Published in final edited form as:

Ann Epidemiol. 2015 February ; 25(2): 65–70. doi:10.1016/j.annepidem.2014.11.018.

Cumulative socioeconomic disadvantage and cardiovascular disease mortality in the Alameda County Study 1965–2000

Vicki Johnson-Lawrence, PhD,
University of Michigan-Flint

Sandro Galea, MD, PhD, and
Columbia University

George Kaplan, PhD
University of Michigan

Abstract

Purpose—Socioeconomic disadvantage is often evaluated at single points in the adult life course in health research. Social mobility models suggest that socioeconomic patterns may also influence disease risk. This study examines cumulative socioeconomic disadvantage (CSD) in relation to CVD mortality.

Methods—Data were from the Alameda County (CA) Study (n=2530). The CSD indices included father's education, the respondent's education, and either average or latent variable trajectory models of adulthood household income (1965–1994). Proportional hazards models were used to assess the associations between CSD and CVD mortality.

Results—The CSD measures were not associated with CVD mortality in men. Among women, the magnitude of the association between CSD and CVD mortality was greater for the income trajectory ($HR_{3 \text{ vs } 0} = 4.73$, 95% CI = 2.20–10.18) compared to the average income ($HR_{3 \text{ vs } 0} = 3.78$, 95% CI = 1.67–8.53) CSD measure.

Conclusions—Measures of CSD that incorporate patterning of resources over the life course were associated with CVD mortality for women but not men. Patterning of available socioeconomic resources may differentially influence chronic disease risk and mortality by gender, and future work should continue to investigate how greater patterns variability in available resources influences health outcomes.

Keywords

income; socioeconomic; social mobility; cardiovascular disease; mortality

© 2014 Elsevier Inc. All rights reserved.

Corresponding Author: Vicki Johnson-Lawrence, 3124 William S White Building, Department of Public Health and Health Sciences, University of Michigan-Flint, 303 E Kearsley St, Flint, MI 48502, Phone: 810-762-3172, vickij@umich.edu.

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

We have no competing interests to declare.

Lower socioeconomic position (SEP) over the life course is strongly associated with increased risk of several chronic health outcomes (1–13), including cardiovascular disease (CVD). The relationships between life course SEP and CVD mortality has been frequently conceptualized using the accumulation model of disease risk (9, 14). Long term socioeconomic disadvantage, often indicated by low parental SEP during childhood (13), lower levels of education of the individual (15), and lower income levels of the individual (16) is associated with increased risk of poor adult health, including CVD mortality risk (16, 17). Socioeconomic disadvantage is often evaluated at single points in the adult life course in studies of health. However, social mobility models suggest that variability or patterns of socioeconomic resource availability, in addition to absolute measures of socioeconomic disadvantage are associated with variations in disease risk (18–21). Life course measures often examine changes or cumulative effects across of socioeconomic disadvantage from childhood to adulthood (16, 18), but few measures also incorporate variations throughout adulthood as an additional determinant of long-term health risks.

Social mobility over the adult life course has been examined in relation to several health outcomes, including mortality (22) and cardiovascular related outcomes (14, 23), and generally show that upwardly mobile groups have better health outcomes (24, 25). Few studies have addressed variation in SEP over time in relation to health (14, 26, 27), and suggest that upward mobility is associated with decreased CVD mortality risk. We were unable to identify any studies, however, that included measures from early stages of the life course along with measures of socioeconomic mobility, particularly measured by income, over the adult life course in relation to CVD mortality risk.

We examined associations between cumulative socioeconomic disadvantage (CSD), captured by both childhood resources and adulthood social mobility measured by income patterns over the adult life course and 6 year (1994–2000) CVD mortality risk among a population-based cohort of older adults who participated in the Alameda County Study from 1965–1994. Our work contributes to the limited body of empirical evidence examining social mobility based on both childhood conditions and SEP variability over the adult life course in relation to CVD mortality risk.

Methods

Study population

The Alameda County Study, initiated in 1965, was designed to collect socio-environmental, behavioral, and health data from men and women aged 20 and older (16 and older if married) in Alameda County, California (28–30). A two stage stratified systematic sample was used to gather data on 8,023 non-institutionalized adults from 4,452 household units (28). The respondents to the baseline survey (n=6928; 3158 (45.6%) men and 3770 (54.4%) women) represented 86% of those sampled. Follow-ups were completed in 1974 (85.1% response), 1983 (87.3% response among a 50% sample of those not known to be dead in 1982), and 1994 (n=2729, 93% response rate of respondents from 1974 and 1983). The analytic sample included all respondents without missing data for age in 1994, race/ethnicity, marital status, and a history of depressive symptoms (n=2530).

