Life course socioeconomic position, depressive symptoms, and cardiovascular disease mortality in the Alameda County Study 1965-2000

by

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This work, which required the relentless patience and love of my husband, daughters, and parents, is dedicated to them. Thank you for holding on until the end.

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List of Abbreviations

ACS	Alameda County Study
ADL	Activities of daily living
AHI	Average household income
CSD	Cumulative socioeconomic position
CVD	Cardiovascular disease
CVDM	Cardiovascular disease mortality
DS	Depressive symptoms
DSM-IV	Diagnostic and Statistical Manual of Mental Disorders, 4th edition
HI	Household income
HITG	Household income trajectory groups
HR	Hazard ratio
IQR	Interquartile range
LCL	Lower confidence limit
MDS	Multiple depressive symptoms
NCS	National Comorbidity Study
NHANES	National Health and Nutrition Examination Survey
OR	Odds ratio
SEP	Socioeconomic position
UCL	Upper confidence limit

Abstract

Background: Lower socioeconomic position (SEP) over the life course has been posited as a contributing factor in the development of chronic illnesses, including cardiovascular disease (CVD) and subsequently CVD mortality (CVDM). Lower SEP has also been shown to be associated with an increased risk of mental health problems, such as multiple depressive symptoms (MDS). The ways in which SEP has been measured have varied, but examination of the variability in measures based on a single SEP indicator such as household income (HI) has been limited, especially within gender.

Methods: Data from the Alameda County Study was used to study the relationships of interest. Chapters 2 and 3 used three measures of HI to capture SEP- HI in 1994 (HI94), average HI (AHI), and HI trajectory groups (HITG). Chapter 4 examined cumulative socioeconomic disadvantage (CSD) based on HI, education, father's education, and father's occupation. Chapters 2 and 4 focused on the relationship between SEP and CSD with 6-year CVDM, respectively, using proportional hazards models. Chapter 3 examined the association between SEP and the prevalence of five or more DS in 1999 using logistic regression.

Results: Chapter 2 analyses suggested significant inverse associations between lower quartiles of HI94 and the hazard of 6-year CVDM among men. Among women, a unit

increase in the interquartile range (IQR) of AHI was associated with lower hazards of 6-year CVDM. In chapter 3, results suggested men in the lower two quartiles of HI94 and AHI and lower three HITG had increased odds of MDS compared to the highest groups. In addition, higher HI94 and higher AHI were inversely associated with odds of MDS for men. Associations were of greatest magnitude for HITG and HI94 compared to the quartile measures and AHI, respectively. Among women, only those in the lowest HITG had significantly increased odds of MDS. Chapter 4 analyses revealed that being the most disadvantaged was associated with increased hazards of CVDM among women but not men. Associations were of greatest magnitude for CSD scores that included HITG.
Conclusions: Men and women with higher SEP or lower CSD were less likely to experience CVDM or MDS, but the magnitude of these associations varied with changes in the HI measure utilized. Among men, measures that captured information about HI over the life course as well were informative. Recent HI was associated with CVDM but not the other measures, while patterns of HI (through HITG) were most strongly associated with MDS compared to the other measures. Among women, AHI was associated with CVDM while patterns of HI were associated with MDS, but not the other measures. Furthermore, CSD measures incorporating HITG were most strongly associated with CVDM, while the other measures were comparable in magnitude of association with CVDM. The magnitude of an association is often used as a gauge to evaluate the information gained from a measure of SEP in relation to health outcomes. Interest must be taken to review the information provided by a single SEP indicator such as HI, in relation to health outcomes. These results show the need to consider the use of gender-specific SEP measures, as well as to carefully select the SEP measures themselves

as the associations with different health outcomes may vary dependent upon the specific measure examined. Careful exploration of the meanings of specific SEP indicators in relation to outcomes such as CVDM and MDS will aid in the provision of transparent evidence to guide health policies designed to reduce the burden of social inequity on health.

Chapter 1

Introduction

Specific Research Aims

There are substantial differences in the incidence and prevalence of many chronic illnesses between groups, particularly gender groups and racial/ethnic groups. Income, along with other measures of socioeconomic position (SEP) that vary greatly between gender and racial/ethnic groups, in part may explain these differences. However, it is increasingly clear that the influence of income on inter-group differences in health is complicated and that income changes during the life course and influences health throughout the life course.

Current research has indicated associations between SEP and various physical and mental health outcomes, independent of other well-known biological risk factors for these health conditions. A number of studies suggest that these relationships vary both by measure of SEP and by specific health outcome. These types of associations have been found between socioeconomic predictors and both depressive symptoms and cardiovascular disease mortality (CVDM), but rarely are the socioeconomic predictors examined over time for their variability in association with different health outcomes. This research aims to study how various measures of SEP over the life course may be differentially associated with the prevalence of depressive symptoms at later periods of the life course as well as the risk of CVDM in middle and later adulthood, and the patterns of these associations within gender.

The specific aims are:

Aim 1: To compare the gender-specific associations between various measures of household income (HI) and CVDM over a 35-year period in the Alameda County Study. Within genders, we hypothesize that average household income (AHI) over time will be more strongly associated with CVDM than HI at one time point, and that associations between household income trajectory groups (HITG) will be more strongly associated with CVDM than either AHI or income at one point in time.

Hypothesis 1a. Low HI in 1994 will be associated with a higher risk of 6-year CVDM within genders.

Hypothesis 1b. Low AHI (defined by incomes between 1965 and 1994) will be more strongly associated with a higher risk of 6-year CVDM than 1994 household income within genders.

Hypothesis 1c. Lower household income trajectories (based upon income from 1965-1994) will be more strongly associated with a higher risk of 6-year CVD mortality than average or 1994 household income within genders.

Aim 2: To compare the gender-specific associations between various measures of household income with depressive symptoms over a 34-year period in the Alameda County Study. We hypothesize that within genders, AHI will be more strongly associated with depressive symptoms than income at one point in time, and that the income trajectory groups will be more strongly associated with depressive symptoms than either AHI or income at one point in time.

Hypothesis 2a. Low household income in 1994 will be associated with the presence of five or more depressive symptoms in 1999 within genders.

Hypothesis 2b. Low AHI (defined by household income from 1965-1994) will be more strongly associated with the presence of five or more depressive symptoms than household income in 1994 within gender.

Hypothesis 2c. Lower income trajectories (based upon household income from 1965-1994) will be more strongly associated with the presence of five or more depressive symptoms in 1999 than average or 1994 household income within genders.

Aim 3: To evaluate the gender-specific effects of cumulative socioeconomic disadvantage over a 35-year period on CVD mortality in the Alameda County Study. We hypothesize that within each gender, the accumulation measures that capture AHI will be more strongly related to CVDM than the measure that includes 1994 household income. Furthermore, the measures including income trajectory groups will have the strongest relationship with CVDM.

Hypothesis 3a. The accumulation of low SEP, evaluated by parental education and occupation, the individual's education, and 1994 adulthood household income will be associated with a higher 6-year risk of CVDM within gender.

Hypothesis 3b. The accumulation of low SEP, evaluated by parental education and occupation, the individual's education, and adulthood AHI will be more strongly associated with a higher 6-year risk of CVDM than the accumulation models including 1994 household income within gender.

Hypothesis 3c. The accumulation of low SEP, evaluated by parental education and occupation, the individual's education, and the individual's adulthood household income trajectory will be more strongly associated with a higher 6-year risk of CVDM compared to the accumulation models that include 1994 or AHI within gender.

Hypothesis 3d. Associations between HI and CVDM will be partially mediated by having a history of depressive symptoms within gender.

Background & Significance

Cardiovascular disease as a major public health concern

Heart disease and stroke are the first and third leading causes of death in the United States based on National Center for Health Statistics (NCHS) mortality data, with approximately 35% of all deaths in the US attributed to CVD and 5% attributed to stroke in 2005 [1, 2]. Although death rates due to heart disease among persons aged 65 and older fell by 52% in men and 49% in women between 1997 and 2002, the death rates among younger women aged 35-54 have been increasing, with significant annual increases of 1.3% from 1997 to 2002. In addition, current research suggests mortality rates from cardiovascular diseases are higher among blacks at all ages [1].

Much of the research that has studied the plausible contributing factors for cardiovascular disease and mortality identified risk factors to include hypertension, diabetes, obesity, smoking, diabetes, tobacco use, blood cholesterol levels, physical inactivity, alcohol use and genetic factors [3]. Studies have also examined the associations between socioeconomic position (SEP) and CVDM and suggest an inverse relationship between SEP and CVDM, and a number of studies suggesting that lower SEP is associated with an increase in the risk of cardiovascular disease [4-22]. Although many individual risk factors for CVD are modifiable, potentially larger structural changes can mitigate the existence of socioeconomic disadvantage, which can therefore reduce the risk of experiencing these individual risk factors as well as the risk of developing cardiovascular disease, and subsequently the risk of death from CVD.

Depression and depressive symptoms as a major public health concern

In the United States, a large proportion of the population experiences some amount of depression throughout the life course. National Health and Nutrition Examination Survey (NHANES) data from 2005-2006 suggests that in any two week period, 5.4% of Americans aged 12 and older experienced depression, and the rates were higher for middle aged adults (aged 40-59), women, non-Hispanic blacks, and those with lower SEP than other demographic and socioeconomic groups. Of those who reported depression, 80% experienced some level of functional impairment, and 35% of males and 22% of the reportedly depressed individuals felt their depressive symptoms made it very difficult to work, manage tasks at home, and get along with others. Furthermore, more than half of those reporting mild depressive symptoms reported some difficulty in daily functioning attributable to their symptoms. Only 29% of these individuals reported contacting a mental health professional [23]. Data from the National Comorbidity Survey indicates a lifetime prevalence of 16.9% and 12-

month prevalence of 6.8% for major depressive disorder based on DSM-IV criterion [24].

The etiology of depression is multifactorial, and is affected by environmental as well as genetic influences. Individuals with an increased number of depressive symptoms may be more likely to suffer from clinically diagnosed depression than those with very few or no depressive symptoms. The psychological and environmental factors that affect the risk of clinical depression, defined as major depressive disorder, include the experiences of traumas and stressors- when an individual is unable to manage the psychological effects of such factors, the onset of clinical depression is more likely [25]. Although there are distinct differences in the clinical relevance of depression and depressive symptoms, knowledge about the presence of depressive symptoms will enable us to continue to investigate mental health at the population level, and potentially make population level changes to decrease both the number of depressive symptoms and the prevalence and incidence of clinical depression.

Several individual characteristics have been suggested as risk factors for depression and increased numbers of depressive symptoms, including age, race/ethnicity, partner/marital status, employment status, income, and chronic medical conditions [23, 26-28]. Although some of these risk factors are modifiable, the approach an individual would use to change them may be stressful in itself. As a result, the change in behavior can also contribute to the psychological distress experienced by the individual. Given such a large number of people in the United States experience bouts of depression, a thorough understanding of the ways in which these factors interact to cause depression and depressive symptoms is necessary. More specifically, an examination of the characteristics that are commonly seen in those with lower SEP is necessary, along with an understanding of the ways in which varying measures of SEP can affect the strength of the associations we see between SEP and depression and depressive symptoms.

SEP and CVDM

There is a body of literature that suggests an effect of socioeconomic position, based on measures including income, occupation, occupational status, wealth, and education, on cardiovascular diseases worldwide [1, 5, 8, 9, 11-13, 29-31]. There has also been work to suggest differences in risk factor prevalence by socioeconomic position [1, 32]. SEP, measured both during childhood and adulthood, has been associated with cardiovascular disease mortality [33, 34]. Although some of these studies looked at SEP early in the life course, none of these studies looked at patterning of income over the life course. In addition, much of the research has focused on primarily male populations, with fewer studies investigating SEP patterning of CVDM within women.

SEP and depression/depressive symptoms

Multiple studies have suggested relationships between SEP and depression as well as depressive symptoms. Inverse associations between SEP, measured by education, income, employment status and depression have been identified [35-38] and it has also been posited that the associations are stronger for women than men [39]. Childhood SEP has also been shown to be associated with lifetime risk of major depression [40]. Although SEP was evaluated at childhood in one of these studies, the effect of income patterns over the life course and subsequent depression as well as depressive symptomatology was not studied.

Life course theory, SEP and CVDM

The development of cardiovascular disease has been shown to occur throughout the life course, with initiation of the process beginning in early childhood [41]. In addition, the particular health behaviors that individuals tend to practice throughout the life course may also be taught in early childhood. Therefore, the factors that influence health and behavior as early as during childhood should be evaluated for their impact on health and behavior at later points in life as has been done in existing research. However, health, behaviors, and social environmental conditions undoubtedly change as an individual ages, and perhaps differently for women and men, and may have additional impacts on later life conditions beyond the effects of conditions in childhood. Current works have used measures of change in social status to examine these patterns over the life course, but few measures account for the variation throughout the life course as well.

Life course theoretical frameworks have been used to conceptualize the plausible mechanisms through which SEP over the life course impacts the development of health outcomes throughout the life course. The critical period model suggests specific points during the life course at which the conditions an individual experiences have a substantially more profound impact on the health outcome of interest than at other times in life [42]. The social mobility model emphasizes the role of change in socioeconomic position in relation to adult health outcomes [42]. The accumulation model suggests that the early life circumstances combined with subsequent circumstances contribute to specific health outcomes throughout the life course [43]. It is through the combination of these approaches that research provides explanations as to how SEP over the life course captured through various measures is related to outcomes such as depressive symptoms and CVDM.

Significance of proposed research

Cardiovascular disease is the leading cause of death in the United States and worldwide [1, 44]. In 2000, depression was the leading cause of disability in the US and worldwide, and it has been predicted that depression will be one of the leading causes of disability worldwide by the year 2020 [45, 46]. SEP has been associated with depression and depressive symptoms, which are risk factors for CVD, and women tend to suffer from depression and depressive symptoms at higher rates and continue to have lower SEP than men. Determination of how different measures of SEP, such as pattern measures, those captured at a single point in time, or measures that incorporate a summary measure of long-term SEP are related to multiple depressive symptoms and CVDM risk. Selection of a measure influences the conclusions drawn about the associations between SEP and these health outcomes. In actuality, the research provided to policy makers should be transparent and unified when possible to provide the most sound evidence possible. Within gender variability of associations between SEP and these outcomes allow for more subpopulation specific policies to be designed in an effort to reduce the effects of social inequity on health.

Conceptual framework

Figures 1.1 and 1.2 show the pathways by which socioeconomic conditions over the life course can affect the risk of CVD mortality and depressive symptoms, respectively, at later points in adulthood. SEP in earlier adulthood may be affected by an individuals' educational status, which can also contribute to the individual's knowledge of behaviors that can affect the risk of experiencing CVDM and depressive symptoms. In addition, SEP at earlier points in life affects an individual's pattern of SEP at later times in life, and these patterns may cause an individual to experience CVDM, or more or less depressive symptoms at a subsequent time point.

Figure 1.3 diagrams the paths through which SEP from childhood through adulthood can affect risk of CVDM. Childhood SEP may have an indirect effect on the risk of CVD mortality by influencing the likelihood that an individual will experience the physiologic modifiable risk factors for CVD, as well as through their effects on socioeconomic position at later points during life, such that those who come from more disadvantaged backgrounds may be less likely to achieve higher education and therefore higher incomes later in life, which could lead to lower SEP throughout life. Similarly, education may represent the ability to change one's SEP at later points in life through wealth accumulation, education and occupation and also through influencing one's knowledge of heart disease risk factors and the ability to reduce the likelihood of experiencing these risk factors and death as a result of poor health behaviors. However, having lower SEP throughout the life course increases the likelihood of an individual experiencing chronic and debilitating diseases that could also negatively impact SEP, thereby creating yet another pathway through which SEP affects the risk of cardiovascular disease mortality.

Figure 1.1: Conceptual diagram for Aim 1: Household income-CVD mortality

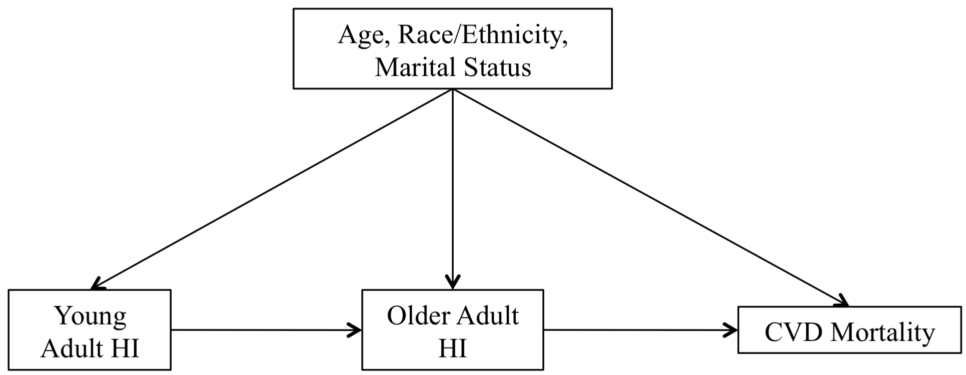


Figure 1.2: Conceptual diagram for Aim 2: Household income-depressive symptoms

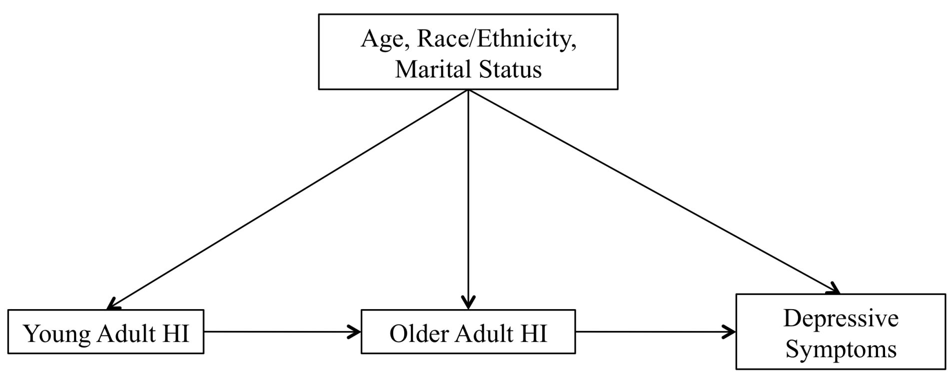
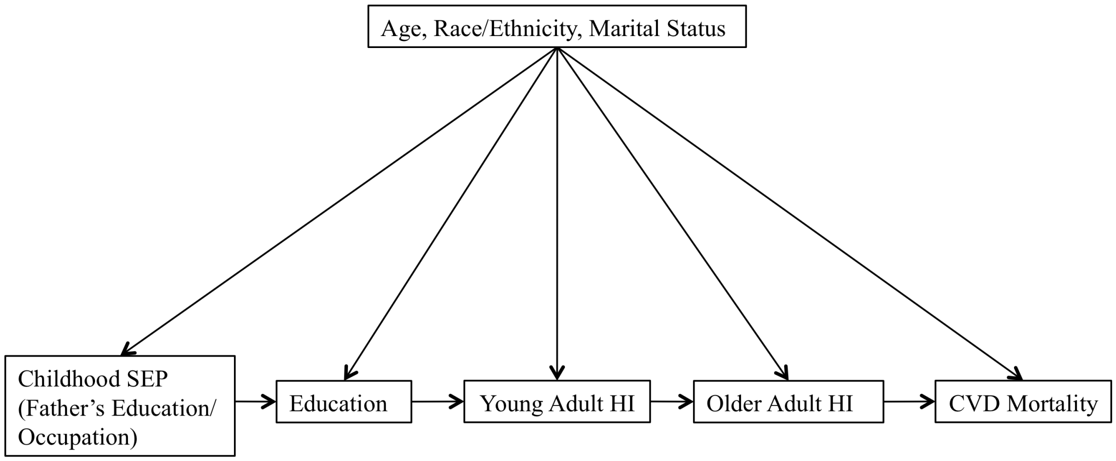


Figure 1.3: Conceptual diagram for Aim 3:
Cumulative socioeconomic disadvantage-CVD mortality



Chapter 2

Gender-specific associations between life course measures of household income and cardiovascular disease mortality in the Alameda County Study 1965-2000

Introduction

The role of socioeconomic position (SEP) in the development of several health outcomes has long been recognized, commonly cited as having inverse associations between SEP and health [33, 47, 48]. The nature of this relationship throughout the life course has also received considerable attention in the literature, providing evidence of long-term effects of SEP on health, and often suggesting physiologic measures, health behaviors, and psychosocial factors as potential mechanisms through which SEP may affect physical outcomes such as cardiovascular disease mortality (CVDM) [4, 13, 49-52].

