expectancy and higher mortality,[33] whereas women have a higher prevalence of functional limitation and associated non-fatal disabling conditions.[32 34 35] Our study also showed that the size of the socioeconomic health gradients differed by sex. Specifically, among the youngest group, relative socioeconomic health inequalities for mortality, functional limitation and disease burden were substantially larger for women, and these relative

Table 2 Probability of dying between 1965 and 1994; by childhood socioeconomic position and cumulative socioeconomic disadvantage, unadjusted (model 1) and adjusted (model 2) for socioeconomic position after baseline (1965)

	Men						Women					
	Model 1†			Model 2‡			Model 1			Model 2		
Childhood SEP and age in 1965	n*	Probability (%)	RR	95% CI	Probability (%)	RR	95% CI	n	Probability (%)	RR	95% CI	Probability (%)	RR	95% CI
18–35 years														
High	36	8.7	1.00		11.6	1.00		26	5.0	1.00		5.7	1.00	
Medium	45	13.1	1.51	1.0 to 2.4	14.7	1.26	0.8 to 1.9	15	3.4	0.68	0.3 to 1.3	3.6	0.63	0.4 to 1.1
Low	22	15.2	1.75	1.0 to 2.9	17.1	1.47	0.9 to 2.5	26	12.6	2.51	1.5 to 4.2	12.9	2.28	1.3 to 3.9
36–45 years														
High	82	26.3	1.00		24.9	1.00		69	22.2	1.00		21.3	1.00	
Medium	50	27.6	1.05	0.8 to 1.4	27.3	1.10	0.8 to 1.5	64	24.0	1.08	0.8 to 1.5	23.8	1.12	0.8 to 1.5
Low	46	31.0	1.18	0.9 to 1.5	31.2	1.26	0.9 to 1.7	30	22.7	1.02	0.7 to 1.5	24.7	1.16	0.8 to 1.7
⩾46 years														
High	440	71.4	1.00		70.4	1.00		547	61.8	1.00		62.1	1.00	
Medium	270	71.0	0.99	0.9 to 1.0	70.4	1.00	0.9 to 1.1	268	65.0	1.05	1.0 to 1.1	66.2	1.07	1.0 to 1.1
Low	205	74.1	1.04	1.0 to 1.1	74.4	1.06	1.0 to 1.1	179	66.0	1.07	1.0 to 1.1	67.0	1.08	1.0 to 1.2
Cumulative disadvantage and age in 1965														
18–35 years														
Least exposure	25	8.6	1.00		11.9	1.00		11	3.3	1.00		3.6	1.00	
Moderate exposure	66	12.4	1.44	0.9 to 2.3	14.3	1.21	0.8 to 1.8	35	5.1	1.56	0.7 to 3.6	5.3	1.47	0.7 to 3.1
Greatest exposure	11	18.9	2.20	1.1 to 4.4	20.1	1.70	0.9 to 3.4	14	14.2	4.34	1.7 to 11.3	14.1	3.92	1.7 to 9.1
36–45 years														
Least exposure	50	21.7	1.00		18.9	1.00		34	16.7	1.00		12.8	1.00	
Moderate exposure	103	30.2	1.40	1.1 to 1.8	30.1	1.60	1.2 to 2.1	97	23.9	1.43	1.0 to 2.0	25.5	2.00	1.3 to 3.1
Greatest exposure	20	34.1	1.57	1.0 to 2.4	35.1	1.86	1.2 to 3.0	24	33.2	1.98	1.3 to 3.1	35.8	2.80	1.7 to 4.6
⩾46 years														
Least exposure	169	64.0	1.00		59.5	1.00		169	59.2	1.00		56.5	1.00	
Moderate exposure	542	73.1	1.14	1.1 to 1.2	73.5	1.23	1.1 to 1.3	575	62.6	1.06	1.0 to 1.2	64.4	1.14	1.0 to 1.2
Greatest exposure	150	76.4	1.19	1.1 to 1.3	76.7	1.29	1.2 to 1.4	137	67.9	1.15	1.0 to 1.3	69.1	1.22	1.1 to 1.4

RR, risk ratio; SEP, socioeconomic position.
Probability of death for each socioeconomic category was estimated using the following components: a, model intercept+logit; b, 29×exp(a); c, exp(−b); d, 1−c; where a is the predicted log rate of death per year for the socioeconomic category, b the mean number of deaths in the socioeconomic category during the 29-year reference period (1965–94) assuming a Poisson distribution, c the probability of no death occurring in the reference period and d the probability of death.
*Number of deaths that occurred in each sex–age subgroup between 1965 and 1994.
†Adjusted for age within each age group using age centreing.
‡Adjusted for age and changes in post-1965 household income.