Cardiovascular disease mortality (CVDM) ascertainment

Cause-specific mortality data were collected from state death certificate data as well as gathered using cross-linkage methods with the National Death Index. Deaths of Alameda County Study participants were ascertained through December 31, 2000. All deaths attributable to diseases of the circulatory system (International Classification of Diseases-9 codes 390–459) were included for purposes of this study.

Definition of SEP measures

SEP during childhood, based on father's level of education, was assessed at the baseline wave in 1965. Respondents indicated their father's level of education, measured as no school, grammar school, completed some high school, was a high school graduate, or completed some college. The responses were categorized as no school/grammar school (disadvantage value of 1) versus completed some high school or more (disadvantage value of 0) for inclusion in the CSD indices described below. Respondent level of education was measured as the number of years of education completed (range = 0–16) as of 1994. Those with 0–12 years of education were assigned a disadvantage score of 1, and those with 13 or more years were assigned a disadvantage score of 0.

At each wave of data collection gross household income from all sources for the previous year was reported in categories. Household income in 1965 was categorized into four categories; fourteen categories in 1974, 19 categories in 1983, and 14 categories in 1994 and 1999. Using demographic data common to both the Alameda County Study and Current Population Surveys (31) of the same year, continuous measures of household income were imputed using IVEware (32), with the income bounded by the categories provided by the respondents in the survey (33). The common data used from the Alameda County Study and Current Population Surveys based on national data to carry out the imputation included age, education, gender, race, marital status, occupation, and number of household members. The Current Population Surveys, conducted monthly by the Census Bureau for the Bureau of Labor Statistics, provides the best national data on income (31). These continuous measures were constructed to reduce misclassification due to fluctuations in the income categories throughout the waves and the widths of the income categories, and the utility of this approach has been discussed elsewhere (33, 34). All respondents were required to have at least three waves of data for household income, and all income measures from each wave were adjusted for household size (35) and to 1993 dollars using the Consumer Price Index.

Each subject was required to have at least three measures of household income, and all income measures were adjusted to 1993 dollars using the Consumer Price Index (CPI). In addition, household income at each time point was adjusted for household size by dividing the CPI adjusted household income by the square root of the household size at that wave as suggested in previous studies utilizing household income (35). Two variants of household income based SEP were used- household income trajectory groups and average household income. Trajectories were created then grouped based on income trajectory patterns using PROC TRAJ (36) and is further discussed in the statistical analysis section below. Membership in the lower trajectories (Groups 1–3) and AHI between 1965 and 1994 less than the median of \$30,419 were categorized as disadvantaged (score of 1).

Two CSD indices were created to characterize life course SEP. The measures were based on the education level of the respondent's father, the individuals' education, and either average household income or the household income trajectories (further described below) for the 5 study waves during 1965–1994. Each index had a score range of 0–3 based on the count of disadvantage indicators.

Covariates

Age, race/ethnicity (categorized as white, black, and other), and marital status in 1994 (dichotomized as married and unmarried) were evaluated as potential confounders of the posited associations. Previous evidence has shown significant gender differences in socioeconomic position over the life course (37). We use gender-stratified analyses to allow examination of differential effects by gender.

Statistical analysis

Model of the income trajectories—Trajectories reflect patterns of household income, in 1994 dollars, from 1965, 1974, 1983, and 1994. Income trajectories were created using a group-based trajectory modeling approach within the PROC TRAJ procedure in the SAS System 9.2 (SAS Institute, Cary, NC) (36). The procedures within PROC TRAJ are performed under the assumption that a mixture of trajectory groups, captured through a parametric model, describes the household income data. The censored normal parametric model was used to model log household income. The likelihood of certain household incomes throughout the study period was then modeled using a latent variable modeling linkages between polynomial functions of time and household income (38).

Maximum likelihood was used to estimate model parameters, with the maximization performed using a general quasi-Newton procedure. Standard error estimates were calculated by inversion of the observed information matrix evaluated at the maximum likelihood parameter estimates. Subjects with some missing household income between 1965 and 1994 were not dropped from analyses, avoiding bias in the sample under the assumption the data were missing completely at random.

The number of trajectory groups most appropriate for the data was determined by fitting models with 2–6 trajectory groups of the same polynomial order for each group, and selecting the model with the most negative Bayesian Information Criterion (BIC) (36). Two-six groups allowed for multiple subgroups to emerge. Patterns of the trajectories were determined based on the highest polynomial order that remained significant for each trajectory over time.(39). All probabilities were greater than 90%. The resulting classification variable was included as a component of the CSD measures used in the analyses. Although the probability of membership for the respective trajectory classes were greater than 90%, the variability of any individual from the modal values of the trajectories was unaccounted for in the regression models.