CVD is the number one cause of death among men and women in the United States [1]. Numerous studies have documented associations between SEP and heart disease incidence as well as heart disease mortality, indicating that people with higher SEP, when measured by education or income, have a lower risk of mortality from CVD [53, 54]. The majority of the work in this area has focused on measures of SEP from middle-age or later periods of life, although the literature has expanded to document the roles of life course SEP in relation to CVD and CVD mortality [33, 34, 54-57]. However, there is limited research that has examined whether variations of individual indicators of SEP are differentially associated with such health outcomes, which may indicate different operating mechanisms through which SEP may affect health.

SEP throughout the life course certainly seems to have a substantial effect on the circumstances to which an individual is subjected, therefore affecting not only exposure to psychologically altering situations, but also to the potential an individual has for participating in health behaviors or general practices that increase an individuals' propensity to develop chronic conditions such as CVD. Three common life course theoretical frameworks used to describe the life course effects of SEP on health include the critical period model, the social mobility model, and the accumulation model. The critical period model suggests specific points during the life course at which the conditions an individual experiences have a substantially more profound impact on the health outcome of interest than at other times in life [42]. In relation to CVDM, the most recent measures of SEP, indicating resource availability during the time immediately prior to death, provide information about the conditions in which an individual is living, and may correlate with practices relative to health outcomes, such as the purchase of medications or access to sufficient health care [58].

The social mobility model emphasizes the role of change in socioeconomic position in relation to adult health outcomes [42]. CVD develops over a vast period of time, and the level of SEP that one experiences over that time is subject to change. With movement of an individuals' family from a lower to higher SEP, the incurred experiences may decrease the likelihood of developing CVD and subsequent mortality. In contrast, the move from a higher to lower SEP may be associated with an individual having less healthy social conditions, and negatively affect physiologic factors and therefore increase risk of CVD and CVDM [59, 60].

The third model of life course theory that is commonly used in the study of health is the accumulation model. This model suggests that the cumulative experiences throughout the life course can ultimately lead to the health outcomes experienced later in life [42, 61-63]. Maintenance of a lower SEP throughout the life course may have negative effects that are compounded with prolonged exposure to the resulting conditions. With each additional period of time through which an individual experiences poor physical and social conditions, the risk of CVD and CVDM may substantially increase [61, 64].

Much of the work conducted in this area has been focused on outcomes among men or men and women combined due to limited samples of women in analyses [13, 54, 57]. Gender differences in the return to health based on SEP have been demonstrated with measures such as education and income, and may reflect gender differentials in resource availability as well as in associations between SEP and health outcomes [50, 52]. Furthermore, evidence is mounting to suggest that the mechanisms through which life course SEP affects health outcomes may vary by gender [65]. Within gender, however, the interpretations of various forms of single SEP indicators, such as education or income, have alternative meanings that may reflect historical biases limiting resource attainment, commonly among women [56, 57, 66, 67].

Income has been utilized in several studies both as functions of personal and household income, likely because personal measures of SEP may be more indicative of health outcomes, while household income is more commonly available in data, especially for women [68-72]. In studies of long-term SEP measures, however, the increased likelihood of women serving in their homes instead of the workforce left them dependent on the household income for resources, thereby making household income the most representative indicator of financial resources [67].

Income measures used to capture SEP in multiple studies of health cardiovascular outcomes including mortality have been studied in relation to outcomes five to fifteen years later [73-75]. The measures were taken from middle and later adulthood, and early adulthood as well documenting inverse associations between these measures and risk of the CVD outcome [74, 75]. Within an individual study, however, the potential for variations in associations between income and CVD outcomes such as CVDM is unclear and poorly documented if known. This additional information can elucidate theoretical pathways through which SEP may affect the CVD outcome for specific subgroups of the study population. As a result, research that investigates these differences can aid in the clarification of what specific pathways are more likely for different subgroups, such as those defined by gender.

Data from the Alameda County Study was therefore used to evaluate the presence of variability in magnitude of associations of various measures of income with CVDM. Using gender-specific models, the variability of the associations between one current static and two long-term measures of SEP based on household income over 29 years was studied in relation to six-year CVDM. We hypothesized that there would be associations between each household income measure and CVDM within both genders. In addition, the magnitude of the associations would be greater for the long-term compared to the short-term measures of SEP.

Methods

Study population

The Alameda County Study (ACS), initially known as the Health and Ways of Living Study, is a prospective study of men and women who were 20 years of age or older in 1965 (16 and older if married) who resided in Alameda County, California. ACS is one of the few studies that collected information on both social and health conditions with a substantial follow-up period. Furthermore, the data allowed for the ascertainment of social conditions throughout the life course, and provided linkage to death data as well. The wealth of data available on participants' socioeconomic conditions, psychological well-being, and physical health status made this data ideal for this research.

The study collected information on health status and behavioral, social, psychological, socioeconomic, neighborhood, and socio-environmental risk factors [76-78]. Alameda County was and since has been a Metropolitan county, which had a population of approximately one million people in 1965. A two stage stratified systematic sample was used to gather data on 8023 non-institutionalized adults from 4452 household units [78]. Questionnaires were received from 6928 (86%) of those sampled. The sample was comprised of 3158 (45.6%) men and 3770 (54.4%) women in 1965, and there were five waves of follow-up data collection in 1974, 1983, 1994, 1995, and 1999. The participants from 1965 were re-contacted in 1974 with an 85.1% response rate among those located, and 50% of those not known to be dead were re-contacted in 1983 (n=1798, 87.3% response rate). All respondents from 1974 and 1983 were re-contacted in 1994 (n=2729, 93% response rate). The final wave of data collection was conducted in 1999 with 2123 respondents (96% response rate).

Cardiovascular disease mortality ascertainment

Cause-specific mortality data was collected from state death certificate data as well as gathered using cross-linkage methods with the National Death Index. Active tracing for deaths of ACS participants was conducted throughout the study. Data was gathered both at and between each wave of follow-up and through the year 2000. All deaths attributable to diseases of the circulatory system, including acute rheumatic fever, chronic rheumatic heart disease, hypertensive disease, ischemic heart disease, all other forms of heart disease, pulmonary heart disease, diseases of the arteries, arterioles, and capillaries, veins, and lymphatics as well as the complications were included for purposes of this study, and were classified based on the International Classification of Disease 9 (ICD-9) codes 390-459.

Definition of SEP measures

Household income (HI) in the previous year was reported in ranges at each wave of data collection in ACS, and represented the gross income for all members of the immediate family. In 1965, income was categorized into $1000 increments from $0-$9,999, and $10,000-14,999, $15,000-24,999, and >$25,000; in 1974, income was categorized as <$2,000, in $1000 categories from $2000-$9,999, and then $10,000-$11,999, $12,000-$14,999, $15,000-$19,999, $20,000-$24,999, and > $25,000. In 1983, income was categorized in the same way as 1974, but higher income categories were added: income was assessed in $5000 categories from $25,000-$39,999, then $40,000-$49,999 and >$50,000. In 1994 and 1999, income was categorized into $5000 categories from $0-$49,999, then $50,000-$74,999, $75,000-$99,999, $100,000-$149,999 and >$150,000. Data on age, education, gender, race, marital status, occupation, and number of household members that was available in both the ACS and the Current Population Surveys (CPS) were then used to impute continuous measures of income. 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. The income range reported by the ACS respondent bound each continuous measure of household income. This procedure was completed using Imputation and Variance Estimation Software (IVEware) based on a multivariate sequential regression method [79]. The Current Population Survey, conducted monthly by the Census Bureau for the Bureau of Labor Statistics, provides the best national data on income [80].

In our analysis, we considered three measures of HI to operationalize the construct of SEP- HI in 1994, average household income (AHI), calculated as the average of the reported household incomes for 1965, 1974, 1983, and 1994, and household income trajectories based on the imputed household income values from 1965, 1974, 1983, and 1994. Each subject was required to have at least three waves of data for household income, and all income measures were adjusted to the 1993 dollars using the Consumer Price Index (CPI). In addition, household size at each time point was accounted for by dividing the CPI adjusted household income by the square root of the household size at that wave. The adjustment was based on evidence suggesting the cost of living is not linearly correlated with household size, and the square root transformation of household size in adjustment for household size was more appropriate [81]. The trajectories were created then grouped based on the trajectory pattern of their income using PROC TRAJ [82] and is further discussed in the statistical analysis section below. These analyses utilized both a continuous and categorical version of these household income measures to allow inspection for linear and non-linear associations between these income measures and CVDM, as well as to allow for comparisons of magnitude of association. Categorical measures were based on quartiles of the continuous measures.

The household income measures studied here were chosen to explore different measures of SEP throughout the life course and their associations with CVDM. Household income in 1994 provides the most recent measure of household income prior to death ascertainment. Average household income is one of the two long-term measures that capture information about the level of income these individuals tended to maintain throughout the study period. HITGs were the other long-term household income measures, and were created to elucidate the patterns of income over the life course, and whether these patterns reveal different information than AHI or HI in 1994 individually.

The primary goals of this analysis were to examine associations between each of the aforementioned measures of household income and an individuals' 6-year CVDM risk within gender, and then to evaluate the differences in associations between the various measures of household income and 6-year CVDM within gender. Age in

1994, race/ethnicity, gender, and marital status in 1994 were included as potential confounders.

Statistical analysis

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

Descriptive statistics for each variable included in these analyses used t-tests and chi-squared tests to assess differences by gender. Gender stratified proportional hazards regression models were used to examine the associations of interest. Two sets of models were run- (1) bivariate models for each HI SEP measure with CVDM, and (2) the HI SEP measure and the confounders in association with CVDM.

Validity of the proportional hazards assumptions for each model was assessed through the inclusion of interaction terms with time for each variable in the models. Statistical significance of the interaction terms as well as all other model variables were evaluated at α=0.05.

Model of the income trajectories

Classification of income trajectories was based on a group-based trajectory modeling approach using the PROC TRAJ procedure in the SAS System (Cary, NC). This approach assumes the population is composed of a mixture of J underlying trajectory groups such that

$$P(Y_i)= \Sigma_j \pi_i P_j(Y_i)$$

–$P_j(Y_i)$= probability of Y given membership in group j for person i

–π_i=proportion of population in group j, j=1, 2, … J

–$P(Y_i)$=unconditional probability of observing person i's sequence of household income measures,

and $P_j(Y_i) = \Pi_t p_{jt}(y_{it})$, and y_{it} are random variables for each subject I at times t=1,2,…,T- the household incomes are independent after we know the trajectory group to which the individual belongs. The group membership probabilities π_j are not estimated directly but through a multinomial logit function

$$\pi_i= \exp(\theta_i) /\Sigma_i \exp(\theta_i),$$

where θ_1 is normalized to zero, and this ensures each of these probabilities lies between 0 and 1. The parametric model used in analyses is chosen to represent the form of $p_{jt}(y_{it})$, and is selected based on the type of data to which y_{it} (household income) belongs, here being treated as censored normal. The linkage between time and household income is established through a latent variable $y_{it}*^j$, which has been thought of as measuring the potential for having a certain household income, and is

$$y_{it}*^j= \beta_{0j} +\beta_{1j} Time_{it} +\beta_{2j}Time_{it}^2 +\beta_{0j}Time_{it}^3 + \varepsilon_{it}$$

where ε_{it} is a disturbance assumed to be normally distributed with a zero mean and constant standard deviation [83].

In these analyses, the log transformation was applied to household income to allow treatment as normal data. The procedure specifically allows for censored normal data, and to allow for the normal data described in this research, the range of the data was extended beyond that of the log-transformed HI values in this data.

Maximum likelihood is 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 data for the main exposure or the time-dependent covariates are not dropped from analyses and do not contribute to the bias of the sample under the assumption the data is missing completely at random.

The appropriate number of trajectory groups 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), which is interpreted as the degree of evidence favoring the alternative model [82]. The model was finalized by determining the highest order polynomial for each trajectory group with a significant p-value. The resulting posterior probabilities for inclusion in each trajectory group were compared, and the trajectory group for which the individual had the greatest probability is the trajectory group assigned to the individual and included as independent variables in the proportional hazards regression models.

The confounder adjusted statistical model being used to assess the associations between continuous measures of HI and CVDM is a proportional hazards model of the form

$h(t|X) = h_0(t)*\exp[\beta_1(\text{IQR for the household income measure}) + \beta_2(\text{age}) + \beta_3(\text{race/ethnicity}) + \beta_4(\text{marital status})]$

where: $h(t|X)$ is the hazard at time t given the covariates X are held constant

$h_0(t)$ represents the baseline hazard that is assumed non-parametric

β_1 reflects the change in the log hazards ratio of CVD death associated with a change equivalent to the interquartile range for the continuous household income measure (1994 or average household income).

The models for the associations between categorical HI measures and CVDM is a similar proportional hazards model of the form

$h(t|X) = h_0(t)*\exp[\beta_1 G_1 + \ldots + \beta_k G_k + \beta_{k+1}(\text{Age}) + \beta_{k+2}(\text{Race/ethnicity}) + \beta_{k+3}(\text{Marital Status})] + \varepsilon_i$

where: $h(t|X)$ is the hazard at time t given the covariates X are held constant

$h(t)$ represents the baseline hazard that is assumed non-parametric

$G_{1\ldots}G_k$ = Indicator variable for household income group k

$\beta_{1\ldots}\ \beta_k$ = log hazards ratio associated with belonging to HI group k compared to the highest HI group (for HI in 1994, AHI, or HI trajectory group).

Results

Of the 2,729 men and women with data collected in 1994, all of these individuals had at least three years of data, and 2,691 (98.6%) of these persons provided information on gender, age, race/ethnicity, marital status, level of education, and household income, for a total of 1157 men and 1534 women included in this analyses. Amongst these groups, there were 64 (5.5%) deaths from CVD in men and 88 (5.7%) deaths from CVD in women. Eighty-two percent of the men and 60% of the women were married, and 89% of the men and 86% of the men were white, and 7% of the men and 9% of the women were black. A total of 61% of the men and 52% of the women had at least 13 years of education or more, and 23% of men and 30% of women had 12 years of education. The average age for both men and women was 65 years, and the average observation time, with a maximum time of 2492 days (6.82 years), was 2213 days (6.06 years) for men and 2250 days (6.16 years) for women. The average household size from 1965-1994 for men was 3.1 and 3.0 for women. The mean household income in 1994 was $43697 for men and $35411 for women. Average household income from 1965-1994 was $39877 for men and $33980 for women. T-tests suggested average household size ($p=0.02$), household income in 1994 ($p<0.01$) and average household income from 1965-1994 ($p<0.01$) were statistically significantly different for men and women.

The patterns that emerged for each of the HI measures (Figures 2.1-2.4) indicate variability in the patterns of HI by measures. Those in lower groups have more stagnant income while those in the highest groups tend to have variability in their income over the study period. Figure 2.1 shows that those in the lower three quartiles based on household income in 1994 tended to have similar slightly decreasing patterns of income throughout the study period. Those in the highest quartile tended to have increasing income over the study period. Figure 2.2 shows that men and women in the bottom three quartiles tended to have constant household income, while annual household income increased for those in the highest quartile. The household income trajectory groups that emerged (Figure 2.3) showed the bottom two groups to have similar constant household incomes over time, while those in the second highest group (Group 3) had increasing incomes, and those in the highest category (Group 4) had incomes that followed a quadratic pattern over the study period. This pattern remained in examination of the annual household incomes by trajectory groups (Figure 2.4). One prominent feature of the data for the HITG was that those in the bottom two groups, which were low and stable, tended to be older individuals, while those in the group with increasing income (Group 3) tended to be the youngest.

A total of six trajectories emerged from the analyses for household income from 1965-1994 for the entire sample, which had membership percentages of 1.6%, 2.6%, 12.2%, 66.0%, 11.0%, and 6.6% for groups one to six (lowest to highest), respectively. For men, the membership percentages were 0.3%, 0.7%, 3.7%, 29.3%, 6.1%, and 3.0%, and for women, they were 1.3%, 1.9%, 8.5%, 36.8%, 5.0%, and 3.6% for groups one to six respectively. Due to the small membership percentages in multiple groups both across and within genders, the trajectory groups were combined into four groups based on overall pattern and initial trajectory dollar value, which resulted in the combination of groups 1-3 for overall membership percentages of 16.4%, 66.0%, 11.0%, and 6.6% for groups one to four representing the lowest to the highest trajectory groups. For men, this resulted in membership percentages among men of 4.7%, 29.3%, 6.1%, and 3.0% and among women 11.7%, 36.8%, 5.0%, and 3.6% for groups one to four. Chi-square tests indicated differences in membership percentages by gender for both the six and four trajectory group measures ($p<0.01$).

Kaplan-Meier survival plots were created to evaluate survival functions by gender, and the log-rank test, wilcoxon test, and twice the negative log-likelihood test each suggested no differences by gender ($p=0.96$, $p=0.96$, $p=0.95$, respectively). Each measure of interest in these analyses was tested for differences in the survival function using wilcoxon tests, and results showed differences for age in 1994 ($p<0.01$), marital status ($p<0.01$), combined HITG ($p<0.01$), household income in 1994 ($p<0.01$), and

1965-1994 average household income ($p<0.01$), but not for race/ethnicity ($p=0.12$). Tests for the validity of the proportional hazards assumption were conducted for each household income measure (Table 2.5), and indicated no violations.

Results of the proportional hazards model are presented in Tables 2.3-2.7. Each model considered the effects of a unit change equivalent to the gender-specific interquartile range (IQR) for the individual measures. The IQR for household income in 1994 among men was $31068.46 and $28727.22 for women, and the IQR for average household income from 1965-1994 was $25477.01 for men and $19832.75 for women.

Among men, bivariate models (Table 2.3) showed an IQR change in household income in 1994 to be associated with decreased hazards of CVDM among men (HR=0.59, 95%CI= 0.35-0.98). Being in any of the lower quartiles of HI in 1994 was also associated with increased hazards of CVDM: HR_1=7.67, 95%CI=2.70-21.81, HR_2=3.43, 95%CI=1.12-10.45, and HR_3=5.21, 95%CI=1.78-15.21. In addition, membership in the second highest compared to highest HITG was associated with decreased risk of CVDM (HR=0.18, 95%CI= 0.04-0.93). After adjusting models for age, race/ethnicity, and marital status and any additional factors (Table 2.4), those in the lower quartile for HI in 1994 (HR=3.57, 95%CI=1.18-10.83) and the third quartile for HI in 1994 (HR=3.91, 95%CI=1.32-11.62) had increased hazards for CVDM compared to those in the highest quartile. No other associations were significant.

Among women, bivariate models (Table 2.3) showed an inverse relationship between continuous HI in 1994 (HR=0.38, 95%CI= 0.22-0.66) and AHI from 1965-1994 (HR=0.54, 95%CI= 0.36-0.81) with the hazard of CVDM. Membership in the lowest two household income quartiles in 1994 (HR_1=6.95, 95%CI= 3.12-15.51,

HR_2=3.33, 95%CI=1.42-7.83) and lowest category for AHI (HR=3.28, 95%CI= 1.80-5.99) compared to the highest categories were associated with increased hazard of CVDM. Membership in the second highest trajectory group (HR=0.10, 95%CI=0.01-0.91) compared to the highest HITG was associated with decreased hazards of CVDM among women as well. After adjustment in the models for age, race/ethnicity, and marital status (Table 2.4), there were no significant associations between any of the household income measures and the hazard of CVDM. [84]

Discussion

The purpose of these analyses was to compare and understand whether differences in magnitude of associations between recent, average, and pattern measures of SEP based on HI and CVDM existed within genders. The hypothesis that lower HI in 1994 would be inversely associated with CVDM risk was supported in these analyses in both bivariate and confounder-adjusted models for men but only in bivariate models for women. The hypothesis that AHI would be more strongly associated with CVDM than HI in 1994 was not supported in these analyses for men or women. The hypothesis that HITG would be most strongly associated with CVDM hazard was supported in the bivariate analyses for both men and women. The results indicated that within men, membership in the lower quartiles of the most recent measure of household income (HI in 1994) was associated with increased hazards of CVDM both prior to and after adjustment for confounders. Based on unadjusted models, the magnitudes of association were greatest between HITG and CVDM. Among women, unadjusted analyses showed that higher average and recent HI based on both continuous measures and quartiles was associated with increased hazards of CVDM, while membership in the second highest HITG was associated with decreased hazards of CVDM. The magnitude of association was greater for the HI measure from 1994 compared to that of AHI. Among categorical measures, the magnitude of associations were greatest with membership in the second highest HITG, then for membership in lower quartiles of HI in 1994 and AHI. With adjustment for confounders, no associations remained significant among women.

Unadjusted models for both men and women suggested that membership in the second highest HITG (Group 3, Figure 2.3) was most strongly associated with CVDM, and had significantly lower hazards of CVDM compared to those in the highest group (Group 4, Figure 2.3). This association is likely due to the continuous increasing pattern of annual household income for Group 3 as compared to Group 4, which followed a quadratic pattern for household income. This result indicates that those with growing household income during the study period were actually at the least risk of having CVDM compared to stagnant patterns or patterns that show temporary income increases over the study period.