Table 3 Probability of functional limitation in 1994; by childhood socioeconomic position and cumulative socioeconomic disadvantage, unadjusted (model 1) and adjusted (model 2) for socioeconomic position after baseline (1965)

		Men							Women					
		Model 1†			Model 2‡				Model 1			Model 2		
Childhood SEP and age in 1994	n*	Probability (%)	RR	95% CI	Probability (%)	RR	95% CI	n	Probability (%)	RR	95% CI	Probability (%)	RR	95% CI
46–64 years														
High	18	6.1	1.00		8.9	1.00		35	9.6	1.00		12.2	1.00	
Medium	14	7.0	1.16	0.6 to 2.3	8.1	0.91	0.4 to 2.0	54	18.0	1.88	1.3 to 2.7	19.0	1.56	1.0 to 2.4
Low	6	7.7	1.26	0.5 to 2.9	8.8	0.99	0.4 to 2.8	20	17.3	1.81	1.1 to 3.1	17.7	1.45	0.8 to 2.6
65–74 years														
High	20	11.8	1.00		12.1	1.00		34	17.6	1.00		14.7	1.00	
Medium	20	19.1	1.61	0.9 to 2.8	17.7	1.46	0.9 to 2.5	39	25.2	1.44	0.9 to 2.2	20.2	1.38	0.9 to 2.2
Low	9	12.0	1.01	0.4 to 2.3	10.0	0.82	0.4 to 1.8	19	26.9	1.53	0.9 to 2.5	19.6	1.33	0.7 to 2.4
⩾75 years														
High	25	23.8	1.00		23.8	1.00		64	38.3	1.00		38.7	1.00	
Medium	16	24.2	1.01	0.5 to 2.0	24.1	1.01	0.5 to 2.0	32	46.9	1.23	0.9 to 1.7	47.9	1.24	0.9 to 1.7
Low	15	35.2	1.48	0.8 to 2.8	34.9	1.47	0.8 to 2.8	13	25.8	0.67	0.4 to 1.1	26.7	0.69	0.4 to 1.2
Cumulative disadvantage and age in 1994														
46–64 years														
Least exposure	12	5.9	1.00		8.5	1.00		21	8.8	1.00		11.5	1.00	
Moderate exposure	23	7.1	1.21	0.6 to 2.4	8.5	1.00	0.5 to 2.0	69	14.6	1.65	1.0 to 2.6	16.0	1.39	0.8 to 2.4
Greatest exposure	2	9.5	1.62	0.4 to 6.0	9.6	1.13	0.3 to 3.7	12	24.9	2.81	1.4 to 5.7	22.9	2.00	1.0 to 4.1
65–74 years														
Least exposure	18	12.7	1.00		14.3	1.00		21	14.7	1.00		13.4	1.00	
Moderate exposure	24	13.6	1.07	0.6 to 1.9	11.7	0.82	0.5 to 1.5	57	24.8	1.69	1.0 to 2.8	19.3	1.43	0.9 to 2.4
Greatest exposure	5	21.8	1.72	0.6 to 4.9	17.2	1.20	0.4 to 3.6	10	34.6	2.36	1.2 to 4.6	25.9	1.93	0.9 to 4.3
⩾75 years														
Least exposure	23	27.7	1.00		27.9	1.00		40	38.8	1.00		39.1	1.00	
Moderate exposure	28	24.3	0.88	0.6 to 1.4	23.6	0.84	0.4 to 1.6	56	36.4	0.94	0.7 to 1.3	37.6	0.96	0.7 to 1.4
Greatest exposure	3	25.1	0.90	0.3 to 2.5	24.0	0.86	0.3 to 2.8	11	44.8	1.15	0.7 to 1.9	46.4	1.19	0.7 to 2.1

RR, risk ratio; SEP, socioeconomic position.
*Number of respondents in 1994 who reported ⩾5 difficulties with functional activities forming the Nagi index.
†Adjusted for age within each age group using age-centreing.
‡Adjusted for age and changes in post-1965 household income.