Survival analysis—Proportional hazards regression models using PROC PHREG in SAS v 9.2 were used to examine the associations. Validity of the proportional hazards assumptions was assessed through the inclusion of interaction terms between time and each

variable in the models. Akaike Information Criterion (AIC) measures were used to compare the fit of the hazards regression models.

Observation time was calculated from the completion date of the survey in 1994, or June 1, 1994 for those with missing data for date of questionnaire completion, until the given date of death or the end of follow-up for deaths (December 31, 2000).

Descriptive statistics for each variable were examined by gender and compared using ttests for continuous variables and chi-square tests for categorical measures. Proportional hazards regression models were used to examine the associations. Validity of the proportional hazards assumptions was assessed through the inclusion of interaction terms between time and each variable in the models.

Results

Sample characteristics

Of the 2,729 men and women with data collected in 1994, all of these individuals had at least three years of data, and 2,530 of these persons provided information on gender, age, race/ethnicity, marital status, level of education, household income, and father's education, and were therefore included in these analyses. As a result, 199 people (7.3%) were excluded from these analyses, and they were more likely to be female, white, married, and had 12 years of education or less.

Descriptive statistics for the sample are presented in Table 1. There were 1103 men and 1427 women included in this analyses. Amongst these groups, there were 59 (5.3%) deaths from CVD in men and 80 (5.6%) deaths from CVD in women. Chi-square tests indicated differences by marital status ($p<0.01$) and education ($p<0.01$) by gender, and t-tests showed no differences in observation time ($p=0.06$) and age ($p=0.54$).

Income trajectory patterns—Information pertaining to the income and disadvantage measures used in this analysis is shown in Table 2. Six trajectories emerged from the analyses for household income from 1965–1994 for the entire sample and are shown in Figure 1. Membership percentages of the groups were 1.34%, 1.90%, 11.62%, 67.22%, 14.51%, and 3.44% for groups one to six (lowest to highest), respectively. For men, the membership percentages were 0.63%, 1.33%, 8.34%, 67.44%, 18.22%, and 4.22%, and for women, they were 1.99%, 2.438%, 14.216%, 67.11%, 11.63%, and 2.99% for groups one to six respectively. Women were more likely to follow lower income trajectory patterns (all with $p<0.01$).

CSD indices. Distributions of the disadvantage measures by gender are shown in Table 2. In the sample, 56.69% of the men and 59.71% for women had fathers that completed at least some high school (. Chi-square tests indicated no differences in father's education by gender ($p=0.12$). Women were more likely than men to have lower average household income from 1965–1994 ($p<0.01$). The greatest proportion of men (38.11%) and women (36.72%) had a disadvantage score of 0, but the disadvantage score distributions were significantly different ($p<0.01$).

Proportional hazards model results

Results of the proportional hazards models are presented in Tables 3 and 4. Two sets of models were run: (1) including the CSD measure only; and (2) including the CSD measure along with age, race/ethnicity, and marital status. For each proportional hazards model, the least disadvantaged group (score of 0) for each disadvantage index was the referent category. No violations of the proportional hazards were detected for any of the models.

Bivariate model results (Table 3) for men indicated that greater cumulative disadvantage based on the measure including average income, education, and father's education was positively associated with the hazards of CVD mortality ($HR_{2 \text{ vs } 0} = 2.18$, 95% CI = 1.02–4.65). Confounder adjusted models including age, race/ethnicity, and marital status (Table 4) showed no significant associations between either of the disadvantage indices and CVD mortality. Among women, greater cumulative disadvantage was associated with CVD mortality across measures in bivariate models. Both the cumulative measures that incorporated the trajectories ($HR_{3 \text{ vs } 0} = 11.56$, 95% CI = 5.50–24.31) and average income ($HR_{3 \text{ vs } 0} = 7.96$, 95% CI = 3.52–17.99) were positively associated with the hazards of CVD mortality. Multivariable models including age, race/ethnicity and marital status results were consistent with the bivariate model results for women (Table 4).

Discussion

We aimed to document whether there were associations between cumulative disadvantage measures that incorporated childhood conditions, young adulthood conditions, and patterning of adulthood socioeconomic resources based on household income variation with CVD mortality. The adverse association between socioeconomic disadvantage over the life course and cardiovascular disease mortality was more evident for women compared to men, and the disadvantage measures that incorporated the trajectory of income patterning over the adult life course were more predictive of CVD mortality than measures that included average household income over the life course instead of the trajectory pattern measure. These associations persisted with adjustment for demographic confounders among women, but not men. Models that adjusted for age alone resulted in non-significant associations between the CSD measures and CVD mortality among men, suggesting stronger age-related changes in health for income based SEP measures. These findings indicate that the life course patterns of experience of SEP, and particularly for women, are more predictive of 6-year CVD mortality among older adults.