The members of the sample in Group 3 tended to be younger adults (median age of 57 in 1994 and 28 in 1965) in the greatest income-earning era of their lives. Those in Group 4, however, were likely already in this period at the start of the study period, and were entering a period of stability in income attainment and then possibly retirement, indicated by the median age of this group. These adults were at a median age of 71 in 1994 (therefore approximately 42 years of age in 1965), and the majority were in or entering a period of retirement, and therefore no longer gaining income, but in a period of stagnant or decreasing income, as 26.6% of the 177 adults in Group 3 were 49-64 years of age [85].

The importance of the significant associations between HI in 1994 and CVDM for men in adjusted analyses and women in unadjusted analyses indicate that the social condition and available resources of an individual closer to the time of ascertainment of the health outcome of interest may be more influential in the development or presence of that particular outcome compared to measures of resource availability taken at times further from the date of disease determination.

The associations between HITG and CVDM indicate that the changes in income over the life course may be more strongly related to the likelihood of experiencing CVDM compared to other measures of HI taken from specific points throughout the life course. Based on these results, it could be not only the pattern than an individual follows over the life course, but also where that pattern lands the individual at the time disease ascertainment begins. In these analyses, those in the HITG that was increasing for the longest duration and had the greatest annual household income at the end of the income assessment period prior to death ascertainment had the lowest hazards of CVDM. The specific answer as to whether it was actually the experience of having the greatest recent household income or the most increasing pattern over the study period is unclear. However, the results for the quartiles of HI in 1994 support the notion that it is not necessarily the pattern of income over the life course but where the sequence of income attainment ends for each member in the study may be important.

In reviewing the results for AHI, the non-significant associations between AHI and CVDM for suggested that higher AHI was associated with decreased hazards of CVDM for men in bivariate (HR=0.83, 95%CI=0.60-1.16) and multivariable (HR=0.91, 95%CI=0.68-1.22) models. The non-significance of the result was likely due to a limited number of cases of CVDM among men in this sample. The direction of this association in conjunction with the result for women indicating an inverse association between AHI and CVDM support the notion that long term SEP based on HI indeed affects health.

The presence of associations among men after adjustment for confounders is consistent with the literature that has documented inverse associations between higher SEP and lower hazards of CVDM [34, 49, 55, 86, 87]. More specifically, the associations between SEP measured by HI and CVDM is similar to that of studies in the literature [74]. Although the associations were only significant in bivariate analyses for women, the significant associations were consistent with those found in the literature as well. In terms of the life course models that could plausibly indicate the ways in which SEP based on HI may affect CVDM risk, the presence of associations between HI in 1994 and CVDM provides evidence that life course frameworks that examine the influence of more proximal measures may be appropriate models in predicting CVDM. The time immediately prior to the evaluation of the presence of a condition may be the most influential in the disease development. Resource availability during this period could make substantial contributions to the health of the individual, as a limited amount of resources could have a profound impact on nutrition, access to reasonable health care resources, and health behaviors through due to their costs [58, 88]. Although discussion of the specific pathways through which SEP based on HI may be associated with CVDM are beyond the scope of this research, the presence of these factors along the pathway would provide evidence in support of this model.

Other life course models are also reasonable to consider based on these results. The presence of associations in bivariate models between HITG and CVDM for both men and women provide evidence to suggest the social mobility model and/or accumulation models are potential candidates in modeling these relationships. The social mobility model is plausible because those who were had the most increasing household income throughout the study period had the lowest hazards of CVDM compared to the group with the highest initial household income. These individuals moved from a lower level of SEP based on HI, which was almost equivalent to that of the second lowest HITG, to the highest HI at the end of the period for household income measurement in these analyses. However, the accumulation models also seem applicable to this data given than those with increasing household income over the life course level off by the end of the income ascertainment period at a higher level than any other HITG. Those who began the study at lower levels of HI and ended with similar levels were not significantly different from the group with the highest level of household income at the onset of the study and completed the income ascertainment period with the same amount. Furthermore, the indication of associations between AHI and CVDM for men and women provide evidence that prolonged periods of a wealth of available resources or deprivation of such resources can affect CVDM risk is in alignment with the accumulation model of SEP and health. These individuals may accumulate resources to help them practice healthy behaviors and receive/attain health care that can potentially lower the risk of CVDM.

This study has several strengths, of which the greatest is the intent of this research to evaluate the information gained through the use of specific conceptualizations of household income throughout the life course in association with CVDM. Furthermore, this study compares the magnitudes of association based on HI SEP with CVDM, which has been minimally, if at all, discussed in the health literature when based on HI as the single construct of SEP. Additional strengths include that there was a long period of follow-up for thousands of individuals. Also, since death information was collected from NDI, we were able to attain death data for the entire sample instead of only having death data for members who remained in the sample over time (we were able to find death data for those who dropped out at earlier waves of the study). Furthermore, we were able to compare multiple measures of SEP throughout the adult life course at various ages, which is not commonly done in analyses. 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 CVDM.

The comparability of associations between the recent static measure based on household income in 1994 with the average household income and household income trajectory class measures indicates that when one particular facet of SEP is utilized in the creation of disadvantage measures there may be little to gain by differentiating between the way that SEP factor is measured, especially in association with CVDM.

Another strength in these analyses was 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. Additional strengths include that we were able to use 98.6% of the data available in 1994, since this proportion of the respondents had complete demographic information. This, however, equated to a wide range of individuals at various points in the life course.

Inclusion in this analysis required individuals to survive to the 1994 survey to be included in these analyses which suggests reasons for concern with healthy survivor selection bias, such that those who died prior to 1994 or those who did not respond to the 1994 survey could have been substantially different from those included in these analyses. Descriptive statistics were assessed for those who died prior to 1994 and those who did not respond to the 1994 survey (but were not dead in 1993) (Table 1.6), and showed a greater proportion of women were included this sample compared to those who died before 1994 ($p<0.01$) as well as in or after 1994 ($p=0.01$), the respondents were more educated ($p<0.01$), there was a much lower proportion of individuals to die from CVDM compared to both excluded samples above ($p<0.01$), there were more whites compared to other race/ethnicities compared to the excluded samples ($p<0.01$), and there were much more likely to be married compared to those who died before 1994 ($p<0.01$) but not those who died in or after 1994 ($p=0.15$). To further examine the possible role of selection bias in these analyses, an additional analysis that examined the association between HI 1965 and 6 year CVDM among the original sample in 1965 (n=6928) was done and compared to the associations between

HI 1994 and 6 year CVDM showed significant associations to be present in both men and women with adjustment for age, race/ethnicity, and marital status, which differed from results for HI 1994 and CVDM (especially for women, for which there were no significant associations after adjustment for confounders), which provides empirical evidence to suggest selection bias may in fact play a role in these analyses.

Another limitation in this analysis is the presence of age cohort effects for which we were unable to properly control. Age was significantly associated with CVDM in both bivariate and multivariable models- a strong indicator that age played a role. It is possible that these analyses did not entirely control for the effects of age in these analyses, leading to an underestimation of the effects of SEP within genders. Further investigation of the data showed the average age in 1965 of the 2486 individuals in the Alameda County Study who died before 1994 from CVD was 61 years of age, while the average age in 1965 of those who died of CVD in the analytic sample (and therefore after 1994) was 46 years of age, revealing a substantial difference in the ages of those excluded and included in these analyses (Table 2.6). Additional analyses investigating the 6-year mortality associated with the annual household income measures from each year were conducted (Table 2.7), examining both bivariate and confounder-adjusted (age, race/ethnicity, and marital status) associations. Among men, inverse associations for both sets of models were present with HI in 1965, and for bivariate models only for HI in 1974 and AHI from 1965-1974 with CVDM. Among women, inverse associations were present for HI in 1965 and 1974 for both sets of models. Bivariate associations were present among women for HI in 1983, AHI from 1965-1974 and AHI from 1965-1983. The associations among men may support the notion of the presence of selection bias, although the impact was not extensive enough to completely attenuate significant associations. The presence of associations among women for each of the earlier income measures in relation to CVDM but not for later measures in 1983 and in the other results of the data after 1994 provides additional evidence of a contributing role of selection bias in these analyses.

One particular approach that would have been ideal to address these age cohort effects would have been to stratify the analyses based on age groups; however, the limited power due to such few cases of CVDM in the sample eliminated this as a possibility while simultaneously gender-specific associations. Future analyses with larger datasets and more cases of CVDM (i.e. longer observation times for CVDM) are necessary to properly address this issue.

A third limitation of this study is that the data used in these analyses were all self-reported with the exception of the mortality data. Self-reported data could result in misclassification bias, and could cause mis-estimation of effect of the HI measures. Mortality data was ascertained from the NDI and in itself is commonly used in the literature, although the accuracy of the cause of death as reported by the death certificates provided by the states may be lead to misclassification bias in these analyses as well [89]. If the number of deaths attributable to CVD is underestimated, then there may again be an underestimation of the associations between HI SEP and CVDM.

Additional limitations include that although this study covers a 35-year period, a total of four waves of data collection were done between 1965 and 1994, indicating wide intervals of time during which the measures we included may have fluctuated significantly, and these variations may differentially relate to CVDM. If there were more information available, we may see slightly different patterns emerge and therefore different SEP measures, and therefore different associations with CVDM. Another limitation of these analyses suggests that the generalizability of the results from this analysis to other populations may be limited because this is among one county in the United States in 1965, and would likely only represent counties similar to Alameda County in 1965.

One final limitation is that wealth data was not available for these analyses, which could have been an important contributor to the ability of the individuals in this study to live and survive comfortably with no income, especially among the older adults (the age range for this sample was 17-73 years in 1965, and 46-102 years in 1994). Wealth information could aid in determining whether a particular life course model (social mobility or the accumulation model) was more or less applicable in assessing the meaning of the long-term measures of HI. Higher wealth with simultaneous decreases in income over the life course would provide evidence of the accumulation model, as those who consistently had more available resources were less likely to experience CVDM. Gaining wealth throughout the life course as a result of the earned income may be more indicative of the social mobility model in effect. These individuals are increasing their resource availability and decreasing other attributes associated with higher risk of CVDM. Wealth is a potential explanation as to why having different levels of household income throughout the life course did not have different associations with CVDM (as with AHI). Those with low household income from the onset of the study may have had wealth to depend upon for the duration of the study. When compared to the group with higher income attainment throughout the study-individuals who may not have yet accumulated as much wealth- the lack of wealth information may have caused underestimation of effects of HI SEP in relation to CVDM among this sample. As a result, future research should incorporate and control for the effects of wealth in the study of relationships between HI and CVDM.

Our findings suggest that there is variability in the magnitude of association between different measures of HI with CVDM among older men and women. Increasing patterns of HI were strongly associated with decreased hazards of CVDM. In addition, the most recent assessment of HI (HI in 1994) was strongly and inversely associated with the hazards of CVDM. Long-term household income measured as average household income may potentially be associated with risk of CVDM although it was not evident in this study. Adjustment for confounders revealed significant inverse associations only between HI in 1994 quartiles and CVDM within men. The magnitudes of association between each of these measures were varied, although the directions of the associations were the same over all of the measures.

This is one of very few studies to explicitly report the differences in magnitude of association between measures of HI and CVDM to determine whether there was variation by measure. Higher SEP is frequently documented as inversely related to the risk of several health outcomes such as CVDM. The confounder-adjusted models in these analyses show this association may not consistently be present with changes in the specific measure of HI within the same sample of individuals. Therefore it is necessary for any researcher to specify the SEP construct used and its particular meaning to their study, as the expected associations may not exist. Efforts in the research examining the effects of social conditions in relation to health outcomes must include the provision of thorough and idealistically unified notions as to the ways these two facets of life are intertwined. Doing so, however, continues to require careful assessment of the methods through which we assess social conditions and health outcomes. The changes that seem miniscule, such as selection of a different measure of SEP based on HI, may impact the results of our studies and the conclusions drawn, and hinder the efforts of the field to move forward in developing health policies to reduce the burden poor social conditions on health.

Figure 2.1: Median annual household income by 1994 household income quartile for 2691 adults from the Alameda County Study in the study of HI and 6 year CVD mortality

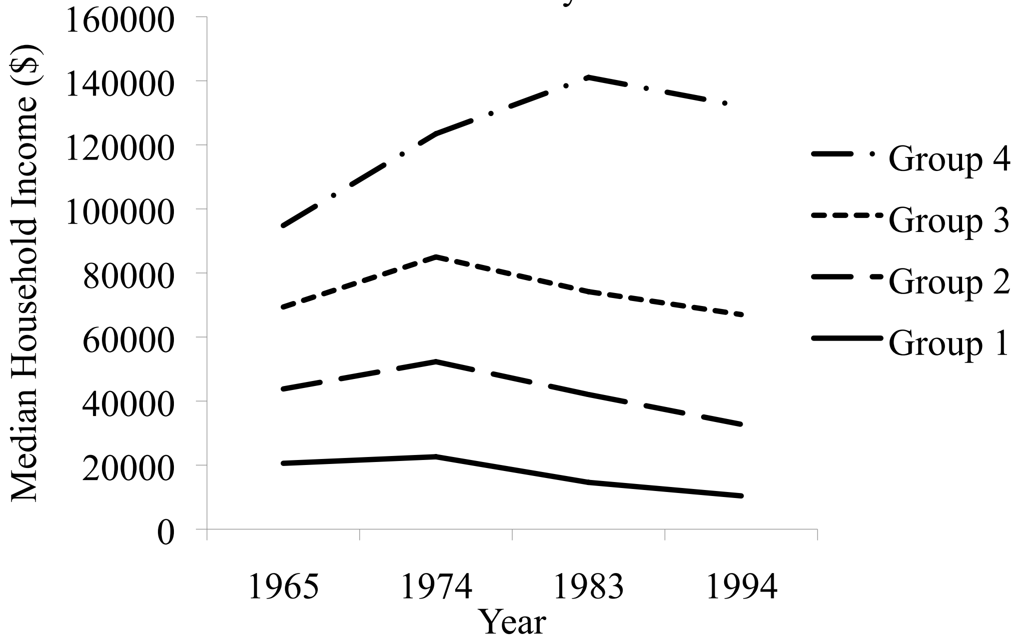


Figure 2.2: Median annual household income by 1965-1994 average household income quartile for 2691 adults from the Alameda County Study in the study of HI and 6 year CVD mortality

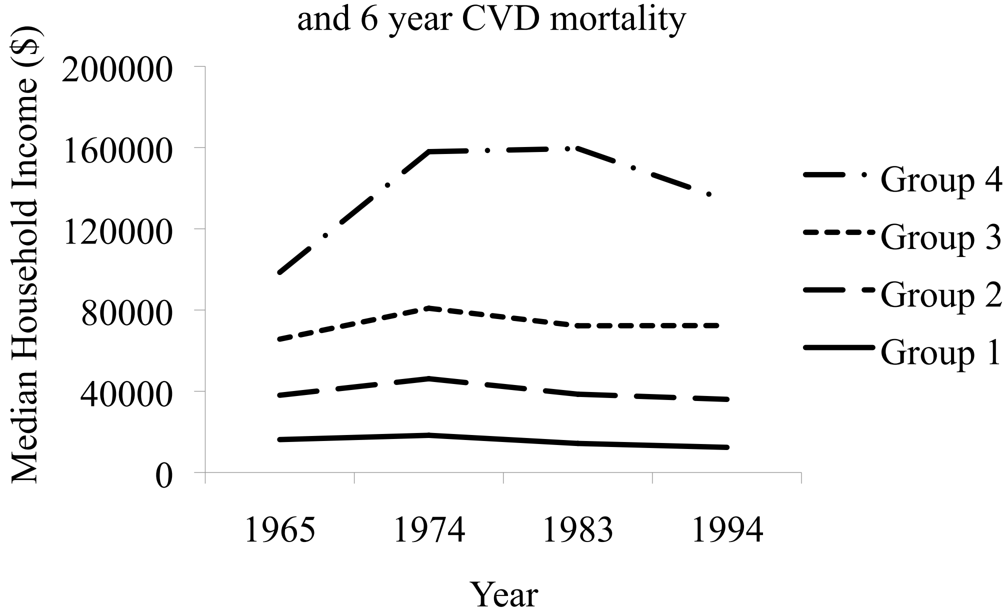
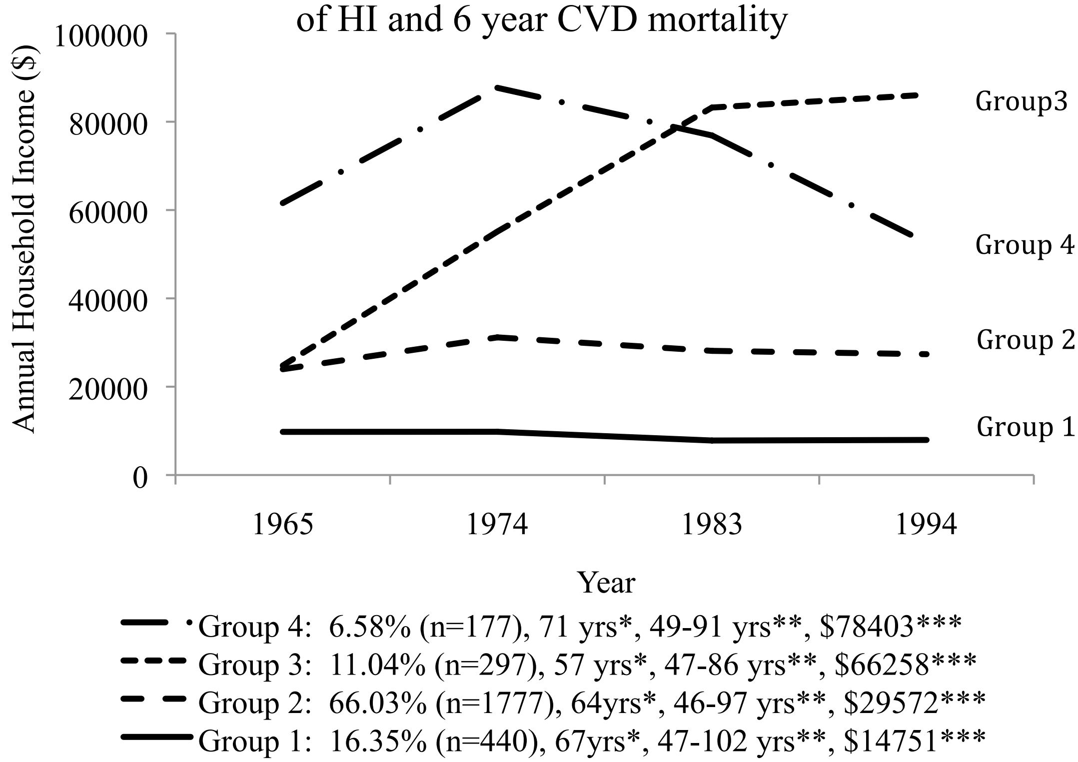


Figure 2.3: Household income trajectory groups for 2691 adults from the Alameda County Study in the study of HI and 6 year CVD mortality



*Median age; **Age range; ***Median Average household income 1965-1994

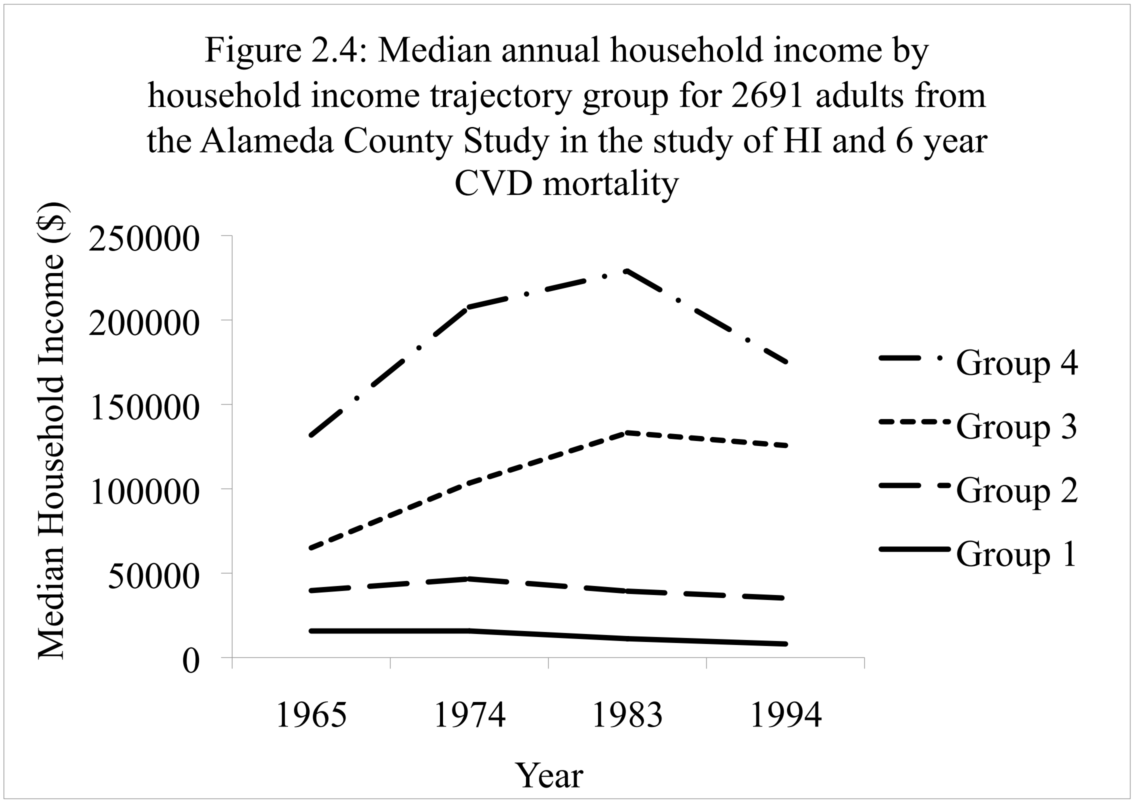


Figure 2.4: Median annual household income by household income trajectory group for 2691 adults from the Alameda County Study in the study of HI and 6 year CVD mortality
Median Household Income ($)
250000
200000
150000
100000
50000
0
1965
1974
1983
1994
Year
Group 4
Group 3
Group 2
Group 1