Table 4 Probability of death or functional limitation; by childhood socioeconomic position and cumulative socioeconomic disadvantage, unadjusted (model 1) and adjusted (model 2) for socioeconomic circumstances after baseline (1965)

	Men						Women					
	Model 1*			Model 2†			Model 1			Model 2		
Childhood SEP and age in 1994	Probability (%)	RR	95% CI	Probability (%)	RR	95% CI	Probability (%)	RR	95% CI	Probability (%)	RR	95% CI
46–64 years												
High	14.2	1.00		19.5	1.00		14.1	1.00		17.2	1.00	
Medium	19.2	1.35	0.9 to 2.1	21.6	1.11	0.7 to 1.7	20.8	1.47	1.1 to 2.0	21.9	1.27	0.9 to 1.8
Low	21.7	1.52	1.1 to 2.1	24.4	1.25	0.9 to 1.7	27.8	1.97	1.4 to 2.8	28.4	1.65	1.1 to 2.4
65–74 years												
High	35.0	1.00		34.0	1.00		35.9	1.00		32.8	1.00	
Medium	41.4	1.18	0.9 to 1.5	40.1	1.18	0.9 to 1.5	43.2	1.20	0.9 to 1.5	39.3	1.20	1.0 to 1.5
Low	39.3	1.12	0.9 to 1.4	38.1	1.12	0.9 to 1.4	43.5	1.21	0.9 to 1.6	39.4	1.20	0.9 to 1.6
⩾75 years												
High	78.2	1.00		77.5	1.00		80.9	1.00		76.8	1.00	
Medium	78.0	1.00	0.9 to 1.1	77.5	1.00	0.9 to 1.1	82.5	1.02	1.0 to 1.1	82.4	1.07	1.0 to 1.1
Low	83.2	1.06	1.0 to 1.1	83.4	1.08	1.0 to 1.2	83.0	1.03	1.0 to 1.1	75.8	0.99	0.9 to 1.1
Cumulative disadvantage and age in 1994												
46–64 years												
Least exposure	14.0	1.00		19.4	1.00		11.8	1.00		14.7	1.00	
Moderate exposure	18.6	1.33	1.0 to 1.9	21.6	1.11	0.8 to 1.5	18.9	1.60	1.1 to 2.4	20.4	1.39	0.9 to 2.1
Greatest exposure	26.6	1.91	1.1 to 3.5	27.8	1.44	0.8 to 2.6	35.5	3.00	1.9 to 4.9	33.8	2.30	1.4 to 3.8
65–74 years												
Least exposure	31.6	1.00		30.5	1.00		28.9	1.00		24.5	1.00	
Moderate exposure	39.7	1.26	1.0 to 1.6	38.3	1.26	1.0 to 1.6	42.8	1.48	1.1 to 1.9	39.8	1.63	1.2 to 2.2
Greatest exposure	48.5	1.54	1.0 to 2.3	46.2	1.52	1.0 to 2.2	56.3	1.95	1.5 to 2.6	52.4	2.14	1.5 to 3.1
⩾75 years												
Least exposure	74.0	1.00		70.8	1.00		75.0	1.00		73.5	1.00	
Moderate exposure	79.7	1.08	1.0 to 1.2	79.7	1.13	1.0 to 1.2	76.2	1.02	0.9 to 1.1	77.8	1.06	1.0 to 1.1
Greatest exposure	82.3	1.11	1.0 to 1.2	82.3	1.16	1.0 to 1.3	82.3	1.10	1.0 to 1.2	83.5	1.14	1.0 to 1.3

RR, risk ratio; SEP, socioeconomic position.
*Adjusted for age within each age group using age-centreing.
†Adjusted for age and changes in post-1965 household income.

differences were largest for cumulative disadvantage. A similar patterning by sex was observed for the middle-age group, whereas no clear sex difference in relative health inequality was evident among the oldest group. The exact reasons for these varying health patterns by sex are unclear; however, they challenge the perception in the epidemiological literature that socioeconomic gradients in health are less marked for women, and they support earlier work which shows that the evidence pertaining to sex differences in socioeconomic health inequalities is mixed and inconsistent, and varies by age-cohort, socioeconomic indicator and health outcome.[36]

Socioeconomic differences by age

Studies investigating the relationship between adult SEP and health for different age groups typically show that health inequalities diminish with age,[24 37] although even for the oldest groups health is usually poorest among those from disadvantaged backgrounds.[38 39] This investigation is the first known prospective life-course study to have stratified its socioeconomic analysis by age. Our findings indicate that for both childhood SEP and accumulated disadvantage, for men and women, and for all three outcomes, relative health inequalities tended to be largest among the youngest group, intermediate among the middle-age group and weakest among the oldest group. Even for this latter group, however, there was evidence that low SEP in childhood and greater exposure to accumulated disadvantage raised the probability of subsequent death and functional limitation. Narrower socioeconomic gradients among older groups for mortality may be a result of selective survival into old age,[38] where survivors of a cohort are biologically ''fitter'' than their non-surviving counterparts, and thus among this resilient group socioeconomic factors discriminate less well.[40] The capacity of socioeconomic indicators to discriminate might also be weakened as the overall prevalence of death increases, particularly when it approaches rates as high as 80% as it did for the oldest group.