The results from these analyses were consistent with the literature, showing adverse associations between SEP disadvantage over the life course and coronary heart disease and heart attack risk (8, 12, 16, 19, 40–45). It has become more evident in the literature that multiple life course models are relevant, although the accumulation model is commonly discussed in studies that employ a score approach to evaluating disadvantage at multiple points throughout the life course (8, 12, 19). However, this analysis differs from that currently in the literature in that it does not suggest any particular life course model as a primary explanatory pathway through which disadvantage affects CVD; instead, it investigates the effects of multiple variations of disadvantage measures based on different measures of a single SEP indicator, and it compares the magnitudes of these associations in

order to learn the potential fluctuation to expect in discussion of associations between SEP disadvantage measures over the life course with CVD mortality.

Additional analyses (not shown) were carried out to determine if disadvantage measures based on the individuals' household income measures from 1965, 1974, and 1983, education, and father's education or occupation were related to 6-year CVD mortality, and showed disadvantage earlier in the life course was with increased hazards of CVD mortality among men but not women. In conjunction with the study findings of this project, these results may indicate the need to incorporate measures of household income that capture longer periods of time for women but earlier periods of the life course for men, and likely reflects the varying levels of employment rates among women (46).

Strengths & Limitations

There were multiple strengths in these analyses that addressed some of the gaps in the current literature about cumulative socioeconomic disadvantage. The measures used in this analysis included information from multiple points in the life course. These analyses were based on the longitudinal nature of the data, which allowed us to look at life course measures of disadvantage and to infer information about the effects of life long diminished access to multiple resources and the effects on health later in life. Although the information gathered on this sample was based on only four waves of data, which introduced wide time intervals in which significant fluctuations in income could have occurred, the repeated measures for several individuals provided us with the opportunity to examine changes in income and their associations with CVD mortality.

There were also limitations to our analyses. All but the mortality data were self-reported. Childhood conditions were recalled by the ACS respondent, which could introduce recall bias and therefore cause results to be biased away from the null values, although the validity of recalled measures has been verified (47). A second limitation of this data is that death certificate data were used to identify CVD deaths, and literature has documented an excess in the number of deaths classified as heart disease that were possibly attributable to other causes (48). We expect these classifications to be non-differential across socioeconomic groups, therefore avoiding bias in the estimated associations.

Third, our analyses were based on the creation of the household income trajectory classes. Due to the limited number of cases of each outcome, we were unable to create gender specific trajectory classes that represented the variability of household incomes between 1965 and 1994. The limited number of CVD mortalities is likely due to the limited six year follow-up period for deaths, and analyses with larger sample sizes or longer follow-ups for mortality ascertainment could be used to investigate the most conceptually appropriate gender-specific household income trajectories while having sufficient numbers of cases to investigate associations with CVD mortality.

Fourth, although several other variables, such as risk factors for CVDM, are plausible mechanisms through which socioeconomic disadvantage may be related to CVDM, these factors are likely intermediaries of the proposed associations, and could be further explored in future analyses. Wealth, through its many forms, is an additional socioeconomic measure

that may be strongly related to CVD mortality as well (49, 50). Limited wealth data were available in the Alameda County Study, and should be also be included in future investigations of life course SEP trajectories in relation to later life health.

Conclusion

In summary, cumulative socioeconomic disadvantage is associated with CVD mortality risk, and including measures that account for patterning of household income over the adult life course increases these cumulative effects. The results suggest that the mechanisms by which these relationships occur may vary for men and women. These results add to the evidence present in the literature suggesting that changes at various points in the life course that decrease disadvantage can be beneficial for the population, especially among women. Further, improvements in socioeconomic conditions that persist over time can have substantial benefits that may far outweigh those delivered only at a single point in time.

This work emphasizes a continued need to examine life course patterns of experiences as correlates of later adulthood health and mortality. The interrelationships of SEP and other social factors that influence health are likely to vary over the life course, and future work could look to evaluate how the covariance of these factors at various points of the adult life course influence later life health outcomes and well-being.

Acknowledgements

These data are publicly available from the Inter-university Consortium for Political and Social Research at the Institute for Social Research at the University of Michigan, in which the data undergo confidentiality reviews, and were reviewed by the University of Michigan IRB Council in April 2006. These data were deemed to not require additional IRB approval. This work was supported by the National Institutes of Health (5R37AG011375 and R24 HD047861 to G.A.K.) and the Rackham Merit Fellowship, University of Michigan (V.D.J.L.).