Table 2.1: Descriptive statistics by gender in the study of HI- 6 year CVD mortality

	Males (n=1157)		Females (n=1534)		
	N or Mean	% or SD	N or Mean	% or SD	P-value
CVD Deaths	64	5.53	88	5.74	0.82
% Married	951	82.2	919	59.9	<0.01
Race/Ethnicity					
White	1030	89.02	1323	86.25	0.05
Black	77	6.66	141	9.19	
Other	50	4.32	70	4.56	
Education					<0.01
0-11 Years	179	15.47	266	17.34	
12 Years	268	23.16	462	30.12	
13+ Years	710	61.37	806	52.54	
Occupation					
Non-manual	600	51.9	479	31.2	<0.01
Manual	389	33.6	114	7.4	
Home maker	168	14.5	941	61.3	
% Employed	829	71.7	519	33.8	<0.01
Observation Time	2213.30	477.01	2249.65	429.73	0.04
Age in 1994 (years)	64.91	9.97	64.74	11.01	0.68
Average Household Size	3.09	0.91	3.01	1.00	0.02
Smoking Status					
Never	437	37.77	758	49.41	<0.01
Former	577	49.87	533	34.75	
Current	141	12.19	241	15.71	
% With Heart Troubles	255	22.04	232	15.12	<0.01
% With High Blood	432	37.34	578	37.68	0.81
% With Diabetes	98	8.47	126	8.21	0.83

CVD=Cardiovascular disease; SD=Standard deviation

Table 2.2: Descriptive statistics for income measures by gender in the study of HI- 6 year CVD mortality

		Men (n=1157)		Women (n=1534)		
		N or Mean	% or SD	N or Mean	% or SD	P-value
HI in 1994 ($)		43697	41495	35411	35858	<0.01
AHI ($)		39877	24260	33980	21589	<0.01
HI in 1994 Quartiles	1	288	24.89	383	25.0	0.99
	2	291	25.2	384	25.0	
	3	289	25.0	383	25.0	
	4	289	25.0	384	25.0	
AHI Quartiles	1	290	25.0	383	25.0	0.99
	2	288	24.9	384	25.0	
	3	290	25.1	384	25.0	
	4	289	25.0	383	25.0	
Combined Trajectory Groups	1	126	10.9	314	20.5	<0.01
	2	787	68.0	990	64.5	
	3	163	14.1	134	8.7	
	4	81	7.0	96	6.3	
Original Trajectory Groups	1	7	0.6	35	2.3	<0.01
	2	20	1.7	50	3.3	
	3	99	8.6	229	14.9	
	4	787	68.0	990	64.5	
	5	163	14.1	134	8.7	
	6	81	7.0	96	6.3	

CVD=Cardiovascular disease; SD=Standard deviation; HI=Household income; AHI=Average household income

Table 2.3: Bivariate proportional hazards model results by gender in the study of HI and 6-year CVD mortality among 2691 adults from the Alameda County Study

	Men				Women			
	HR	95% LCL	95% UCL	AIC	HR	95% LCL	95% UCL	AIC
HI in 1994	0.59	0.35	0.98	877.98	0.38	0.22	0.66	1243.08
HI in 1994 Quartile 1	7.67	2.70	21.81	871.58	6.95	3.12	15.51	1243.24
HI in 1994 Quartile 2	3.43	1.12	10.45		3.33	1.42	7.83	
HI in 1994 Quartile 3	5.21	1.78	15.21		2.20	0.89	5.41	
HI in 1994 Quartile 4	ref				ref			
AHI	0.83	0.60	1.16	889.57	0.54	0.36	0.81	1256.53
AHI Quartile 1	1.60	0.77	3.31	892.53	3.28	1.80	5.99	1247.18
AHI Quartile 2	1.22	0.56	2.63		1.69	0.87	3.27	
AHI Quartile 3	1.67	0.82	3.40		0.57	0.24	1.36	
AHI Quartile 4	ref				ref			
HITG 1	1.49	0.52	4.31	883.29	2.09	0.89	4.90	1243.62
HITG 2	0.91	0.36	2.29		0.64	0.27	1.52	
HITG 3	0.18	0.04	0.93		0.11	0.01	0.91	
HITG 4	ref				ref			

CVD=Cardiovascular disease; HR=Hazards Ratio; LCL= Lower confidence limit; UCL=Upper confidence limit; HI=Household income; AHI=Average household income; HITG=Household income trajectory group.

Table 2.4: Multivariable proportional hazards model by gender in the study of HI and 6-year CVD mortality among 2691 adults from the Alameda County Study

	Men				Women			
	HR	95% LCL	95% UCL	AIC	HR	95% LCL	95% UCL	AIC
HI in 1994	0.81	0.54	1.21	838.69	0.67	0.40	1.11	1134.04
HI in 1994 Quartile 1	3.57	1.18	10.83	834.10	2.39	0.98	5.82	1136.87
HI in 1994 Quartile 2	1.96	0.63	6.08		1.55	0.65	3.72	
HI in 1994 Quartile 3	3.91	1.32	11.62		1.33	0.53	3.29	
HI in 1994 Quartile 4	ref				ref			
AHI	0.91	0.68	1.22	840.40	0.71	0.50	0.99	1132.53
AHI Quartile 1	1.20	0.58	2.51	841.89	1.92	0.97	3.78	1130.79
AHI Quartile 2	1.03	0.47	2.27		1.40	0.71	2.77	
AHI Quartile 3	1.70	0.83	3.48		0.55	0.23	1.30	
AHI Quartile 4	ref				ref			
HITG 1	1.73	0.59	5.08	841.59	2.46	0.97	6.22	1132.56
HITG 2	1.36	0.53	3.44		1.16	0.47	2.87	
HITG 3	0.53	0.10	2.92		0.49	0.06	4.30	
HITG 4	ref				ref			

CVD=Cardiovascular disease; HR=Hazards Ratio; LCL= Lower confidence limit; UCL=Upper confidence limit; HI=Household income; AHI=Average household income; HITG=Household income trajectory group. Each model included age, race/ethnicity, and marital status.

Table 2.5: Proportionality tests p-values by model and gender in the study of HI and 6-year CVD mortality among 2691 adults from the Alameda County Study

	Men		Women	
	Bivariate	Adjusted Model*	Bivariate	Adjusted Model*
HI in 1994	0.37	0.28	<0.01	0.08
HI in 1994 Quartiles	0.98	0.42	0.13	0.26
AHI	0.75	0.37	0.89	0.66
AHI Quartiles	0.74	0.41	0.89	0.68
HITG	0.57	0.36	0.74	0.63

HI=Household income; CVD=Cardiovascular disease. *The adjusted model refers to model from Table 2.4, including the household income measure, age, race/ethnicity, and marital status.

Table 2.6: Comparison of the analytic sample (n=2691) to excluded members of the original Alameda County Study population in the study of HI and 6-year CVD mortality

	Analytic sample		Died before 1994			Non-respondents who died in or after 1994			Non-respondents who were alive in 2000		
	N=2691	%	N=2486	%	p-value	N=308	%	p-value	N=1443	%	p-value
Gender											
Males	1157	43.00	1226	49.32	<0.01	154	50.50	0.02	621	43.04	0.98
Females	1534	57.00	1260	50.68		154	50.00		822	56.96	
Race/Ethnicity											
White	2353	87.44	2066	83.11	<0.01	236	76.62	<0.01	1137	78.45	<0.01
Black	218	8.10	351	14.12		58	18.83		232	15.99	
Other	120	4.46	67	2.70		14	4.55		80	5.56	
Education in 1965											
0-11 Years	532	19.77	1330	53.50	<0.01	140	46.61	<0.01	472	32.66	<0.01
12 Years	903	33.57	607	24.42		107	34.85		483	33.15	
13+ Years	1250	46.46	529	21.28		60	19.54		495	34.19	
Married in 1965	2186	81.23	1659	66.73	<0.01	238	77.27	0.09	1085	74.71	<0.01
CVD Death	152	5.65	1140	45.86	<0.01	125	40.58	<0.01	0	0	<0.01

Table 2.7: Proportional hazards model results by gender in the study of annual HI and 6-year CVD mortality among 2691 adults from the Alameda County Study

		Men				Women			
		HR	95% LCL	95% UCL	AIC	HR	95% LCL	95% UCL	AIC
HI in 1965	Model 1	0.56	0.41	0.76	2242.88	0.51	0.37	0.69	1985.66
	Model 2	0.82	0.71	0.96	1949.93	0.85	0.73	0.99	1670.53
HI in 1974	Model 1	0.47	0.28	0.78	1385.40	0.35	0.22	0.56	1817.07
	Model 2	0.83	0.65	1.04	1206.07	0.75	0.56	0.99	1617.78
HI in 1983	Model 1	0.43	0.15	1.26	505.39	0.42	0.18	0.99	626.86
	Model 2	0.70	0.31	1.57	465.74	0.80	0.50	1.28	569.14
AHI 1965-1974	Model 1	0.43	0.28	0.66	1405.05	0.63	0.41	0.97	1830.42
	Model 2	0.91	0.76	1.08	1208.20	0.79	0.62	1.01	1618.75
AHI 1965-1983	Model 1	0.63	0.32	1.27	513.37	0.49	0.25	0.97	630.10
	Model 2	0.80	0.47	1.38	466.91	0.79	0.55	1.15	568.51

CVD=Cardiovascular disease; HR=Hazards ratio; LCL=Lower confidence limit; UCL=Upper confidence limit; HI=Household income; AHI=Average household income. Model 1 is a bivariate model; Model 2 includes age, race/ethnicity, and marital status.

Chapter 3

Gender-specific associations between life course measures of household income and depressive symptoms in the Alameda County Study 1965-1999

Introduction

The burden of mental illness in the United States population has become extensive. The effects of mental illnesses like depression are apparent in multiple aspects of life, including financial setbacks as well as general function, as persons experiencing depression have difficulty managing responsibilities both at home and at work [23, 90, 91]. In the United States, data from the 2005-2006 National Health and Nutrition Examination Survey (NHANES) indicated the prevalence of individuals experiencing multiple depressive symptoms (MDS) as an indicator of depression to be 5.4% for the overall population, although the rates were higher for women (6.7%) and lower for men (4.0%). Data from the National Comorbidity Study data showed the annual prevalence of major depressive disorder (MDD) to be 6.8%, with a similar pattern by gender as above- 8.6% of women and 4.9% of men were affected by MDD [92]. Associations have been documented between socioeconomic position (SEP) and mental health outcomes, suggesting that people with lower SEP are more likely to experience these outcomes [40, 93, 94]. More specifically, NHANES data provided evidence that individuals of lower SEP had higher rates of depression compared to those of higher SEP [23].

Resource availability has been suggested as a contributing factor to the increased presence of mental health outcomes such as MDS and depression in the multiple studies [40, 93-95]. The ways in which these factors interact over the life course have been less frequently studied, although considerable evidence has shown long-term effects of SEP over the life course on health [40, 96]. The measures used to capture these effects have included parental SEP, education, income, and occupation. Parental SEP has been used as a proxy for childhood social conditions. In adolescence and young adulthood, measures incorporating years of education or degree attainment have been used. In adulthood, income and occupation have been used to evaluate SEP, and often at single points in adulthood rather than multiple time points throughout adulthood in relation to mental health outcomes [37, 40, 93, 96, 97].

Three life course theories that have been used to describe the development of health outcomes throughout life have included the critical period, social mobility, and accumulation models. The critical period model suggests that there is some specific point during the life course at which the conditions an individual faces have a substantially more profound impact on the health outcome of interest than at other times in life [42, 61-63]. In relation to MDS, life experiences during a particularly developmentally important period, such as in childhood, may affect an individuals' likelihood of experiencing MDS or depression outcomes in adulthood [40, 96].

The social mobility model emphasizes the role of change in social condition over the life course and its role in changes in health throughout the life course resulting from these changes [42]. Adults who have raised their SEP over the life course may also be moving from more stressful situations to more stable and calm conditions. This change could introduce the opportunity to reduce factors that may increase the likelihood of experiencing MDS, such as poor social support or increased social isolation, therefore reducing the individual's risk of MDS [94].

The accumulation model suggests that the cumulative experiences throughout the life course can affect health outcomes later in life [42]. The accumulation of multiple factors that increase a persons' likelihood of MDS, such as stressful life events, poor social support, increased social isolation, or other health problems for sustained periods of time could contribute to the likelihood an individual would experience MDS or similar outcomes [94, 98]. Each of these frameworks is therefore plausible in determining the pathways through which SEP may have an effect on the presence of MDS.

Although research has studied associations between SEP and MDS through a variety of SEP indicators, rarely have variations in associations of a single SEP indicator, such as income, with health outcomes been compared. Measuring the associations between multiple measures of income and MDS is important in evaluating whether various measures of income are differentially related to MDS, especially within gender. These associations could suggest specific pathways through which SEP may affect the prevalence of MDS within gender.

Gender differences in the return to health based on SEP have been demonstrated with measures such as education and income, and may reflect gender differentials in resource availability as well as in associations between SEP and health outcomes [50, 52]. Furthermore, evidence is mounting to suggest that the mechanisms through which life course SEP affects health outcomes may vary by gender [65]. Within gender, however, the interpretations of various forms of single SEP indicators, such as education or income, have alternative meanings that may reflect historical biases limiting resource attainment, commonly among women [56, 57, 66, 67]. Measures that capture SEP over different lengths of time in the life course as well as SEP at different points in time may be associated with MDS differently by gender.

Income has been utilized in several studies both as functions of personal and household income, likely because personal measures of SEP may be more indicative of health outcomes, while household income is more commonly available in data, especially for women [68-72]. In studies of long-term SEP measures, however, the increased likelihood of women serving in their homes instead of the workforce left them dependent on the household income for resources, thereby making household income the most representative indicator of financial resources over a long period of time [67].

SEP has been studied in its relationship with depression outcomes, such as the experience of major depressive episodes (MDE). The SEP measures used, however, have been focused on recent measures of income in relation to the time of outcome, and reported significant associations with MDE and depressive symptoms as well [37, 93, 97, 99, 100]. However, no studies were found that examined long-term measures of household income in relation to depression outcomes. This limitation of the literature exhibited the need for studies that look at long-term SEP based on HI in relation to depression outcomes, and how they vary from the measures currently used.

The goal of this analysis was to examine SEP based upon static and long-term household income measures over the adult life course and their associations with the presence of multiple depressive symptoms using gender-specific models for adults in the Alameda County Study. We hypothesized inverse associations would be present between each household income measure and MDS for both men and women, but the magnitude of the associations would be greater for the long-term measures compared to static measure of HI within each gender.

Methods

Study population

The Alameda County Study (ACS) began data collection in 1965 among men and women aged 20 and older or 16 and older if married in Alameda County, California. Data pertaining to both social and health conditions with several years of follow-up is characteristic of this study, and rare of studies initiated during this time and with such substantial follow-up. The breadth of information available in these data pertinent to study participants' socioeconomic conditions, mental well-being, and physical health status made this data expedient for the research.

Data relevant to health status and behavioral, social, psychological, socioeconomic, neighborhood, and socio-environmental risk factors were collected in this study [76-78]. Alameda county, with a population of approximately one million people in 1965, was and since has been a metropolitan county. A two stage stratified systematic sample was used to gather data on 8023 non-institutionalized adults from 4452 household units [78]. The respondents to the survey (n=6928) represented 86% of those sampled, and were comprised of 3158 (45.6%) men and 3770 (54.4%) women in 1965. Five waves of follow-up were completed 1974, 1983, 1994, 1995, and 1999. In 1974, 85.1% of the persons from interviewed in 1965 were re-interviewed, and 50% of those not known to be dead were re-contacted in 1983 (n=1798, 87.3% response rate). Respondents from 1974 and 1983 were re-contacted in 1994 (n=2729, 93% response rate). A short questionnaire was mailed to all 1994 respondents in 1995 (n=2569, 93% response rate). A sixth wave of data collection was conducted in 1999 with 2123 respondents (96% response rate).

Assessment of multiple depressive symptoms

Depressive symptoms were assessed based on a set of 12 items designed to capture the diagnostic criteria for a major depressive disorder based on the Diagnostic Statistical Manual for Mental Disorders Fourth Edition (DSM-IV), and referred to as the DSM-12D, adapted from the Primary Care Evaluation of Mental Disorders (PRIME-MD) mood disorders section. The items included (1) feeling sad, blue, or depressed, (2) loss of interest or pleasure in most things, (3) feeling tired out or low on energy most of the time, (4) loss of appetite or weight loss, (5) overeating or weight gain, (6) trouble falling asleep or staying asleep, (7) sleeping too much, (8) more trouble than usual concentrating on things, (9) feeling down on yourself, no good, or worthless, (10) being so fidgety or restless that you moved around a lot more than usual, (11) moved or spoke so slowly that other people could have noticed, and (12) thought about death more than usual, either your own, someone else's, or death in general. Cases of MDS were individuals who reported experiencing five or more of these symptoms almost daily for the past two weeks.

Definition of SEP measures

At each wave of data collection, bracketed household income (HI) was reported, and represented the gross income for all members of the immediate family who received income in the previous year. HI in 1965 was categorized into $1000 increments from $0-$9,999, and $10,000-14,999, $15,000-24,999, and >$25,000; in 1974, income was categorized as <$2,000, in $1000 categories from $2000-$9,999, and then $10,000-$11,999, $12,000-$14,999, $15,000-$19,999, $20,000-$24,999, and > $25,000. Higher income categories were added to the 1974 categories for 1984: $5000 categories were included from $25,000-$39,999, then $40,000-$49,999 and >$50,000. HI data from 1994 and 1999 was bracketed into increments of $5000 for $0-$49,999, then $50,000-$74,999, $75,000-$99,999, $100,000-$149,999 and >$150,000. Using demographic data common to both ACS and monthly Current Population Surveys (CPS) of the same year, continuous measures of household income were computed and bounded by the income categories provided by the respondents in the survey. 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. The data used from the ACS and CPS included age, education, gender, race, marital status, occupation, and number of household members. The CPS, conducted monthly by the Census Bureau for the Bureau of Labor Statistics, provides the best national data on income [80]. Imputation was done using IVEware- Imputation and Variance Estimation Software based on a multivariate sequential regression method [79].

Three measures of HI were created to operationalize the construct of SEP- HI in 1994, average household income (AHI), calculated as the average of the household incomes for 1965, 1974, 1983, and 1994, and household income trajectories based on the household income values from 1965, 1974, 1983, and 1994. All respondents in the analytic sample were required to have at least three waves of data for HI, and all income measures were adjusted to 1993 dollars using the Consumer Price Index (CPI). In addition, each income measure was adjusted for household size by dividing the CPI adjusted HI by the square root of the household size at that wave. This approach was based on previous research suggesting the cost of living to be non-linearly correlated with household size, and the square root transformation of household size in adjustment for household size as more appropriate [81]. Trajectories of household income were created using PROC TRAJ in the SAS System (SAS Institute, Cary, NC), then grouped based on the trajectory patterns and is further discussed in the statistical analysis section below [82]. These analyses utilized both a continuous and categorical version of these household income measures to allow inspection for linear and non-linear associations between these income measures and MDS, as well as to allow for comparisons of magnitude of association. Categorical measures were based on quartiles of the continuous measures.

The household income measures used in these analyses were chosen to explore multiple measures of SEP throughout the life course and their differential effects on MDS. Household income in 1994 provides a current measure of household income that reflects middle to later adulthood for the adults in this study. The measure is intended to represent the available resources of an individual at the most current point of data collection. Average household income is one of the two long-term measures that captured information about the level of income these individuals tended to maintain for the duration of the study period. The other long-term household income measure was based on the trajectory groups. The HITG were created to elucidate the patterns of income over the life course, and whether these patterns reveal different information than AHI or HI in 1994 individually.