Study limitations

1. The measures of childhood SEP and accumulated disadvantage were based on respondent recall at baseline. Although retrospective accounts of some early-life socioeconomic conditions are reliable and valid for use in life-course research,[41 42] associations between health and recalled SEP in childhood are weaker than associations based on actual measured SEP.[43]
2. The use of father's occupation and respondent's education and household income was admittedly a crude attempt to measure life-course socioeconomic conditions. The three measures are broad and imprecise markers of SEP, and they provide few (if any) reliable insights into the actual economic and material conditions experienced by the respondents in childhood and later in life. Relatedly, the measures of SEP are indirect distal markers of unobserved socioeconomic variation in biological, psychological, social and behavioural processes (eg, early life growth and development, nutrition, smoking, unemployment and stress) that interact in complex ways and often at different time points to ultimately shape and circumscribe socioeconomic inequalities in adult health. The measures of SEP used in this study tell us nothing directly about these processes; hence, it is difficult (except in general terms) to advance knowledge about how and why childhood SEP and cumulative disadvantage were associated with mortality and functional limitation in middle and late adulthood.
3. The estimates of functional limitation were based on respondents who survived between baseline and 1994. The overall probability of survival over this period was lower for men, and particularly so for men from disadvantaged childhood circumstances and men exposed to ⩾2 occasions of accumulated social and economic adversity over the life course. As a consequence, only a small number of men were alive in 1994 who reported difficulties with functional limitation; hence, estimates of limitation for this group were of low precision and need to be interpreted with caution.
4. The links between childhood SEP and mortality in adulthood often show a different pattern and strength of association depending on the cause of death. Studies have reported strong relationships between early-life SEP and cardiovascular disease, but weak or no association with deaths from lung cancer, or accidents and injury.[8 29] These findings reflect processes inherent in the two main life-course models—critical period and accumulation of risk[31]—with some causes of death in adulthood having clear socioeconomic, biological and psychosocial precursors in childhood, and other causes reflecting influences and exposures experienced in later life. Our focus on all-cause mortality largely precluded the identification of likely pathways linking childhood SEP and death in adulthood; rather, we attempted to capture the burden of life-course disadvantage on overall health in adulthood, and for this purpose, all-cause mortality, combined with a marker of morbidity, was appropriate.
5. As with all longitudinal studies, the ACS is characterised by sample attrition and non-response at follow-up; however, the nature and extent of this over the 29-year reference period was difficult to ascertain accurately. Respondents lost to follow-up in longitudinal studies are (often) more likely to come from disadvantaged backgrounds,[44–46] hence ''missingness'' in the ACS probably biases against our findings.
6. Our study measured physical function only in 1994. It is possible, however, that some respondents experienced

What this paper adds

- This study examines the association between life-course socioeconomic position and health in middle and late adulthood using a composite health indicator that combines the probability of mortality or experiencing functional limitation.
- We show that the greatest burden of poor health in later life is borne by those from the most disadvantaged group in childhood, and those who experienced more episodes of accumulated socioeconomic disadvantage over the life course.
- Our findings suggest that multiple exposures to disadvantage may have a larger effect on health than a single exposure at one point in time.

Policy implications

- Socioeconomic position in childhood and accumulated disadvantage over the life course seemingly constitute distinct socioeconomic influences on health in middle and late adulthood, hence policies and interventions directed at reducing health inequalities may need to be tailored accordingly.

functional limitation in the years before this, resulting in downward socioeconomic mobility (ie, health selection); thus the effects of life-course SEP on function may be overestimated.

CONCLUSION

All-cause mortality, functional limitation and overall disease burden in middle and late adulthood are shaped by socioeconomic conditions experienced during childhood and cumulative disadvantage over the life course. Thus, all stages of life play a role in influencing adult health, although the findings of this study indicate that multiple exposures to socioeconomic disadvantage seemingly have a larger effect than a single exposure at one point in time. The contributions made to adult health by childhood SEP and accumulated disadvantage suggest that each constitutes a distinct socioeconomic influence that may demand different policy responses and intervention options, and that the greatest gains in advancing population health and reducing health inequalities are likely to result from investments that improve social and economic conditions in both early and later life.

ACKNOWLEDGEMENTS

GT is supported by a National Health and Medical Research Council/National Heart Foundation Career Development Award (CR 01B 0502).

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Competing interests: None.

Ethical approval: Ethical approval for the study was granted by the University of Michigan Institutional Review Board, file number H03-00000397.

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