References

1. Turrell G, Lynch JW, Kaplan GA, Everson SA, Helkala EL, Kauhanen J, et al. Socioeconomic position across the lifecourse and cognitive function in late middle age. *J Gerontol B Psychol Sci Soc Sci*. 2002 Jan; 57(1):S43–S51. PubMed PMID: 11773232. Epub 2002/01/05. eng. [PubMed: 11773232]
2. Frank JW, Cohen R, Yen I, Balfour J, Smith M. Socioeconomic gradients in health status over 29 years of follow-up after midlife: the Alameda county study. *Soc Sci Med*. 2003 Dec; 57(12):2305–2323. PubMed PMID: 14572839. Epub 2003/10/24. eng. [PubMed: 14572839]
3. Galobardes B, Lynch JW, Davey Smith G. Childhood socioeconomic circumstances and cause-specific mortality in adulthood: systematic review and interpretation. *Epidemiol Rev*. 2004; 26:7–21. PubMed PMID: 15234944. Epub 2004/07/06. eng. [PubMed: 15234944]
4. Everson SA, Maty SC, Lynch JW, Kaplan GA. Epidemiologic evidence for the relation between socioeconomic status and depression, obesity, and diabetes. *J Psychosom Res*. 2002 Oct; 53(4):891–895. PubMed PMID: 12377299. Epub 2002/10/16. eng. [PubMed: 12377299]
5. Gilman SEK, Fitzmaurice I, Buka GM, L S. Socioeconomic status in childhood and the lifetime risk of major depression. *Int J Epidemiol*. 2002 Apr; 31(2):359–367. PubMed PMID: 11980797. Epub 2002/05/01. eng. [PubMed: 11980797]
6. Song YM, Ferrer RL, Cho SI, Sung J, Ebrahim S, Davey Smith G. Socioeconomic status and cardiovascular disease among men: the Korean national health service prospective cohort study. *Am J Public Health*. 2006 Jan; 96(1):152–159. PubMed PMID: 16373668. Pubmed Central PMCID: 1470435. Epub 2005/12/24. eng. [PubMed: 16373668]

7. Whooley MA, de Jonge P, Vittinghoff E, Otte C, Moos R, Carney RM, et al. Depressive symptoms, health behaviors, and risk of cardiovascular events in patients with coronary heart disease. *JAMA : the journal of the American Medical Association*. 2008 Nov 26; 300(20):2379–2388. PubMed PMID: 19033588. Epub 2008/11/27. eng.
8. O'Rand AM, Hamil-Luker J. Processes of cumulative adversity: childhood disadvantage and increased risk of heart attack across the life course. *Journal of Gerontology*. 2005; 60B:117–124.
9. Pollitt RA, Rose KM, Kaufman JS. Evaluating the evidence for models of life course socioeconomic factors and cardiovascular outcomes: a systematic review. *BMC Public Health*. 2005; 5(7)
10. Ramasubbu R, Patten SB. Effect of depression on stroke morbidity and mortality. *Can J Psychiatry*. 2003 May; 48(4):250–257. PubMed PMID: 12776392. Epub 2003/06/05. eng. [PubMed: 12776392]
11. Ross CE, Mirowsky J. Sex differences in the effect of education on depression: resource multiplication or resource substitution? *Soc Sci Med*. 2006 Sep; 63(5):1400–1413. PubMed PMID: 16644077. Epub 2006/04/29. eng. [PubMed: 16644077]
12. Singh-Manoux A, Ferrie JEC, 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. [PubMed: 15256527]
13. Davey Smith GD, Hart C, Blane D, Hole D. Adverse socioeconomic conditions in childhood and cause specific adult mortality: prospective observational study. *BMJ*. 1998 May 30; 316(7145): 1631–1635. PubMed PMID: 9603744. Pubmed Central PMCID: 28561. Epub 1998/06/17. eng. [PubMed: 9603744]
14. Lemelin ET, Diez-Roux AV, Franklin TG, Carnethon M, Lutsey PL, Ni H, et al. Lifecourse socioeconomic positions and subclinical atherosclerosis in the multi-ethnic study of atherosclerosis. *Social Science & Medicine*. 2009; 68:444–451. [PubMed: 19081660]
15. Lee JR, Paultre F, Mosca L. The association between educational level and risk of cardiovascular disease fatality among women with cardiovascular disease. *Womens Health Issues*. 2005 Mar-Apr; 15(2):80–88. PubMed PMID: WOS:000227868600006. [PubMed: 15767198]
16. Beebe-Dimmer J, Lynch JW, Turrell G, Lustgarten S, Raghunathan T, Kaplan GA. Childhood and adult socioeconomic conditions and 31-year mortality risk in women. *American Journal of Epidemiology*. 2004; 159(5):481–490. [PubMed: 14977644]
17. Murray ET, Mishra GD, Kuh D, Guralnik J, Black S, Hardy R. Life course models of socioeconomic position and cardiovascular risk factors: 1946 birth cohort. *Ann Epidemiol*. 2011 Aug; 21(8):589–597. PubMed PMID: 21737047. Pubmed Central PMCID: 3226834. Epub 2011/07/09. eng. [PubMed: 21737047]
18. Lynch J, Smith GD. A life course approach to chronic disease epidemiology. *Annual review of public health. Annual Review of Public Health*. :1–35. 262005.
19. Hallqvist J, Lynch J, Bartley M, Lang T, Blane D. Can we disentangle life course processes of accumulation, critical period, and social mobility? An analysis of disadvantaged socio-economic positions and myocardial infarction in the Stockholm Heart Epidemiology Program. *Soc Sci Med*. 2004; 58:1555–1562. [PubMed: 14759698]
20. Tiikkaja S, Hemstrom O. Does intergenerational social mobility among men affect cardiovascular mortality? A population-based register study from Sweden. *Scand J Public Health*. 2008 Aug; 36(6):619–628. PubMed PMID: 18775818. Epub 2008/09/09. eng. [PubMed: 18775818]
21. Tiikkaja S, Hemstrom O, Vagero D. Intergenerational class mobility and cardiovascular mortality among Swedish women: A population-based register study. *Soc Sci Med*. 2009 Feb; 68(4):733–939. PubMed PMID: 19091450. Epub 2008/12/19. eng. [PubMed: 19091450]
22. McDonough P, Duncan GJ, Williams D, House J. Income dynamics and adult mortality in the United States: 1972 through 1989. *American Journal of Public Health*. 1997 Sep; 87(9):1476–1483. PubMed PMID: WOS:A1997XY23500014. English. [PubMed: 9314800]
23. Chaix B, Isacson SO, Rastam L, Lindstrom M, Merlo J. Income change at retirement, neighbourhood-based social support, and ischaemic heart disease: Results from the prospective cohort study "Men born in 1914". *Social Science & Medicine*. 2007 Feb; 64(4):818–829. PubMed PMID: WOS: 000244237100008. [PubMed: 17126973]