The primary goal of this analysis was to determine whether associations were present between three measures of HI and MDS five years later, to evaluate the differences in associations between the various measures of HI and MDS within gender, and whether different measures were associated with MDS between genders. Age in 1994, race/ethnicity, gender, and marital status in 1994 were included as confounders in these analyses. Another strong potential confounder was having a history of depressive symptoms, and was therefore considered in these models [97]. Although other variables were recognized as potential cofounders of this association as well, the alternative mediating role of these variables was not under investigation in these models, and discussion of these factors was therefore beyond the scope of this work.

Having a history of depressive symptoms between 1965 and 1994 was established using the same criterion as above in 1994. For 1965, 1974, and 1983, the experience of five or more depressive symptoms was based on the Human Population Laboratory 18-item index that included whether the individual was bothered by getting tired in a short time, felt vaguely uneasy without knowing why, whether the individual felt depressed or very unhappy, poor appetite, trouble getting to sleep or staying asleep, felt lonely or remote from other people, felt on top of the world, felt little enjoyment from leisure time, felt too tired even to do things he or she enjoys, less energy than other people, felt pleased about accomplishing something, felt bored, felt so restless that he or she could not sit still long, felt excited or interested in something, found it hard to feel close to others, felt left out even in a group, never satisfied with his or her own performance, and not able to relax easily. A response of “often” for any of these items was considered experiencing the symptom, compared to “never” and “sometimes.” Social isolation was based on six questions from the survey: How many friends can you confide in, how many relatives do you feel close to, how many friends and relatives do you see at least once a month, how many friends and relatives can you turn to for help, how many friends and relative can you talk to about personal measures, and how many friends and relatives do you have you can ask for advice or information. A response of less than three for any of the questions was considered isolated, and the sum of the scores were categorized into three groups of social isolation- 0,1-2, and 3 or more, where a higher score meant greater isolation.

Statistical Analysis

Descriptive statistics for each variable included in these analyses were completed, which incorporated the use of t-tests and chi-squared tests to assess differences by gender. Gender stratified logistic regression models were used to examine the associations of interest within gender. Three sets of models were run- (1) bivariate models for each HI SEP measure, (2) the HI SEP measure and the confounders, and (3) the HI SEP measure, confounders, and a history of depressive symptoms. Goodness-of-fit tests based on the Akaike Information Criterion (AIC) were used to compare model fit.

Model of the Income Trajectories

Income trajectories were created using a group-based trajectory modeling approach within the PROC TRAJ procedure in the SAS System (The SAS Institute, Cary, NC). This approach assumes the population is composed of a mixture of J underlying trajectory groups such that

$$P(Y_i)= \Sigma_j \pi_i P_j(Y_i)$$

–$P_j(Y_i)$= probability of Y given membership in group j for person i

–π_i=proportion of population in group j, j=1, 2, … J

–$P(Y_i)$=unconditional probability of observing person i's sequence of household income measures

and $P_j(Y_i) = \Pi_t p_{jt}(y_{it})$, and y_{it} are random variables for each subject I at times t=1,2,…,T- the household incomes are independent after we know the trajectory group to which the individual belongs. Group membership probabilities π_j are not estimated directly but through a multinomial logit function

$$\pi_i= \exp(\theta_i) /\Sigma_i \exp (\theta_i),$$

where θ_1 is normalized to zero, ensuring each of these probabilities falls between 0 and 1. The parametric model, here the censored normal model, is based on the data type (household income) and represents the form of $p_{jt}(y_{it})$. The linkage between time and household income is established through a latent variable $y_{it}{*}^{j}$, which has been thought of as measuring the potential for having a certain household income, and is

$$y_{it}{*}^{j}= \beta_{0j} +\beta_{1j} Time_{it} +\beta_{2j}Time_{it}^{2} +\beta_{0j}Time_{it}^{3} + \varepsilon_{it}$$

where ε_{it} is a disturbance assumed to be normally distributed with a zero mean and constant standard deviation [83].

By fitting models with 2-6 trajectory groups, each with the same polynomial order, determination of the appropriate number of trajectory groups was completed by selecting the model with the most negative Bayesian Information Criterion (BIC) [82]. Model finalization was dependent upon the highest order polynomial for each trajectory group with a significant p-value. Using the resulting posterior probabilities the trajectory group for which the individual had the greatest probability was the group assigned to the individual and included as an explanatory variable in the statistical models.

The confounder adjusted statistical model being used to assess the associations between continuous measures of HI and MDS is a logistic model of the form

$$\text{Logit}(p) = \exp\left[\beta_0 + \beta_1\text{(Household Income Measure)} + \beta_2\text{(Age)} + \beta_3\text{(Race/ethnicity)} + \beta_4\text{(Marital status)} + \beta_5\text{(Education)}\right] + \varepsilon_i$$

where:

p = the probability of experiencing MDS in 1999 for the i^{th} individual, given their covariates

β_1 = the log odds ratio of MDS associated with a unit change equivalent to the gender specific interquartile range (IQR) of the continuous household income measure (1965, 1994, or average household income).

and the confounder adjusted logistic model for the trajectory categorical HI measures group income measure is of the form

$$\text{Logit}(p) = \exp[\beta_0 + \beta_1 TG_1 + \ldots + \beta_k TG_k + \beta_{k+1}(\text{Age}) + \beta_{k+2}(\text{Race/ethnicity}) + \beta_{k+3}(\text{Marital status}) + \beta_{k+4}(\text{Education})] + \varepsilon_i$$

where:

p = the probability of experiencing five or more depressive symptoms in 1999 for the i^th^ individual, given their covariates

$TG_{1\ldots}TG_k$ = Indicator variable for household income trajectory group k

$\beta_{1\ldots}\ \beta_k$ = log odds ratio associated with belonging to HI measure trajectory group k compared to the highest trajectory group.

Results

Of the 2,123 men and women with data collected in 1999, all of these individuals had at least three years of data, and 2,102 of these persons provided information on gender, age, race/ethnicity, marital status, level of education, and household income, and were therefore included in these analyses. As a result, 21 people were excluded from these analyses, and they were primarily female, white, married, and had missing education data.

There were 908 men and 1194 women included in this analyses, of which 72 (8%) of the men and 133 (11%) of the women had MDS. A total of 21% of the men and 27% of the women experienced five or more depressive symptoms at some time between 1965 and 1994. Eighty-four percent of the men and 65% of the women were married, and 91% of the men and 88% of the men were white, and 5% of the men and 8% of the women were black. Sixty-six percent of the men and 57% of the women had at least 13 years of education or more, and 22% of men and 30% of women had 12 years of education. The average age for both men and women was 63 years, and the average household size for men was 3.13 and 3.09 for women. Chi-square tests showed differences in the presence of five or more depressive symptoms (p=0.01), marital status (p<0.01), race/ethnicity (p=0.04), years of education (p<0.01), history of depressive symptoms (p<0.01), but not age (p=0.11). The mean household income in 1994 was $47155 for men and $39259 for women. Average household income from 1965-1994 was $41424 for men and $36019 for women. T-tests suggested household income in 1994 (p<0.01) and average household income from 1965-1994 (p<0.01) were statistically significantly different for men and women, but not for household income in 1965 (p=0.10).

Six trajectories emerged from the analyses for household income from 1965-1994 for the entire sample, which had membership percentages of 0.6%, 6.2%, 9.4%, 65.1%, 15.5%, and 3.2% for groups one to six (lowest to highest), respectively. For men, the membership percentages were 0.3%, 4.3%, 6.6%, 65.6%, 19.4%, and 3.7% for men, and for women, they were 0.8%, 7.7%, 11.5%, 64.7%, 12.5%, and 2.9% for groups one to six respectively. Due to the small membership percentages in multiple groups across genders, the trajectory groups were combined into four groups based on overall pattern and dollar value, which resulted in the combination of groups one and three as well as groups two and six for overall membership percentages of 18.7%, 65.1%, 9.4%, and 6.9% for groups one to four representing the lowest to the highest trajectory groups. For men, this resulted in membership percentages 4.6%, 6.6%, 65.4%, and 23.1% and among women, 8.5%, 11.5%, 64.5%, and 15.3% for groups one to four. Chi-square tests indicated differences in membership percentages by gender for both the six and four trajectory group measures ($p<0.01$).

Models with continuous measures of household income were run, with the unit change for each model based on a change in household income equivalent to the IQR. Among men, the IQR was $39000.33 for household income in 1994 and $26908.78 for average household income. For women, the IQR was $29481.76 for household income in 1994 and $21192.93 for average household income.

Bivariate models (Table 3.3) showed inverse associations between higher HI in 1994 and odds of MDS among men (OR=0.35, 95%CI=0.17-0.71), AHI (OR=0.54, 95%CI=0.33-0.88), as well as between membership in lower HI in 1994 quartiles (OR_1=5.35, 95%CI=2.31-12.37, OR_2=3.37, 95%CI=1.41-8.06) and lower AHI quartiles (OR_1=3.27, 95%CI=1.50-7.12, OR_2=2.87, 95%CI=1.30-6.31) compared to the highest quartiles with odds of MDS. Similar associations were present between lower HITG and odds of MDS (OR_1=10.63, 95%CI=3.61-31.27, OR_2=1.45, 95%CI=1.45-13.93, OR_3=3.05, 95%CI=1.28-7.22) relative to the highest HITG (Group 4).

When the models for men were adjusted for age, race/ethnicity and marital status (Table 3.4), higher household income in 1994 (OR=0.42, 95%CI=0.21-0.85) and higher AHI (OR=0.59, 95%CI=0.38-0.94) were associated with lower odds of MDS. Membership in the lower quartiles for HI in 1994 (OR_1=4.18, 95%CI=1.74-10.04, OR_2=2.98, 95%CI=1.24-7.21) and for AHI (OR_1=2.73, 95%CI=1.24-6.00, OR_2=2.75, 95%CI=1.25-6.04) was associated with increased odds of MDS compared to the highest quartile. In addition, membership in the lower compared to the highest HITG, Group 4, was also associated with increased odds of MDS (OR_1=8.02, 95%CI=2.50-25.76, OR_2=3.66, 95%CI=1.19-11.23, OR_3=2.79, 95%CI=1.17-6.65).

When models for men were further adjusted for having a history of depressive symptoms (Table 3.5), higher HI in 1994 was associated with decreased odds of MDS (OR=0.43, 95%CI=0.20-0.94). In addition, lower HI in 1994 quartiles were associated with increased odds of MDS (OR_1=3.92, 95%CI=1.52-10.14, OR_2=2.98, 95%CI=1.14-7.76), as were lower AHI quartiles (OR_1=2.25, 95%CI=1.00-5.10, OR_2=2.53, 95%CI=1.13-5.65) and lower HITG (OR_1=7.32, 95%CI=2.01-26.62, OR_2=3.76, 95%CI=1.15-12.27, OR_3=2.61, 95%CI=1.07-6.38) compared to the highest groups.

Among women, the bivariate models (Table 3.3) showed that neither continuous HI measure was significant. However, membership in the lowest HI in 1994 quartile was associated with increased odds of MDS (OR=1.71, 95%CI=1.07-2.74), as was membership in the lowest HITG (OR=2.18, 95%CI=1.10-4.31) compared to the highest groups. After adjusting models for age, race/ethnicity and marital status (Table 3.4), the association was more pronounced between HI in 1994 quartiles and odds of MDS (OR_1=4.18, 95%CI=1.74-10.04, OR_2=2.98, 95%CI=1.24-7.21), but was approximately the same for HITG (OR=2.22, 95%CI=1.07-4.61). Models further adjusted for a history of depressive symptoms (Table 3.5) showed no associations between any of the SEP measures and odds of MDS for women.

Discussion

Multiple studies have examined and found significant relationships between various measures of SEP in relation to the experience of depression or depressive symptoms in the literature [37, 40, 96, 97]. Fewer studies have investigated the relationships between measures of SEP that cover a period of time in life, especially based on measures of income. However, virtually no studies could be found that examined long-term measures of SEP captured through household income in relation to depression outcomes. This gap in the literature was the premise for which this analysis was designed, in which we studied the gender-specific differences of associations between various measures of HI and the experience of MDS.

This analysis showed that the associations between multiple measures of household income and the experience of multiple depressive symptoms are variable in nature for both men and women. The hypothesis that there were associations between each measure of household income and odds of MDS were supported in these analyses. Results for men indicated higher continuous HI in 1994 to be more strongly associated with decreased odds of MDS compared to AHI, and only the association between HI in 1994 and MDS remained when models were adjusted for a history of depressive symptoms. Evidence favoring the hypothesis of stronger associations between HITG compared to HI in 1994 and AHI was provided as well. Among the categorical measures, lowest HITG was most strongly associated with increased odds of MDS, followed by membership in the lowest HI in 1994 and AHI quartiles relative to the highest groups. With further adjustment for a history of depressive symptoms, the associations and relations between the measures followed the same trend.

Among men, there was support for both the hypothesis of each measure being associated with MDS in all models. The associations between HITG and MDS were great in magnitude but had wide confidence intervals, likely caused by small sample sizes within particular HITGs (Table 3.2). The association between HITG and MDS, however, demonstrates the importance of the patterns of household income over the life course in relation to mental health outcomes. The association provides evidence to support the importance of the social mobility and accumulation life course frameworks. Those with income building throughout the study period were plausibly moving from poorer to better social conditions. Alternatively, the individuals with increasing income were building long-term availability of resources, which supports the accumulation model.

In contrast, the reasons for which the associations between HI in 1994 and MDS were stronger than those between AHI and MDS may be heavily affected by the distribution and variability of household income for the quartile measures. The average household income measure allows for variation in household income throughout the life course measure, and among four quartiles, the annual household income at which the groups started in 1965 were relative close to where they ended in 1994 (Figure 3.2), although at different values of income. In addition, the variability of AHI was smaller than that of HI in 1994 (Table 3.2), which meant the quartiles were possibly more similar in income value than the quartiles of HI in 1994. Ultimately, however, each HI measure was strongly associated with the experience of MDS. The associations between AHI and MDS provide evidence that may support the presence of the accumulation model, as individuals within household that gained more income could be accumulating resources over time, and therefore less likely to experience environments associated with increased odds of MDS. The associations between HI in 1994 and

MDS, however, favor the critical period model. Those with higher household income in 1994 had lower odds of experiencing MDS compared to those of lower HI in 1994.

Within women, the associations prior to adjustment for a history of depressive symptoms were as hypothesized. The presence of associations between HI in 1994 and MDS provide support of the critical period model among older women, while the presence of associations between HITG and MDS lent support of the social mobility and accumulation models. The lack of association any measure of HI with MDS after adjustment for a history of MDS may indicate a cyclical relationship between MDS and HI throughout the life course. High correlation between a history of MDS and HI suggests the need for additional examination into long-term patterns of income and depressive symptoms earlier compared to later in the life course for women.

For both men and women, The patterns of HI for the HITG (Figure 3.3) were similar to the patterns of HI in 1994 (Figure 3.1), in that the relation between the final measures of household income for each measure were similar in the relationships between the groups or quartiles of the specific measure. The similarity of the patterns, however, may be an indicator that the information gained from the trajectories may not only be related to the patterns of the trajectories but the end points when determining the effects on subsequent health outcomes.

This study has several strengths, including the comparison of the use of specific conceptualizations of household income throughout the life course in association with MDS. Furthermore, this study compares the magnitudes of association based on HI SEP with MDS, which has been minimally, if at all, discussed in the health literature when HI is utilized as the construct of SEP. Additional strengths include that we were able to use 99% of the data available in 1999, since this proportion of the respondents had complete demographic information, as well as education and occupation.

Potential limitations of this analysis include that the individuals had to survive to the 1999 survey to be included in these analyses, suggesting reasons for concern with selection bias. Those who died prior to 1999 or those who did not respond to the 1999 survey could have been substantially different from those included in these analyses, and therefore caused mis-estimation of the association between these HI SEP measures and MDS. In addition, these were all self-reported data, which lend themselves to reporting and recall biases that could potentially inflate the associations presented in this work. Although this study covers a 34-year period, the information was obtained through five waves of data collection. Each of the household income measures included here are therefore based on a small number of data points which could suggest some amount of uncertainty about how well the measures used actually represent the household income at regular intervals over this 29 year period, and that the individuals in the study were not experiencing times of uncertainty at the times for which data was requested.

An additional limitation is that there was no wealth data available for these analyses, which could have been an important contributor to the ability of the individuals in this study to live and survive comfortably with no income, especially among the older adults (the age range for this sample was 18-65 years in 1965, and 47-94 years in 1994). Since this is an aging population who were adults at baseline in 1965, the role of wealth becomes quite substantial as these individuals retire and no longer work, and future research should incorporate this information. The lack of wealth information may have caused an overestimation of effects of HI SEP in relation to MDS among this sample. One final limitation of these analyses suggests that the generalizability of the results from this analysis to other populations may be limited because this is among one county in the United States in 1965, and would likely only represent counties similar to Alameda County in 1965.

In summary, this study directly compares various measures of household income and their associations with the presence of multiple depressive symptoms to determine whether differences in the magnitudes of association are present within genders. Resource availability both throughout the life course and at specific points in the life course may be substantial in evaluating risk of experiencing MDS. This work is not oblivious to the potential role of other risk factors of MDS in their effects on MDS as well as how they may be affected by HI, although the specific role of these factors in this analysis were beyond the scope of this work. Future analyses can directly address the relationships between various measures of HI and risk factors for MDS or other depression outcomes, and may move forth to determine if it is through these risk factors that HI is solely affecting an individual's risk of experiencing MDS.

Research utilizing HI as an SEP indicator must examine the gender specific associations, and recognize that different measures of the HI indicators may yield drastically different results. Lack of association for one particular long-term measure of HI may not directly suggest a lack of importance of that construct. Therefore knowledge of multiple measures that confer different information in relation to the outcome is required. Awareness of possible differences in associations between HI measures and MDS will provide the needed clarity in evidence to support social change in health policy creation.