24. Gunasekara FI, Carter K, Blakely T. Change in income and change in self-rated health: Systematic review of studies using repeated measures to control for confounding bias. *Social Science & Medicine*. 2011 Jan; 72(2):193–201. PubMed PMID: WOS: 000289911300010. [PubMed: 21146277]
25. Kaplan GA, Shema SJ, Leite CM. Socioeconomic determinants of psychological well-being: the role of income, income change, and income sources during the course of 29 years. *Ann Epidemiol*. 2008 Jul; 18(7):531–537. PubMed PMID: 18504142. Pubmed Central PMCID: 2771109. Epub 2008/05/28. eng. [PubMed: 18504142]
26. Cerda M, Johnson-Lawrence VD, Galea S. Lifetime income patterns and alcohol consumption: Investigating the association between long- and short-term income trajectories and drinking. *Social Science & Medicine*. 2011; 73:1178–1185. [PubMed: 21890256]
27. Johnson-Lawrence V, Kaplan G, Galea S. Socioeconomic mobility in adulthood and cardiovascular disease mortality. *Annals of epidemiology*. 2013 Apr; 23(4):167–171. 2013 PubMed PMID: MEDLINE: 23453385. [PubMed: 23453385]
28. Berkman, LF.; Breslow, L. *Health and Ways of Living: The Alameda County Study*. New York: Oxford University Press; 1983.
29. Kaplan GA, Baltrus PT, Raghunathan TE. The shape of health to come: prospective study of the determinants of 30-year health trajectories in the Alameda County Study. *Int J Epidemiol*. 2007 Jun; 36(3):542–548. PubMed PMID: 17376802. Epub 2007/03/23. eng. [PubMed: 17376802]
30. Hochstim, JR. The community as an epidemiologic laboratory. In: KLaL, ML., editor. *Health and ways of living-- The Alameda County, California, Population Laboratory*. Baltimore: Johns Hopkins University Press; 1970.
31. Bureau of Labor Statistics UCB. Current population survey: design and methodology. US Department of Labor and US Department of Commerce. 2002 Technical Paper No.: 63RV.
32. Raghunathan TE, Lepkowski JM, Van Hoewyk J, Solenberger P. A multivariate technique for multiple imputing missing values using a sequence of regression models. *Surv Methodol*. 2001; 27:12.
33. Baltrus PT, Lynch JW, Everson-Rose S, Raghunathan TE, Kaplan GA. Race/ethnicity, life-course socioeconomic position, and body weight trajectories over 34 years: the Alameda County Study. *American Journal of Public Health*. 2005 Sep; 95(9):1595–1601. PubMed PMID: 16051936. Pubmed Central PMCID: 1449403. Epub 2005/07/30. eng. [PubMed: 16051936]
34. Raghunathan TE. What do we do with missing data?. Some options for analysis of incomplete data. *Annual Review of Public Health*. 2004; 25:99–117.
35. Figini P. Measuring inequality: on the correlation between indices. *Luxembourg Income Study Working Paper No 229*. 2000
36. Jones B, Nagin D, Roeder K. A SAS procedure based on mixture models for estimating developmental trajectories. *Sociological Methods Research*. 2001; 29:19.
37. Golden, C. Understanding the Gender Gap: An Economic History of American Women. National Bureau of Economic Research I. , editor. 1990.
38. Jones BL, Nagin DS. Advances in Group-Based Trajectory Modeling and as SAS Preocdure for Estimating Them. *Sociological Methods Research*. 2007; 35(542):30.
39. Jones B, Nagin D, Roeder K. A SAS procedure based on mixture models for estimating developmental trajectories. *Sociological Methods and Research*. 2001; 29:374–393.
40. Wamala SP, Lynch J, Kaplan GA. Women's exposure to early and later life socioeconomic disadvantage and coronary heart disease risk: the Stockholm Female Coronary Risk Study. *International Journal of Epidemiology*. 2001 Apr; 30(2):275–284. PubMed PMID: WOS: 000168789500015. [PubMed: 11369727]
41. Davey Smith G, Hart C. Life-course socioeconomic and behavioral influences on cardiovascular disease mortality: The Collaborative Study. *American Journal of Public Health*. 2002; 92:1295–1298. [PubMed: 12144987]
42. Blane D, Hart CL, Davey Smith G, R GC, Hole DJH, V M. Adverse socioeconomic conditions in childhood and cause specific adult mortality: prospective observational study. *BMJ*. 1996; 316:1631–1651. [PubMed: 9603744]

43. Vagero D, Leon D. Effect of social class in childhood and adulthood on adult mortality. *Lancet*. 1994; 343:1224–1225. [PubMed: 7909885]
44. Hart C, Davey Smith G, Blane D. Inequalities in mortality by social class measured at three stages of the life course. *American Journal of Public Health*. 1998; 88:471–475. [PubMed: 9518987]
45. Lynch JW, Kaplan GA, Cohen RDKJ, Wilson TW, Smith NL, Salonen JT. Childhood and adult socioeconomic status as predictors of mortality in Finland. *Lancet*. 1994; 343:524–527. [PubMed: 7906766]
46. Bureau of Labor Statistics UCB. Employment status of the civilian noninstitutional population 16 years and over by sex, 1973 to date. 2009
47. Kauhanen L, Lakka H, Lynch JWKJ. Social disadvantages in childhood and risk of all-cause death and cardiovascular disease in later life: a comparison of historical and retrospective childhood information. *Int J Epidemiol*. 2006; 35:962–968. [PubMed: 16556645]
48. Lloyd-Jones D, Martin DO, Larson MG, Levy D. Accuracy of death certificates for coding coronary heart disease as the cause of death. *Annals of Internal Medicine*. 1998; 129(12):1020–1026. [PubMed: 9867756]
49. Connolly S, O'Reilly D, Rosato M. House value as an indicator of cumulative wealth is strongly related to morbidity and mortality risk in older people: a census-based cross-sectional and longitudinal study. *Int J Epidemiol*. 2009:1–9. Epub December 21, 2009.
50. Laaksonen MT, L. Martikainen P. Housing wealth and mortality: A register linkage study of the Finnish population. *Soc Sci Med*. 2009; 69(5):754–760. [PubMed: 19604611]

Figure 1.
Household income trajectory group patterns in the Alameda County Study (n=2530).

Table 1

Demographic characteristics of the Alameda County Study sample, n=2530

	Men (n=1103)		Women (n=1427)		p-value
	N or Mean	% or SD	N or Mean	% or SD	
Cardiovascular disease deaths	59	5.35	80	5.61	0.79
Age Group					
<65 years	569	51.59	752	52.70	0.58
65+ years	534	48.41	675	47.30	
Race/ethnicity					
White	988	89.57	1254	87.88	0.22
Black	67	6.07	112	7.85	
Other	48	4.35	61	4.27	
Married	908	82.32	867	60.76	<0.01
Years of Education					
0-11 years	157	14.23	234	16.40	<0.01
12 years	250	22.67	412	28.87	
13+ years	696	63.10	781	54.73	
Years of education (M, SD)	13.83	2.99	13.23	2.74	<0.01
Age in 1994 (M, SD)	64.74	9.98	64.48	10.99	0.55
Average household size (M, SD)	3.09	0.91	3.01	0.99	0.04
Observation time (days) (M, SD)	2216.84	471.78	2251.25	427.41	0.06

D= Standard deviation.