Figure 3.1: Median annual household income by 1994 household income quartile for 2102 adults from the Alameda County Study in the study of HI and multiple depressive symptoms

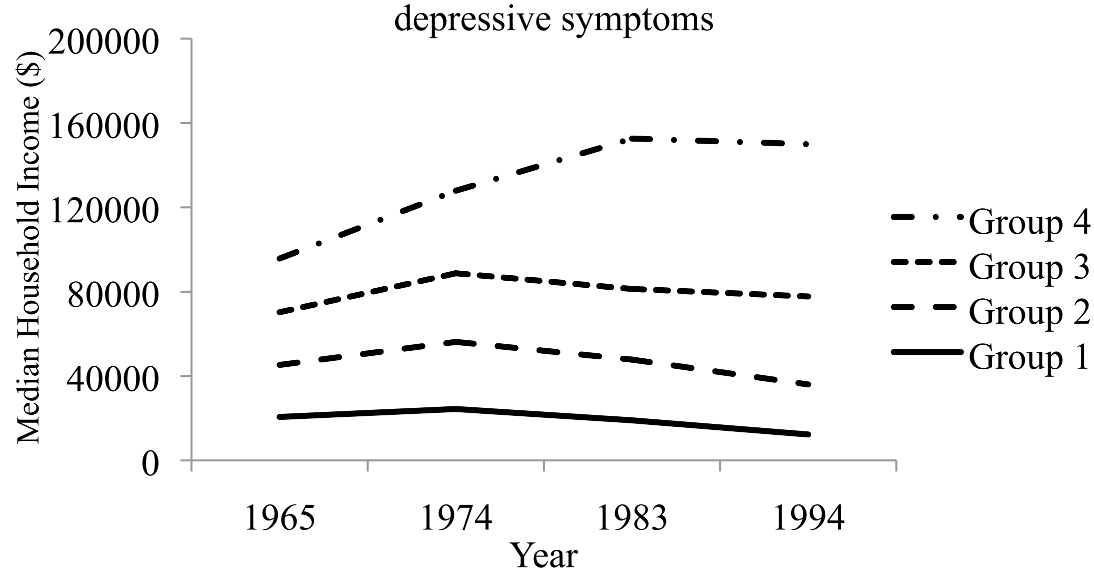
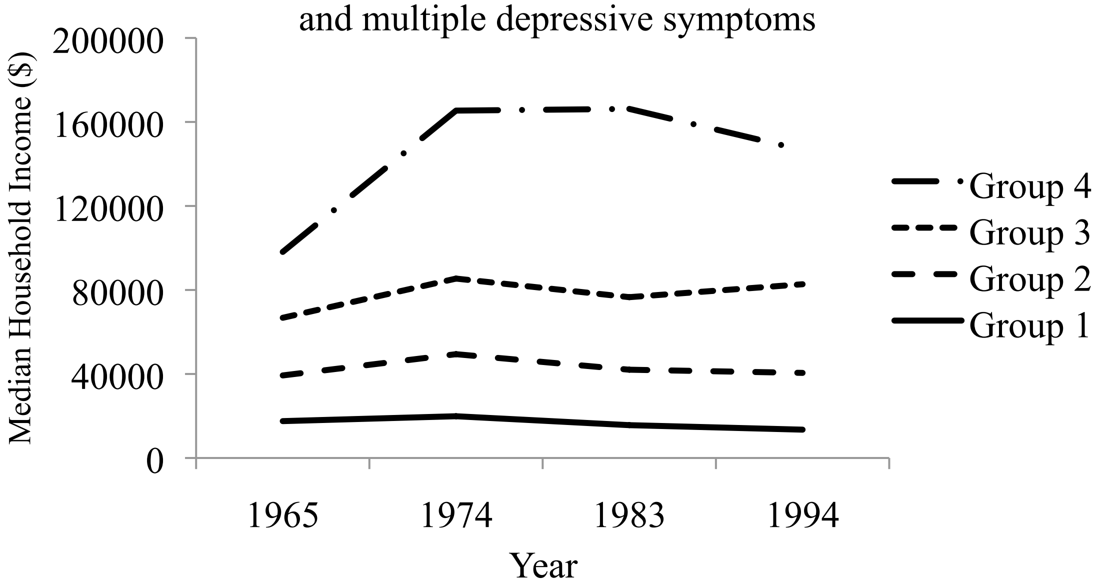


Figure 3.2: Median annual household income by 1965-1994 average household income quartile for 2102 adults from the Alameda County Study in the study of HI and multiple depressive symptoms



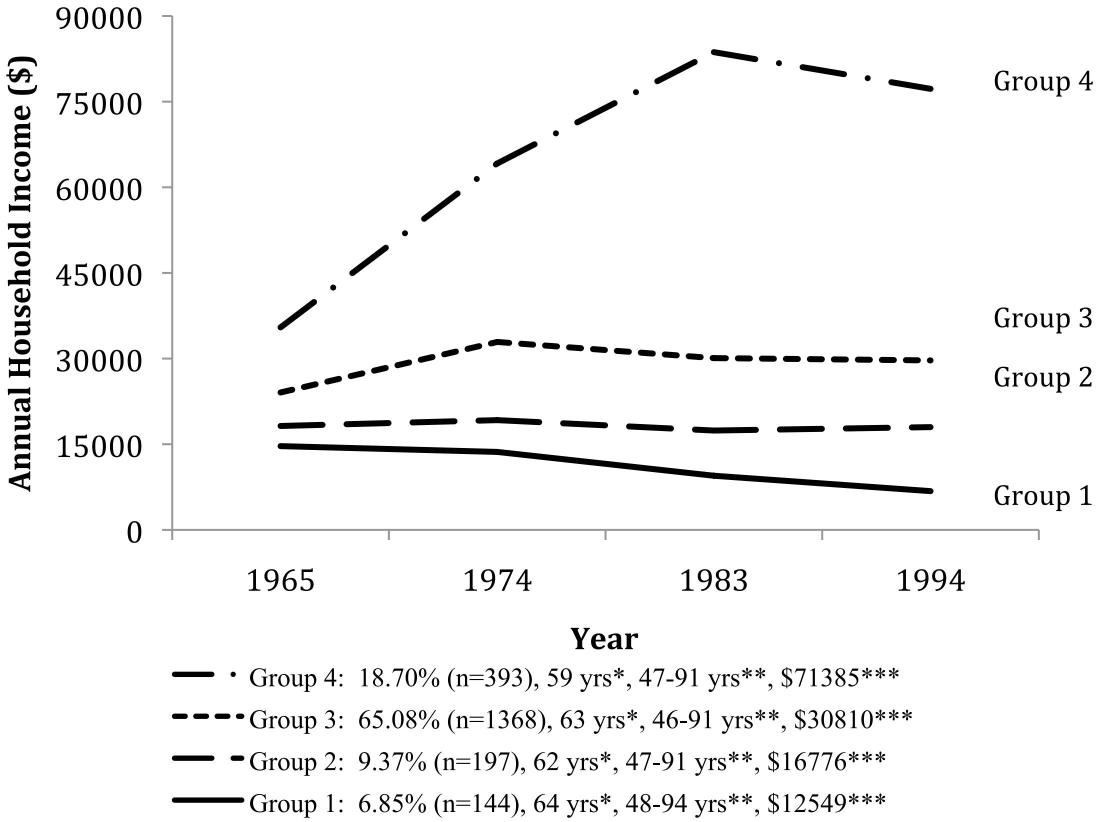


Figure 3.3: Household income trajectory groups for 2102 adults from the Alameda County Study in the study of HI and multiple depressive symptoms

*Median age; **Age range; ***Median Average HI 1965-1994

Figure 3.4: Median annual household income by household income trajectory group for 2102 adults from the Alameda County Study in the study of HI and multiple depressive symptoms

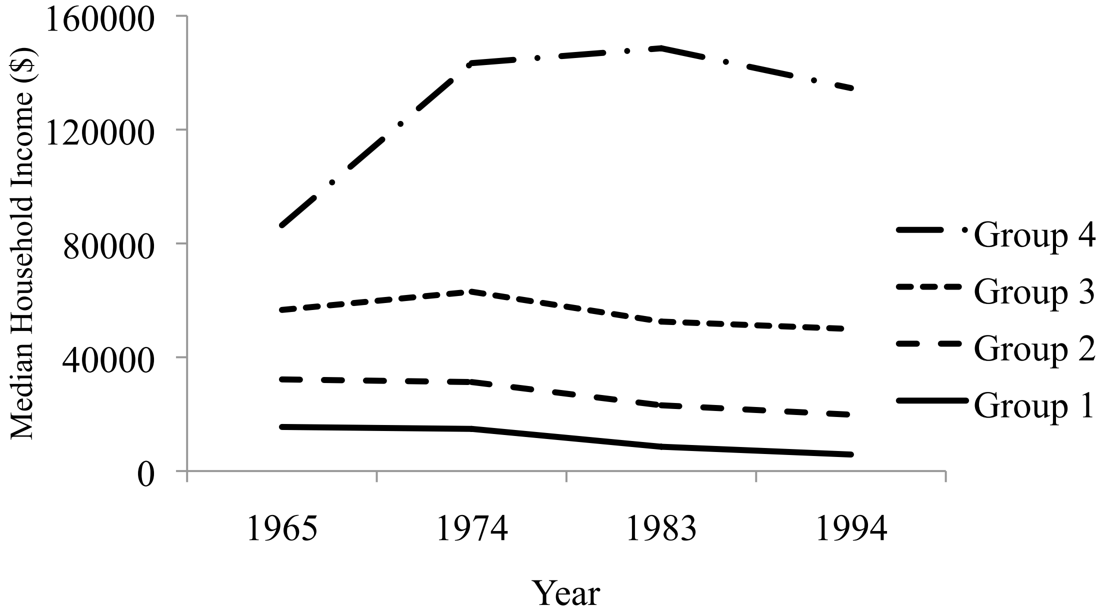


Table 3.1: Descriptive statistics by gender in study of HI-multiple depressive symptoms (DS) in 1999

	Men (n=908)		Women (n=1194)		
	N or Mean	% or SD	N or Mean	% or SD	P-value
5 or more DS in 1999	72	7.93	133	11.14	0.01
% Married	761	83.81	775	64.91	<0.01
Race/ethnicity					
White	827	91.08	1047	87.69	0.04
Black	46	5.07	91	7.62	
Other	35	3.85	56	4.69	
Years of Education					
0-11 Years	109	12	159	13.32	<0.01
12 Years	203	22.36	353	29.56	
13+ Years	596	65.64	682	57.12	
Age in 1994 (Years)	63.35	9.28	62.67	9.83	0.11
Average Household Size	3.13	0.9	3.09	0.97	0.29
% with ADL problems	67	7.38	97	8.12	0.52
Social Isolation in 1994					
0 (Low)	221	24.34	367	30.74	<0.01
1	294	32.38	362	30.32	
2 (High)	393	43.28	464	38.86	
Social Support in 1994					
0 (Low)	168	7.99	281	13.37	<0.01
1	316	15.03	434	20.65	
2 (High)	422	20.08	477	22.69	
History of depressive symptoms 1965-1994	193	21.26	319	26.72	<0.01
Non-cases with a history of multiple DS	155	18.54	234	22.05	
Cases with a history of multiple DS	38	52.78	85	63.91	

SD=Standard deviation; ADL=Activities of daily living

Table 3.2: Descriptive statistics for income measures by gender in the study of HI-multiple depressive symptoms in 1999

		Men (n=908)		Women (n=1194)		
		N or Mean	% or SD	N or Mean	% or SD	P-value
HI in 1994 ($)		47155	43324	39259	38343	<0.01
Average Household Income ($)		41423	24697	36019	22177	<0.01
1994 HI Quartiles	1	227	25.00	299	25.04	1.00
	2	227	25.00	298	24.96	
	3	227	25.00	298	24.96	
	4	227	25.00	299	25.04	
AHI Quartiles	1	227	25.00	299	25.04	1.00
	2	227	25.00	298	24.96	
	3	227	25.00	298	24.96	
	4	227	25.00	299	25.04	
Combined HI Trajectory Groups	1	42	4.63	102	8.54	<0.01
	2	60	6.61	137	11.47	
	3	596	65.64	772	64.66	
	4	210	23.13	183	15.33	
Original HI Trajectory Groups	1	3	0.33	10	0.84	<0.01
	2	39	4.30	92	7.71	
	3	60	6.61	137	11.47	
	4	596	65.64	772	64.66	
	5	176	19.38	149	12.48	
	6	34	3.74	34	2.85	

SD=Standard deviation; HI=Household income; AHI=Average household income

Table 3.3: Bivariate logistic model results by gender in the study of HI and multiple depressive symptoms (DS) among 2102 adults in the Alameda County Study

	Men				Women			
	HR	95% LCL	95% UCL	AIC	HR	95% LCL	95% UCL	AIC
HI in 1994	0.35	0.17	0.71	480.07	1.01	0.86	1.18	838.40
HI in 1994 Quartile 1	5.35	2.31	12.37	485.20	1.71	1.07	2.74	827.78
HI in 1994 Quartile 2	3.37	1.41	8.06		0.82	0.48	1.40	
HI in 1994 Quartile 3	1.45	0.54	3.87		0.70	0.40	1.22	
HI in 1994 Quartile 4	ref				ref			
AHI	0.54	0.33	0.88	494.08	0.91	0.74	1.12	837.17
AHI Quartile 1	3.27	1.50	7.12	496.50	1.57	0.94	2.61	837.17
AHI Quartile 2	2.87	1.30	6.31		1.28	0.75	2.16	
AHI Quartile 3	1.35	0.56	3.27		1.14	0.67	1.96	
AHI Quartile 4	ref				ref			
HITG 1	10.63	3.61	31.27	490.53	2.18	1.10	4.31	835.41
HITG 2	4.49	1.45	13.93		1.08	0.53	2.21	
HITG 3	3.05	1.28	7.22		1.03	0.61	1.73	
HITG 4	ref				ref			

CVD=Cardiovascular disease; HR=Hazards Ratio; LCL= Lower confidence limit; UCL=Upper confidence limit; HI=Household income; AHI=Average household income; HITG=Household income trajectory group.

Table 3.4: Multivariable logistic model results by gender in the study of HI and multiple depressive symptoms (DS) among 2102 adults from the Alameda County Study

	Men				Women			
	OR	95% LCL	95% UCL	QICu	OR	95% LCL	95% UCL	QICu
HI in 1994	0.42	0.21	0.85	483.65	1.04	0.88	1.21	841.18
HI in 1994 Quartile 1	4.18	1.74	10.04	488.80	1.64	0.97	2.79	832.15
HI in 1994 Quartile 2	2.98	1.24	7.21		0.77	0.44	1.35	
HI in 1994 Quartile 3	1.40	0.52	3.77		0.69	0.39	1.22	
HI in 1994 Quartile 4	ref				ref			
AHI	0.59	0.38	0.94	491.48	0.91	0.74	1.13	840.32
AHI Quartile 1	2.73	1.24	6.00	494.30	1.56	0.91	2.66	842.42
AHI Quartile 2	2.75	1.25	6.04		1.28	0.76	2.17	
AHI Quartile 3	1.38	0.57	3.36		1.17	0.68	2.01	
AHI Quartile 4	ref				ref			
HITG 1	8.02	2.50	25.76	490.27	2.22	1.07	4.61	838.95
HITG 2	3.66	1.19	11.23		1.09	0.52	2.30	
HITG 3	2.79	1.17	6.65		1.02	0.60	1.74	
HITG 4	ref				ref			

OR=Odds Ratio; LCL= Lower confidence limit; UCL=Upper confidence limit; HI=Household income; AHI=Average household income; HITG=Household income trajectory group. Each model included age, race/ethnicity, and marital status.

Table 3.5: Multivariable logistic model results including a history of multiple depressive symptoms (DS) by gender in the study of HI and multiple DS among 2102 adults from the Alameda County Study

	Men				Women			
	OR	95% LCL	95% UCL	QICu	OR	95% LCL	95% UCL	QICu
HI in 1994	0.43	0.20	0.94	441.96	1.09	0.93	1.27	748.99
HI in 1994 Quartile 1	3.92	1.52	10.14	445.31	1.23	0.72	2.12	746.80
HI in 1994 Quartile 2	2.98	1.14	7.76		0.66	0.37	1.18	
HI in 1994 Quartile 3	1.30	0.46	3.67		0.65	0.36	1.18	
HI in 1994 Quartile 4	ref				ref			
AHI	0.65	0.42	1.03	449.82	0.99	0.82	1.20	750.23
AHI Quartile 1	2.25	1.00	5.10	451.43	1.12	0.63	1.97	753.98
AHI Quartile 2	2.53	1.13	5.65		1.10	0.64	1.92	
AHI Quartile 3	1.18	0.46	3.01		1.07	0.60	1.88	
AHI Quartile 4	ref				ref			
HITG 1	7.32	2.01	26.62	447.32	1.27	0.59	2.74	752.42
HITG 2	3.76	1.15	12.27		0.74	0.34	1.65	
HITG 3	2.61	1.07	6.38		0.84	0.48	1.47	
HITG 4	ref				ref			

OR=Odds Ratio; LCL= Lower confidence limit; UCL=Upper confidence limit; HI=Household income; AHI=Average household income; HITG=Household income trajectory group. Each model included age, race/ethnicity, marital status, and history of depressive symptoms.

Chapter 4

Gender-specific associations between cumulative socioeconomic disadvantage and cardiovascular disease mortality in the Alameda County Study 1965-2000

Introduction

Socioeconomic position (SEP) has been thoroughly documented as an influential factor in the development of chronic health outcomes [21, 40, 47, 48, 101-103]. Furthermore, the interrelationships between SEP and health outcomes over the life course have been also been well documented, and involves several biologic as well as psychosocial components [34, 39, 62, 64, 103-105]. However, the associations between particular markers of SEP and chronic health outcomes have been varied in nature and magnitude, and investigation as to how these associations vary is warranted. Cardiovascular disease, the number one cause of death among men and women in the United States annually, is negatively affected by lower SEP.

Cardiovascular disease (CVD) is the number one cause of death among men and women in the United States each year [1]. A number of studies have documented inverse associations between socioeconomic position (SEP), commonly measured as education, income, or occupation, and risk of heart disease as well as heart disease mortality. The majority of the work in this area has grown to include SEP measured at single points in the adult life course and to capture measures of SEP throughout the life course, beginning as early as before birth. However, significantly fewer studies have reviewed the cumulative effects of SEP over the life course through socioeconomic accumulation measures, and how the inclusion of different SEP indicators in these measures affects the associations with health outcomes. Furthermore, differences in SEP by gender have long been elucidated, although gender differences in cumulative measures of socioeconomic disadvantage and their associations with CVDM have been less frequently studied, although of paramount importance.

In addition to the substantial influence of cardiovascular disease on mortality, the effects of mental illness such as depression have also taken a toll on the United States population, as the burden of depression has grown worldwide, with more women than men experiencing multiple depressive symptoms (MDS) and depression annually according to data from the NHANES and National Comorbidity Study [23, 92]. SEP over the life course has also been suggested as a contributing factor in the increased presence of MDS in the population, but the mechanisms through which this association may operate throughout the life course remain unclear. In the United States, the rates of depression have continued to increase, with more women than men displaying MDS annually. Several proponents have been suggested as factors contributing to the increased presence of depressive symptoms in the population, but the interactions of these factors remain unclear. Increased numbers of depressive symptoms have been more commonly seen among individuals of low SEP, and have differing rates among subgroups of the population, such as those defined by racial/ethnic categories or cultures. Some literature implicates psychosocial factors in the development of CVD, but the evidence suggesting placing these factors as mediators or on the pathway from between SEP to CVDM is limited [106-108].

Cumulative socioeconomic disadvantage (CSD), as compared to SEP, is a measure of the long-term socioeconomic disadvantage based on multiple indicators of an individual's available resources. The amount of disadvantage incurred during one's life course can often indicate information about their inability to gain resources, and also about the intergenerational beliefs practices to which an individual was exposed. The patterning of such disadvantage may vary by gender due to inequitable distribution of resources that has been inevitably present in American society. Most research studies of associations between life course SEP and CVD tend to avoid discussion of gender specific demographic differences, but among the one we found that did, results show that women have lesser amounts or worse childhood social conditions, income, as well as differences in educational attainment and occupational rank [64]. With the differences in each of these measures by gender, which cover the life course, it is highly likely that the accumulation of disadvantaged positions held by women throughout the life course may be more detrimental than fewer resources at single or few times over the life course, to a woman's health, and perhaps to a greater extent than for men.

The way in which SEP has been posited to affect CVDM lies primarily in the health behavior profiles of individuals with different SEP. Current literature suggests that persons with lower SEP are more likely to participate in unhealthy behaviors such as smoking and poor nutrition [58, 88, 109, 110]. In addition, they may have more problems gaining access to reasonable health care resources, and health behaviors through due to their costs [58, 88]. Other pathways have also been suggested, such as those through stress and genetic predisposition, although the extent to which the combination of these factors may affect an individual's risk of CVDM is unknown.

A vast amount of research has studied the life course influence of SEP on the development of several health outcomes. At least three theoretical frameworks to conceptualize ways in which socio-environmental conditions affect health throughout the life course, and include the critical period, social mobility, and accumulation models. The critical period model suggests specific points during the life course at which the conditions an individual experiences have a substantially more profound impact on the health outcome of interest than at other times in life. The social mobility model suggests that changes in social status and conditions may be influential on health outcomes such as CVD and CVDM [59, 60]. The accumulation m model suggests that the cumulative experiences throughout the life course can ultimately lead to the health outcomes experienced later in life [42, 61-64]. These models have been used as the theoretical basis for chronic health outcomes such as CVD or CVDM since research has shown that the development of CVD begins as early as childhood, and with exposure to poor social conditions, poor health behaviors, and perhaps genetically inherited risk factors as well, an individual can be at much higher risk of developing CVD and subsequent mortality.

The relevance of these models to the assessment of the effects of CSD on CVDM lies in that CSD can be measured with different constructs of SEP, such as income, education, and occupation. Education may be evaluated based on degree attainment or years of education [39, 74, 93]. Occupation has been categorized based on the need for manual or non-manual labor [59, 111]. Income can be measured in both continuous and categorical terms. As for any measure of SEP, the time at which it is measured may be differentially related to the health outcome of interest. The amalgamation of these constructs into a single unit to evaluate an individuals' cumulative disadvantage throughout the life course may provide insight as to the effects of extreme social conditions in relation to health outcomes. The presence of associations between such measures with health outcomes, including CVDM, would provide evidence in favor of an accumulation model of the effects of social conditions over the life course on health outcomes.

Much of the work conducted in this area has been focused on outcomes among men or men and women combined due to limited samples of women in analyses [13, 54, 57]. Gender differences in the return to health based on SEP have been demonstrated with measures such as education and income, and may reflect gender differentials in resource availability as well as in associations between SEP and health outcomes [50, 52]. Furthermore, evidence is mounting to suggest that the mechanisms through which life course SEP affects health outcomes may vary by gender [65]. Within gender, however, the interpretations of various forms of single SEP indicators, such as education or income, have alternative meanings that may reflect historical biases limiting resource attainment, commonly among women [56, 57, 66, 67].

Through the use of data collected in the Alameda County Study (ACS), this research examined gender-specific associations between six measures of CSD and CVDM. The CSD measures were based on combinations of adult household income information (captured through a current static household income measure, an average household income measure, and trajectory classes of household income throughout adulthood), educational attainment, and the father's education and occupation. The role of experiencing multiple depressive symptoms (MDS) was evaluated in the associations between each CSD measure and CVDM as well.

We hypothesized associations between each household income measure and CVDM to be present for both genders, but the magnitude of the associations would be greater for women, and would be greater when non-static household income was included in the CSD measure. In addition, we hypothesize that history of depressive symptoms would also partially mediate the relationships between SEP and CVD mortality.