Table 2

Socioeconomic disadvantage measures by gender in the Alameda County Study sample, n=2530

	Men (n=1103)		Women (n=1427)		
	N or Mean	% or SD	N or Mean	% or SD	p-value
Trajectory group + education + father's education					
0	420	38.08	524	36.72	<0.01
1	360	32.64	448	31.39	
2	269	24.39	329	23.06	
3	54	4.90	126	8.83	
Average household income + education + father's education					
0	300	27.20	384	26.91	0.98
1	316	28.65	419	29.36	
2	279	25.29	357	25.02	
3	208	18.86	267	18.71	
Low respondent education	469	42.52	646	45.27	0.17
Low father's education	478	43.34	575	40.29	0.12
Low average household income	551	49.95	713	49.96	0.99
Low household income in 1994	551	49.95	713	49.96	0.99
Low household income trajectory group	113	10.24	263	18.43	<0.01
Average household income (\$)	40361.80	24317.73	34600.18	21595.79	<0.01
Household income trajectory groups					
1	7	0.63	27	1.89	<0.01
2	14	1.27	34	2.38	
3	92	8.34	202	14.16	
4	743	67.36	957	67.06	
5	201	18.22	166	11.63	
6	46	4.17	41	2.87	

SD=Standard deviation; All socioeconomic measures were dichotomized at the median.

Table 3

Bivariate proportional hazards models of CVD mortality by gender in the Alameda County Study

	Men (n=1103)			Women (n=1427)		
	HR	95% CI	AIC	HR	95% CI	AIC
CSD measure based on household income trajectories (ref=0)			808.55			1103.49
3	4.35	1.78–10.62		11.56	5.50–24.31	
2	2.23	1.15–4.34		4.09	1.95–8.58	
1	1.35	0.67–2.70		2.68	1.26–5.67	
CSD measure based on average household income (ref=0)			814.56			1110.75
3	2.22	0.99–4.95		7.96	3.52–17.99	
2	2.18	1.02–4.65		3.99	1.72–9.29	
1	1.58	0.72–3.46		1.88	0.76–4.67	
Age (yrs)	1.10	1.07–1.12	768.09	1.13	1.10–1.15	1018.03
Married (ref=Not Married)	0.61	0.34–1.09	813.41	0.37	0.23–0.58	1129.44
Race/Ethnicity						
African American (ref=White)	1.17	0.42–3.25	817.17	1.86	0.99–3.49	1147.75
Other Race/Ethnicity (ref=White)	1.63	0.59–4.49		0.89	0.29–2.75	

HR=Hazards Ratio; CI = Confidence Interval; AIC = Akaike Information Criterion

Table 4

Multivariable proportional hazards models of CVD mortality by Cumulative Socioeconomic Disadvantage (CSD) Index and gender controlling for age, race/ethnicity and marital status

		Men (n=1103)		Women (n=1427)	
		HR	95% CI	HR	95% CI
Model 1					
	CSD measure based on household income trajectories (ref=0)				
	3	2.00	0.72–5.57	4.73	2.20–10.18
	2	1.21	0.59–2.48	2.44	1.15–5.19
	1	0.96	0.48–1.95	2.29	1.08–4.86
	Age (yrs)	1.09	1.06–1.12	1.11	1.09–1.14
	Married (ref=Not Married)	0.64	0.36–1.14	0.91	0.53–1.56
	African American (ref=White)	0.64	0.23–1.82	1.02	0.51–2.06
	Other Race/Ethnicity (ref=White)	1.31	0.43–4.02	0.75	0.26–2.21
	AIC	774.72		1010.51	
Model 2					
		HR	95% CI	HR	95% CI
	CSD measure based on average household income (ref=0)				
	3	1.08	0.46–2.54	3.78	1.67–8.53
	2	1.43	0.66–3.11	2.35	0.99–5.61
	1	1.35	0.62–2.94	1.74	0.70–4.32
	Age (yrs)	1.09	1.06–1.13	1.12	1.09–1.15
	Married (ref=Not Married)	0.62	0.35–1.10	0.84	0.51–1.39
	African American (ref=White)	0.76	0.28–2.07	1.11	0.57–2.17
	Other Race/Ethnicity (ref=White)	1.58	0.56–4.48	0.81	0.27–2.46
	AIC	775.82		1013.55	

HR= Hazards Ratio; CI = Confidence Interval; AIC= Akaike Information Criterion