Methods

Study population

Over a period of 34 years, the Alameda County Study (ACS) collected data pertaining to health and social conditions on men and women aged 20 and older (16 and older if married) in Alameda County, California, and provided linkage to death data as well. The wealth of data available pertaining to study participants' socioeconomic conditions, mental well-being, and physical health status made this data expedient for the research presented here. Information on health status and behavioral, social, psychological, socioeconomic, neighborhood, and socio-environmental risk factors was collected [76-78]. Alameda County had a population of approximately one million people in 1965 when the study was initiated, in which a two stage stratified systematic sample was used to gather data on 8023 non-institutionalized adults from 4452 household units [78]. Among the individuals sampled, questionnaires were received from 6928 (86%) of these persons, and comprised of 3158 (45.6%) men and 3770 (54.4%) women in 1965. Five waves of follow-up data collection occurred in 1974, 1983, 1994, 1995, and 1999. Participants from 1965 were re-contacted in 1974 with an 85.1% response rate among those located, and 50% of those not known to be dead were re-contacted in 1983 (n=1798, 87.3% response rate). All respondents from 1974 and 1983 were re-contacted in 1994 (n=2729, 93% response rate), of which 96% responded in 1999 (n=2123).

Cardiovascular disease mortality ascertainment

Cause-specific mortality data collected from the California Master Death Index, state death certificate data, as well as the National Death Index were used in these analyses. Death information of ACS participants was collected throughout the study at and between each wave of follow-up and through the year 2000. Deaths attributable to diseases of the circulatory system based on the International Classification of Disease 9 (ICD-9) codes 390-459 were included as CVD deaths, and specifically included acute rheumatic fever, chronic rheumatic heart disease, hypertensive disease, ischemic heart disease, all other forms of heart disease, pulmonary heart disease, diseases of the arteries, arterioles, and capillaries, veins, and lymphatics along with complications for purposes of this study.

Definition of SEP measures

At each wave of data collection, household income (HI), representing the gross income for all members of the immediate family who received income in the previous year, was reported in bracketed ranges. The ranges for 1965 were $1000 increments from $0-$9,999, and $10,000-14,999, $15,000-24,999, and >$25,000; income was categorized as <$2,000, in $1000 categories from $2000-$9,999, and then $10,000-$11,999, $12,000-$14,999, $15,000-$19,999, $20,000-$24,999, and > $25,000 in 1974 and 1983, although additional categories in $5000 increments were included from $25,000-$39,999, then $40,000-$49,999 and >$50,000. In 1994 and 1999, categories of $5000 increments from $0-$49,999 were used, then $50,000-$74,999, $75,000-$99,999, $100,000-$149,999 and >$150,000. The responses were combined with demographic data from monthly Current Population Surveys for the same reference periods to compute continuous income measures bounded by the bracketed income range to reported by the respondent. The Current Population Survey, conducted monthly by the Census Bureau for the Bureau of Labor Statistics, provides the best national data on income [80]. Imputation was done using IVEware- Imputation and Variance Estimation Software based on a multivariate sequential regression method [79].

Six cumulative disadvantage scores were created based on HI, the individuals' education, and either father's education or occupation, each score with a range of 0-3. Each subject was required to have at least three measures of household income, and all income measures were adjusted to the $1993 using the Consumer Price Index (CPI). In addition, HI 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 [81]. Three variants of HI SEP were used-one measure that captured income at a single time point-HI in 1994 (HI94), and two measures that captured long-term cumulative effects of HI SEP-household income trajectory groups (HITG) and average income (AHI). Trajectories were created then grouped based on the trajectory pattern of their income using PROC TRAJ [82] and is further discussed in the statistical analysis section below. HI in 1994 less than the median of $28352.71, AHI between 1965 and 1994 less than the median of $$30419.16, those in the lower HITGs, those with 0-13 years of education a s of 1994, those whose father's education was grammar school or no school, and those whose father's occupation was categorized as craft, operatives/apprentice craftsman, service worker, laborer, or other occupation all had values of 1, and 0 if greater than the given cut points (father completed some high school, was a high school graduate, or some college, and if the father's occupation was categorized as professional, technical, proprietor, manager, clerk, or sales.)

The primary goal of this analysis was to determine the existence and variation in associations of six cumulative disadvantage measures and 6-year CVDM risk within gender for adults in the Alameda County Study. The secondary goal was to evaluate the role of having a history of multiple depressive symptoms (MDS) in 1994 as a potential mechanism through which these CSD measures relate to CVDM. A history of MDS was assessed with a set of 12 items based on the diagnostic criteria for a major depressive disorder based on the DSM-IV, and referred to as the DSM-12D, adapted from the PRIME-MD mood disorders section. The items included feeling sad, blue, or depressed, loss of interest or pleasure in most things, feeling tired out or low on energy most of the time, loss of appetite or weight loss, overeating or weight gain, trouble falling asleep or staying asleep, sleeping too much, more trouble than usual concentrating on things, feeling down on yourself, no good, or worthless, being so fidgety or restless that you moved around a lot more than usual, moved or spoke so slowly that other people could have noticed, and thought about death more than usual, either your own, someone else's, or death in general. Individuals were classified as having a history MDS if they experienced five or more of the items above almost daily for the previous two weeks from the completion of the survey in 1994. 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. Although several other variables, such as risk factors for CVDM, are plausible mechanisms through which HI may be related to CVDM, the role of these factors were beyond the scope of this work and therefore not investigated in these analyses.

Statistical analysis

T-tests and chi-squared tests were used to compare descriptive statistics by gender. Gender stratified proportional hazards regression models were used to examine the associations of interest within gender. Three sets of models were run- the first were bivariate models for each HI SEP measures, confounder, and mediator; the second included the CSD measure and the confounders; and the third set of models included the CSD measure, confounders, and combinations of other variables of interest.

Proportional hazards model assumptions for each model were assessed by (1) examining parallelism of the survival curves for each categorical variable, and (2) with the inclusion of an interaction term with time for each variable included in the model, which was evaluated for the statistical significance of the term at α=0.05.

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).

Model of the Income Trajectories

Income trajectory patterns emerged from a group-based trajectory modeling approach using the PROC TRAJ procedure in the SAS System (Cary, NC). This approach assumes the population is composed of a mixture of J underlying trajectory groups such that

$$P(Y_i)= \Sigma_j \pi_i P_j(Y_i)$$

–$P_j(Y_i)$= probability of Y given membership in group j for person i

–π_i=proportion of population in group j, j=1, 2, … J

–$P(Y_i)$=unconditional probability of observing person i's sequence of household income measures

and $P_j(Y_i) = \Pi_t p_{jt}(y_{it})$, and y_{it} are random variables for each subject I at times t=1,2,…,T- the household incomes are independent after we know the trajectory group to which the individual belongs. The group membership probabilities π_j are not estimated directly but through a multinomial logit function

$$\pi_i= \exp(\theta_i) /\Sigma_i \exp (\theta_i),$$

where θ_1 is normalized to zero, and this ensures each of these probabilities lies between 0 and 1. The parametric model used in analyses is chosen to represent the form of $p_{jt}(y_{it})$, and is selected based on the type of data to which y_{it} (household income) belongs, here being treated as censored normal. The linkage between time and household income is established through a latent variable $y_{it}{*}^{j}$, which has been thought of as measuring the potential for having a certain household income, and is

$$y_{it}{*}^{j} = \beta_{0j} + \beta_{1j}\,Time_{it} + \beta_{2j} Time_{it}^{2} + \beta_{0j} Time_{it}^{3} + \varepsilon_{it}$$

where ε_{it} is a disturbance assumed to be normally distributed with a zero mean and constant standard deviation [83].

A log transformation was applied to household income to allow treatment as normal data. The procedure specifically allows for censored normal data, and to allow for the normal data described in this research, the range of the data was extended beyond that of the log-transformed HI values in this data. 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 data for the main exposure or the time-dependent covariates are not dropped from analyses and do not contribute to the bias of the sample under the assumption the data is missing completely at random.

The number of trajectory groups most appropriate for the data was evaluated 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) [82]. The final model was then based on the highest order polynomial for each trajectory group with a significant p-value. The group for which the person had the greatest posterior probability was the group assigned to the individual, and the resulting measure was included as a component of the CSD measures.

The statistical model used to assess the associations between each CSD measure and CVDM is a proportional hazards model of the form

$$h(t|X) = h_0(t)*\exp[\beta_1 CSD_1 + \beta_1 CSD_2 + \beta_2 CSD_3 + \beta_3(\text{Age}) + \beta_4(\text{Race/ethnicity}) + \beta_5(\text{Marital Status}) + \beta_6(\text{Education}) + \beta_7(\text{History of DS})]] + \varepsilon_i$$

where: $h(t|X)$ is the hazard at time t given the covariates X are held constant;

$h(t)$ represents the baseline hazard that is assumed non-parametric;

CSD_1, CSD_2, CSD_3 = Indicator variable for CSD scores 1-3;

β_1, β_2, and β_3 = log hazards ratio associated with having a CSD score of 1-3 compared to having a CSD score of 0 (least disadvantaged).

Results

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, father's education, and father's occupation, and were therefore included in these analyses. As a result, 199 people (7.3%) were excluded from these analyses, and they were primarily female, white, married, and had 12 years of education or less.

Descriptive statistics for the sample are presented in Table 4.1. 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. 82% of the men and 61% of the women were married. Within this sample, 90% of the men and 88% of the men were white, and 6% of the men and 8% of the women were black. A total of 63% of the men and 55% of the women had at least 13 years of education or more, and 23% of men and 29% of women had 12 years of education. The average age for men and women was 65 years and 64 years respectively, and the average observation time, with a maximum time of 2492 days (6.82 years), was 2217 days (6.08 years) for men and 2251 days (6.16 years) for women. The average household size for men over the period 1965-1994 was 3.1 and 3.0 for 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). A greater proportion of the 1103 men (7.7%, n=85) compared to women (10.4%, n=149) experienced five or more depressive symptoms in 1994 (p=0.02).

Wilcoxon tests for the overall sample suggested differences in the survival curves for marital status (p<0.01), education level (p<0.01), employment status (p=0.03), experiencing MDS in 1994 (p<0.01), and each of the disadvantage measures (p<0.01), but not for race/ethnicity (p=0.27) or gender (p=0.86). Within genders, there were no differences by race/ethnicity for men (p=0.56) or women (p=0.22), but there were differences by education category (p<0.01) and whether the occupation was manual or non-manual (p<0.01) for both men and women. There were no differences by employment status (p=0.44) or history of depressive symptoms in 1994 for men (p=0.13) although there were for women (p<0.01).

Information pertaining to the income and CSD measures used in this analysis is shown in Table 4.2. Six trajectories emerged from the analyses for household income from 1965-1994 for the entire sample and are shown in Figure 4.1. Membership percentages of the groups were 1.34%, 1.9%, 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. There were 56.7% of the men with a father's education score of 0 and 59.71% for women. A total of 49.3% of men and 47.9% of women had father's occupation scores of 0. Chi-square tests indicated no differences for these two items by gender (p=0.47 and p=0.12 for father's occupation and education, respectively). The measure including HI in 1994 + education + father's education (measure 1), the majority of the men (29.9%) had a score of 0, while the majority of women had a score of 2 (27.9%). The measure with HI in 1994 + education + father's occupation (measure 2) had 28.5% of the men with a score of 1, and 30.8% of the women with a score of 2 as the maximum proportions. For the AHI + education + father's education measure (measure 3), the majority of the men (29.5%) and women (27.82%) had a score of 1. For the AHI + education + father's occupation measure (measure 4), the majority of the men (28.74%) had a score of 1, and the majority of women (30.62%) had a score of 2. The measure including 1994 household income + education + father's education, the majority of the men (29.92%) had a score of 0, while the majority of women had a score of 2 (27.89%). The measure with 1994 household income + education + father's occupation had 28.47% of the men with a score of 1, and 30.76% of the women with a score of 2 as the maximum proportions. The measure with HI trajectory category + education +father's education (measure 5) had the greatest proportion of men with a score of 0 (38.11%) and the greatest proportion of women with a score of 1 (32.766%). For the final measure that included HITG + education + father's occupation (measure

6), the majority of men had a score of 1 (35.54%) as did women (32.10%). Chi-square tests suggested revealed gender differences in the proportions for each score by gender ($p<0.01$) and t-tests showed gender differences for mean HI in 1994 and mean AHI as well. In addition, mean household income in 1994 and average household income from 1965-1994 were both different by gender as well ($p<0.01$). Wilcoxon tests revealed no differences in survival among the CSD measures for men on measures 1 ($p=0.06$), measure 2 ($p=0.32$), or measure 6 ($p=0.31$), but differences existed for measure 3 ($p<0.01$), measure 4 ($p=0.01$), and measure 5 ($p<0.01$). All 6 CSD measures showed differences in the survival curves by category level for women ($p<0.01$).

Results of the proportional hazards model are presented in Tables 4.3-4.5. Three sets of models were run: (1) including the CSD measure only; (2) including the CSD measure along with age, race/ethnicity, and marital status; and (3) including the CSD measure, the confounders, and the experience of a history of depressive symptoms at the last wave of data collection in 1994. For each proportional hazards model, the most advantaged group for each measure was the referent category.

Among men, the bivariate model results (Table 4.3) suggested positive associations among men between CSD measure 1 (HR_3=2.62, 95%CI=1.18-5.56, HR_2=2.20, 95%CI=1.02-4.74), CSD measure 3 (HR_3=3.00, 95%CI=1.37-6.56, HR_2=2.81, 95%CI=1.33-5.93), CSD measure 4 (HR_2=2.69, 95%CI=1.29-5.59), and CSD measure 5 (HR_3=4.35, 95%CI=1.78-10.62, HR_2=2.23, 95%CI=1.15-4.34) with CVDM risk, such that those with greater disadvantage had greater risk of CVDM. Models including age, race/ethnicity, and marital status (Table 4.4) or with a history of depressive symptoms (Table 4.5) showed no significant associations between the CSD measures and CVD mortality.

Among women, similar associations were present: CSD measure 1 (HR_3=7.31, 95%CI=3.08-17.35, HR_2=3.74, 95%CI=1.53-9.12), CSD measure 2 (HR_3=5.07, 95%CI=1.97-13.05, HR_2=4.10, 95%CI=1.60-10.55), CSD measure 3 (HR_3=5.98, 95%CI=2.66-13.45, HR_2=2.94, 95%CI=1.27-6.84), CSD measure 4 (HR_3=4.06, 95%CI=1.69-9.76, HR_2=3.33, 95%CI=1.39-8.00), CSD measure 5 (HR_3=10.88, 95%CI=5.05-23.42, HR_2=3.69, 95%CI=1.73-7.89), and CSD measure 6 (HR_3=8.77, 95%CI=3.75-20.54, HR_2=2.92, 95%CI=1.26-6.78, HR_1=3.21, 95%CI=1.40-7.38) when compared to the most advantaged.

When the models for women were adjusted for age, race/ethnicity and marital status, the associations above among the most disadvantaged were reduced when compared to the most advantaged: for the HI in 1994 + education + father's education: (HR_1=2.88, 95%CI=1.28-6.49); for the HI in 1994 + education + father's occupation HR=3.20, 95%CI=1.35-7.61); for the AHI + education + father's education HR=2.85, 95%CI=1.20-6.75; for AHI + education + father's occupation HR=3.23, 95%CI=1.27-8.22; for HITG + education + father's education HR_1=4.05, 95%CI=1.84-8.91, HR_2=2.34, 95%CI=1.08-5.07; and for HITG + education + father's occupation HR_1=6.52, 95%CI=2.78-15.26; HR_3=2.96, 95%CI=1.30-6.73.

Models further adjusted for a history of depressive symptoms among women (Table 4.5) continued to show inverse relationships between the highest CSD and risk of CVD mortality: for the HI in 1994 + education + father's education HR_3=2.58, 95%CI=1.08-6.16; for the HI in 1994 + education + father's occupation HR_3=2.90, 95%CI=1.13-7.45; for the AHI + education + father's education HR_3=2.66, 95%CI=1.18-6.03; for the AHI + education + father's occupation HR_3=2.85, 95%CI=1.19-6.83; for the HITG + education + father's education HR_3=3.68, 95%CI=1.65-8.17, HR_2=2.26, 95%CI=1.04-4.92; and for the HITG + education + father's occupation HR_3=5.40, 95%CI=2.23-13.09, HR_1=3.00, 95%CI=1.32-6.84.

Tests for the validity of the proportional hazards assumption were conducted for each household income measure when adjusted for confounders by including time-dependent covariates that were interactions between time and the confounders. For each model that included the income measures individually along with the time-dependent covariates described above, the proportionality tests revealed no violations of the proportionality of the hazards for any CSD measure for men or women (Table 4.6).

Discussion

Inverse associations between socioeconomic disadvantage over the life course and cardiovascular disease mortality exist for women but not men. Among women, inverse associations with the adjustment for confounders, mediators of this association in addition to the presence of age, race/ethnicity, marital status, manual occupation, history of depressive symptoms, and risk factors for CVDM, and demonstrated higher hazards of CVDM with increased cumulative social disadvantage. CSD measures with HI captured through trajectories were most strongly associated with CVDM. Among the other measures, those including father's occupation tended to be more strongly associated with CVDM than those with father's education. When history of depression in 1994 was included in the models, associations were minimally affected in confounder-adjusted models, but with inclusion of CVDM risk factors, a protective effect of decreased disadvantage remained among three of the CSD measures.

In the examination of the magnitudes of the associations under study, there appeared to be minimal variability in these values between the multiple CSD measures among women, which suggests that the measures are capturing similar facets of disadvantage when the life course perspective of social disadvantage was considered. Slightly stronger associations among measures that included father's education were present for women, although the type of household income measure was not related to the magnitude of the association.

The lack of association among men may indicate alternative measures of socioeconomic disadvantage of importance that were excluded in these analyses, such as that pertaining wealth. Wealth, through its many forms, may provide financial means for men otherwise at great disadvantage. Research has demonstrated associations between wealth and mortality, and it may be strongly related to CVDM as well [112, 113].

The results from these analyses were consistent with that presented in the literature, showing inverse associations between SEP disadvantage over the life course and coronary heart disease and heart attack risk [55, 61, 64, 68, 69, 104, 114-117]. It has become more evident in the literature that multiple life course models may be 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 [61, 64, 104]. 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 CSD 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 CVDM.

Limitations to the results presented in this analysis include that a cascade of ages were present among the individuals surveyed in 1994, suggesting a series of age cohorts in the data that may have exhibit different associations between CSD and CVDM. An additional problem is the limited number of CVDM cases in the data, which could underestimate the true association between CSD and CVDM, and can be resolved in future analyses with increased sample sizes or additional follow-up of subjects. One particularly useful way to handle the patterning of socioeconomic measures and CVDM by age would have been to stratify the sample into age groups and repeat these analyses, although this was not feasible due to the limited frequency of outcomes.

Related to the issue above is the problem with the presence of age cohorts and potentially a healthy survivor effect. These issues were not only evident in the household income trajectory groups of which younger people tended to have higher household income, but also with the CVDM deaths, there were 59 total cases of CVDM among men and 80 among women, which were primarily among older individuals (the average age among those who died from CVDM was 76 years, while the average age of those who were did not die from CVDM was 64 years). As a result, we studied the differences between the analytic sample and the other members of the original Alameda County Study cohort. Compared with those who died prior to 1994 (Table 4.7), among the 2486 people who died prior to 1994, 1226 were men and 1260 were women, of whom 553 men and 587 women died from CVDM, which suggests 45% and 46% of men and women who died before 1994 died from CVDM. Among men who died from CVD, the average age in 1965 was 58 years, while the average age of women who died from CVD was 64 years, indicating that men who died from CVD died at younger ages compared to women. There were more older women than men who were alive to be in these analyses, and suggests that the men who survived to 1994 could be healthy survivors that are more resistant to the effects of increased CSD compared to women.

A comparison of the adults in this sample to those who died in or after 1994 (n=335) showed there were a greater proportion of females, whites, and married persons in the analytic sample, but a greater proportion of deaths from CVD occurred in or after 1994. The bias resulting from this issue arises from the inclusion of healthier people who are of older ages, and underestimates the association between CSD and CVDM. Additional comparison showed there was no difference in the gender ratio, but there were fewer whites, a more equal distribution of education among respondents, and a lower proportion of married individuals among the ineligible respondents who were alive in 2000. Each of these comparisons indicated that the analytic sample was different front those who were not in the sample but followed in the original cohort.

Additional analyses were done to determine if CSD 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 CVDM. Bivariate models (Table 4.8) showed that among men, being disadvantaged was associated with increased hazards of CVDM with measures based on HI in 1965, HI in 1974, average household income from 1965-1974, HI in 1983, and average household income from 1965-1983. Among women, bivariate associations were present between measures that included HI in 1965, HI in 1974, AHI from 1965-1974, and HI in 1983 (with father's education) with CVDM. With adjustment for age, race/ethnicity, and marital status, associations among men were present between the HI in 1974 + education + father's occupation and AHI from 1965-1974 + education + father's occupation with CVDM. Among women, no associations between any of the measures of HI were associated with CVDM. Multivariable models that included age, race/ethnicity, and marital status were also run (Table 4.9), and showed no associations among women, but showed disadvantage based on 1974 + education + father's occupation and AHI 1965-1973 + education + father's occupation to be associated with increased odds of CVDM among men.

The presence of associations among men between CSD measures that capture HI from earlier years in relation to 6-year CVDM provide evidence of selection bias in the analytic sample. The lack of associations among earlier samples among women, however, may indicate the need to incorporate measures of HI that capture longer periods of time. Data from longer periods of time reflect information both from periods of lesser and greater employment rates among women in this analysis. The likelihood of women working and therefore contributing to the household income has increased substantially from 1965 to 1994 [67]. With greater variation in the available resources of women at later points in the study period, the associations of CSD measures with CVDM become more plausible, and are evident in these analyses.

One of the final limitations of this analysis is that while additional the confounder adjusted model seems to have reasonably accounted for age, race/ethnicity, and marital status, the adjustments of education and occupation may not have been adequate due to the substantial variation in the meanings of these variables across the age ranges included in this analysis. The lack of age-specific adjustment for these confounders/mediators could have resulted in an overestimation of the effects of CSD on CVDM. Another limitation of the data is that all data were self-reported with the exception of the mortality data, which may have resulted in overstatements in the measures of SEP and overestimates of the effects of the CSD measures. For each measure in these analyses, 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 [118]. A final 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 attributed to other causes [89]. This overestimate could potentially lead to mis-estimation of the associations between CSD and CVDM.

There were also multiple strengths in these analyses that addressed some of the gaps in the current literature about cumulative socioeconomic disadvantage within genders. The measures used in this analysis incorporated information from multiple points in the life course, and in four of the six measures, were based in part of household income measures that were in themselves cumulative in nature. The comparability of associations between the static measure based on household income in 1994 with the average household income and household income trajectory class measures indicates that when one particular facet of SEP is utilized in the creation of disadvantage measures there may be little to gain by differentiating between the way that SEP factor is measured, especially in association with CVDM. Another strength in these analyses was 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 CVDM.

In summary, gender differences in associations between cumulative socioeconomic disadvantage and CVDM exist, but the reasons for these differences are unclear. With household income included in the disadvantage measures, there is a strong association between the measure and CVDM among women, which appeared to be of greatest magnitude when constructed using patterns of HI captured with HITG. Having a history of depressive symptoms partially mediated the associations between CSD and CVDM, providing evidence of the interrelationships between long-term chronic mental and physical health outcomes. 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, inflicting long-term change to SEP can have substantial benefits that may far outweigh those delivered through change of SEP at single time points. Future research must determine whether other indicators of SEP such as wealth would be more strongly associated with CVDM than income. In addition, researchers must carefully determine the way in which the SEP indicator will be measured, as the associations between the measure and CVDM can vary significantly and can also fluctuate in the presence of mediators such as a history of depressive symptoms. With continued efforts to positively inflict social change as public health professionals, the burden resulting from the presence of CSD can be reduced and ultimately bring about a reduction in the occurrence of CVDM.

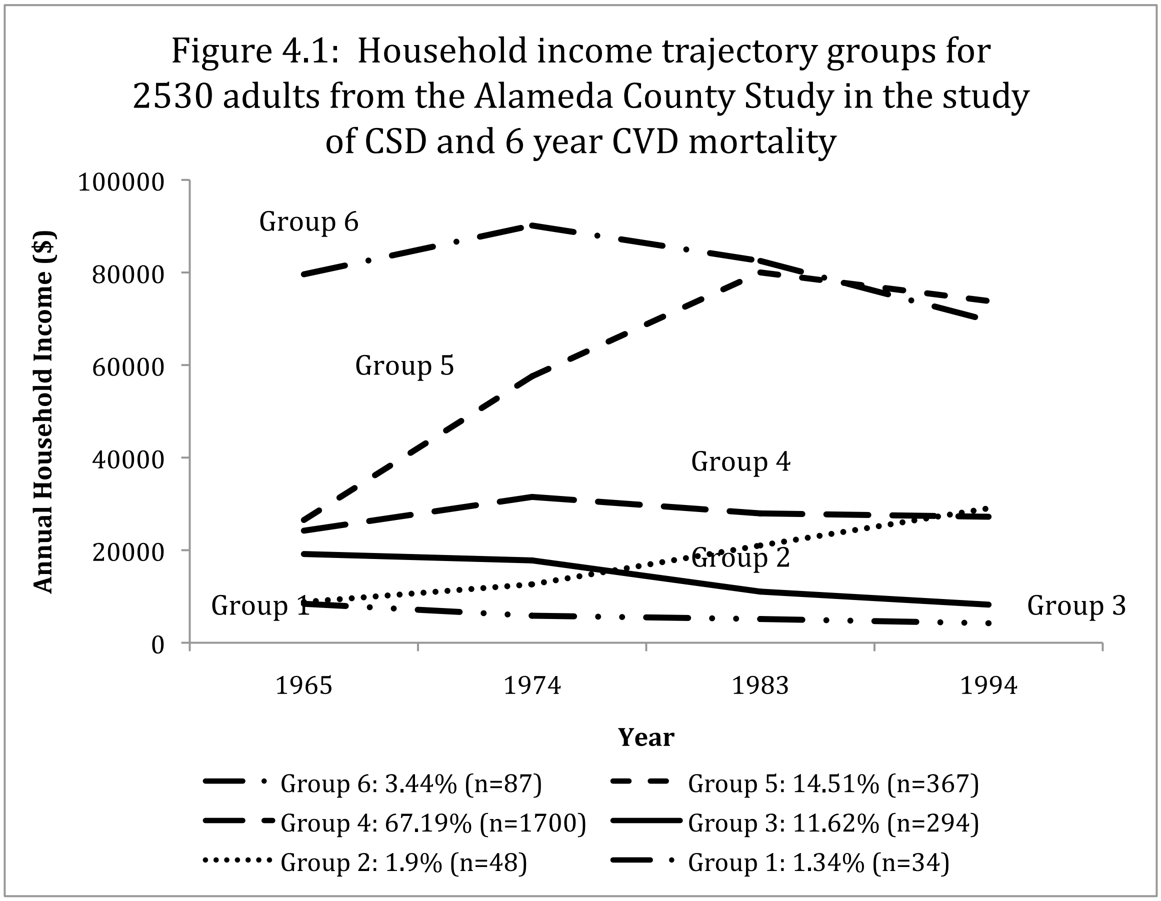


Figure 4.1: Household income trajectory groups for 2530 adults from the Alameda County Study in the study of CSD and 6 year CVD mortality
100000
80000
60000
40000
20000
0
Annual Household Income ($)
Group 6
Group 5
Group 4
Group 2
Group 1
Group 3
1965
1974
1983
1994
Year
Group 6: 3.44% (n=87)
Group 5: 14.51% (n=367)
Group 4: 67.19% (n=1700)
Group 3: 11.62% (n=294)
Group 2: 1.9% (n=48)
Group 1: 1.34% (n=34)

Table 4.1: Sample characteristics by gender for 2530 adults in the Alameda County Study in the study of cumulative socioeconomic disadvantage (CSD) and 6-year CVD mortality

	Men (n=1103)		Women (n=1427)		
	N or Mean	% or SD	N or Mean	% or SD	p-value
CVD Deaths	59	5.35	80	5.61	0.79
Married	908	82.32	867	60.76	<0.01
Race/ethnicity					
White	988	89.57	1254	87.88	0.23
Black	67	6.07	112	7.85	
Other	48	4.35	61	4.27	
History of DS in 1994	85	7.71	149	10.44	0.02
Smoking Status					
Never	419	37.99	705	49.4	<0.01
Former	550	49.86	498	34.9	
Current	132	11.97	222	15.56	
Heart Troubles	236	21.4	210	14.72	<0.01
High Blood Pressure	410	37.17	523	36.65	0.84
Diabetes	93	8.43	114	7.99	0.71
Years of Education					
0-11 Years	157	14.23	234	16.4	<0.01
12 Years	250	22.67	412	28.87	
13+ Years	696	63.1	781	54.73	
Occupation					
Non-manual	586	53.13	455	31.89	<0.01
Manual	357	32.37	95	6.66	
Home maker	160	14.51	877	61.46	
HI 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	
Age in 1994 (years)	64.74	9.98	64.48	10.99	0.54
Observation Time (Days)	2216.84	471.78	2251.25	427.41	0.06

CVD=Cardiovascular disease; SD=Standard deviation; DS=depressive symptoms

Table 4.2: Descriptive statistics for the cumulative socioeconomic disadvantage (CSD) measures and components by gender in the study of CSD and 6 ear CVD mortality among 2530 adults from the Alameda County Study

		Men		Women		
		N or Mean	% or SD	N or Mean	% or SD	p-value
HI in 1994 + Education + Father's Education	0	330	29.92	323	22.63	<0.01
	1	310	28.11	382	26.77	
	2	267	24.21	398	27.89	
	3	196	17.77	324	22.70	
HI in 1994 + Education + Father's Occupation	0	291	26.38	263	18.43	<0.01
	1	314	28.47	367	25.72	
	2	295	26.75	439	30.76	
	3	203	18.40	358	25.09	
AHI + Education + Father's Education	0	316	28.65	313	21.93	<0.01
	1	326	29.56	397	27.82	
	2	274	24.84	401	28.10	
	3	187	16.95	316	22.14	
AHI + Education + Father's Occupation	0	284	25.75	266	18.64	<0.01
	1	317	28.74	365	25.58	
	2	307	27.83	437	30.62	
	3	195	17.68	359	25.16	
HITG + Education + Father's Education	0	420	38.08	444	31.11	<0.01
	1	360	32.64	466	32.66	
	2	269	24.39	385	26.98	
	3	54	4.90	132	9.25	
HITG + Education + Father's Occupation	0	361	32.73	370	25.93	<0.01
	1	392	35.54	458	32.10	
	2	301	27.29	454	31.81	
	3	49	4.44	145	10.16	
HI in 1994		44425.63	41840.90	36377.24	36514.90	<0.01
AHI		40361.80	24317.73	34600.18	21595.79	<0.01
Low Father's Education		478	43.34	575	40.29	0.12
Low Father's Occupation		559	50.68	744	52.14	0.47
Low HITG Category		113	10.24	263	18.43	<0.01
Low AHI Category		488	44.24	778	54.52	<0.01
Low HI in 1994 Category		485	43.97	781	54.73	<0.01
Low Education		469	42.52	794	55.64	<0.01

Table 4.3: Bivariate proportional hazards model results by gender in the study of cumulative socioeconomic disadvantage (CSD) and 6-year CVD mortality among 2530 adults from the Alameda County Study

		Men				Women			
		HR	95% LCL	95% UCL	AIC	HR	95% LCL	95% UCL	AIC
HI in 1994 + Education +Father's Education	3	2.62	1.18	5.86	807.40	7.31	3.08	17.35	1109.39
	2	2.20	1.02	4.73		3.74	1.53	9.12	
	1	1.69	0.78	3.69		1.30	0.46	3.67	
	0	ref				ref			
HI in 1994 + Education + Father's Occupation	3	1.54	0.64	3.70	810.66	5.07	1.97	13.05	1128.56
	2	1.96	0.92	4.19		4.10	1.60	10.55	
	1	1.73	0.80	3.70		1.62	0.56	4.68	
	0	ref				ref			
AHI + Education + Father's Education	3	3.00	1.37	6.56	813.31	5.98	2.66	13.45	1114.29
	2	2.81	1.33	5.93		2.94	1.27	6.84	
	1	1.32	0.57	3.05		1.15	0.44	3.01	
	0	ref				ref			
AHI + Education + Father's Occupation	3	1.68	0.71	3.93	816.54	4.06	1.69	9.76	1133.53
	2	2.69	1.29	5.59		3.33	1.39	8.00	
	1	1.22	0.54	2.78		1.48	0.55	3.96	
	0	ref				ref			
HITG + Education + Father's Education	3	4.35	1.78	10.62	808.55	10.88	5.05	23.42	1104.85
	2	2.23	1.15	4.34		3.69	1.73	7.89	
	1	1.35	0.67	2.70		2.08	0.94	4.61	
	0	ref				ref			
HITG + Education + Father's Occupation	3	2.19	0.73	6.60	816.68	8.77	3.75	20.54	1122.04
	2	1.69	0.86	3.29		2.92	1.26	6.78	
	1	1.24	0.64	2.42		3.21	1.40	7.38	
	0	ref				ref			

CVD=Cardiovascular disease; HR= Hazards Ratio; LCL= Lower confidence limit; UCL=Upper confidence limit; HI=Household income; AHI=Average household income; HITG=Household income trajectory group. Each model also included age, race/ethnicity, and marital status.

Table 4.4: Multivariable proportional hazards model results by gender in the study of cumulative socioeconomic disadvantage (CSD) and 6-year CVD mortality among 2530 adults from the Alameda County Study

		Men				Women			
		HR	95% LCL	95% UCL	AIC	HR	95% LCL	95% UCL	AIC
HI in 1994 + Education + Father's Education	3	1.30	0.55	3.08	774.81	2.88	1.28	6.49	1015.44
	2	1.41	0.64	3.11		1.83	0.78	4.31	
	1	1.38	0.64	2.98		1.10	0.42	2.89	
	0	ref				ref			
HI in 1994 + Education + Father's Occupation	3	0.86	0.34	2.15	772.20	3.20	1.35	7.61	1016.31
	2	1.71	0.78	3.74		2.09	0.86	5.06	
	1	0.98	0.43	2.25		1.34	0.51	3.52	
	0	ref							
AHI + Education + Father's Education	3	1.18	0.50	2.78	776.17	2.85	1.20	6.75	1017.72
	2	1.50	0.67	3.34		2.05	0.83	5.08	
	1	0.90	0.39	2.06		1.23	0.44	3.46	
	0	ref				ref			
AHI + Education + Father's Occupation	3	0.86	0.34	2.15	774.85	3.23	1.27	8.22	1018.53
	2	1.71	0.78	3.74		2.39	0.92	6.19	
	1	0.98	0.43	2.25		1.68	0.60	4.76	
	0	ref				ref			
HITG + Education + Father's Education	3	1.18	0.50	2.78	774.72	4.05	1.84	8.91	1013.73
	2	1.50	0.67	3.34		2.34	1.08	5.07	
	1	0.90	0.39	2.06		1.82	0.82	4.05	
	0	ref				ref			
HITG + Education + Father's Occupation	3	0.86	0.34	2.15	776.47	6.52	2.78	15.26	1006.15
	2	1.71	0.78	3.74		2.27	0.98	5.26	
	1	0.98	0.43	2.25		2.96	1.30	6.73	
	0	ref				ref			

CVD=Cardiovascular disease; HR= Hazards Ratio; LCL= Lower confidence limit; UCL=Upper confidence limit; HI=Household income; AHI=Average household income; HITG=Household income trajectory group. Each model also included age, race/ethnicity, and marital status.

Table 4.5: Multivariable proportional hazards model results including a history of depressive symptoms (DS) by gender in the study of cumulative socioeconomic disadvantage (CSD) and 6-year CVD mortality among 2530 adults from the Alameda County Study

		Men				Women			
		HR	95% LCL	95% UCL	AIC	HR	95% LCL	95% UCL	AIC
HI in 1994 + Education + Father's Education	3	1.20	0.51	2.85	758.29	2.58	1.08	6.16	999.39
	2	1.49	0.67	3.31		2.09	0.85	5.17	
	1	0.82	0.35	1.92		1.18	0.42	3.33	
	0	ref				ref			
HI in 1994 + Education + Father's Occupation	3	0.91	0.37	2.25	756.34	2.90	1.13	7.45	1000.52
	2	1.68	0.76	3.71		2.43	0.94	6.32	
	1	0.89	0.38	2.09		1.71	0.60	4.82	
	0	ref				ref			
AHI + Education + Father's Education	3	1.43	0.59	3.48	759.41	2.66	1.18	6.03	997.53
	2	1.65	0.74	3.69		1.85	0.79	4.35	
	1	1.52	0.68	3.37		1.09	0.42	2.84	
	0	ref				ref			
AHI + Education + Father's Occupation	3	1.14	0.46	2.86	758.30	2.85	1.19	6.83	998.81
	2	1.70	0.74	3.92		2.12	0.87	5.16	
	1	1.67	0.75	3.70		1.34	0.51	3.52	
	0	ref				ref			
HITG + Education + Father's Education	3	2.05	0.69	6.10	758.81	3.68	1.65	8.17	996.39
	2	1.34	0.65	2.77		2.26	1.04	4.92	
	1	1.04	0.51	2.13		1.90	0.86	4.20	
	0	ref				ref			
HITG + Education + Father's Occupation	3	1.67	0.52	5.39	760.25	5.40	2.23	13.09	990.90
	2	1.21	0.58	2.52		2.26	0.97	5.25	
	1	1.20	0.60	2.40		3.00	1.32	6.84	
	0	ref				ref			

CVD=Cardiovascular disease; HR= Hazards Ratio; LCL= Lower confidence limit; UCL=Upper confidence limit; HI=Household income; AHI=Average household income; HITG=Household income trajectory group. Each model also included age, race/ethnicity, and marital status.

Table 4.6: Proportionality tests p-values by gender in the study of cumulative socioeconomic disadvantage (CSD) and 6-year CVD mortality among 2530 adults from the Alameda County Study

	Men			Women		
	Bivariate	Model 1	Model 2	Bivariate	Model 1	Model 2
HI in 1994 + Education + Father's Education	0.99	0.55	0.20	0.62	0.11	0.19
HI in 1994 + Education + Father's Occupation	0.38	0.48	0.64	0.98	0.10	0.15
AHI + Education + Father's Education	0.80	0.53	0.60	0.64	0.13	0.22
AHI + Education + Father's Occupation	0.52	0.56	0.71	0.97	0.11	0.15
HITG + Education + Father's Education	0.87	0.55	0.70	0.86	0.13	0.21
HITG + Education + Father's Occupation	0.35	0.49	0.66	0.86	0.12	0.20

CVD=Cardiovascular disease; HI=Household income; AHI=Average household income; HITG=Household income trajectory groups. Bivariate model refer to Table 4.3. Model 1 includes age, race/ethnicity, and marital status (Table 4.4); Model 2 includes Model 1 + history of depressive symptoms (Table 4.5).

Table 4.7: Comparison of the analytic sample (n=2530) to excluded members of the original Alameda County Study population in the study of cumulative socioeconomic disadvantage (CSD) and 6-year CVD mortality

	Analytic sample		Died before 1994			Died in or after 1994			Ineligible respondents alive in 2000		
	N=2530	%	N=2486	%	p-value	N=335	%	p-value	N=1577	%	p-value
Gender											
Males	1103	43.60	1226	49.32	<0.01	166	49.55	0.04	663	42.04	0.33
Females	1427	56.40	1260	50.68		169	50.45		914	57.96	
Race/Ethnicity											
White	2242	87.44	2066	83.11	<0.01	255	76.12	<0.01	1220	77.61	<0.01
Black	179	8.10	351	14.12		66	19.70		261	16.60	
Other	109	4.46	67	2.70		14	4.18		91	5.79	
Education in 1965											
0-11 Years	466	19.77	1330	53.50	<0.01	155	46.55	<0.01	462	33.12	<0.01
12 Years	834	33.56	607	24.42		117	35.14		467	34.08	
13+ Years	1225	46.45	529	21.28		61	18.32		483	32.80	
Married in 1965	2060	81.23	1659	66.73	<0.01	257	77.78	0.04	1185	75.14	<0.01
CVD Death	139	5.65	1140	45.86	<0.01	138	41.19	<0.01	0	0	<0.01

Table 4.8: Bivariate proportional hazards model results by gender in the study of cumulative socioeconomic disadvantage (CSD) measures based on annual HI and 6-year CVD mortality among 2530 adults from the Alameda County Study

		Men				Women			
		HR	95%	95%	AIC	HR	95%	95%	AIC
HI in 1965 + Education +	3	3.94	1.99	7.79	1666.1	4.07	1.83	9.05	1579.4
Father's Education	2	1.71	0.84	3.46		1.98	0.87	4.48	
	1	1.06	0.49	2.29		1.20	0.49	2.91	
	0	ref				ref			
HI in 1965 + Education +	3	2.07	0.99	4.30	1690.3	3.07	1.36	6.92	1593.0
Father's Occupation	2	2.22	1.12	4.39		2.13	0.95	4.77	
	1	1.40	0.67	2.93		1.33	0.55	3.20	
	0	ref				ref			
HI in 1974 + Education +	3	8.18	3.21	20.87	1107.1	3.95	1.80	8.67	1399.0
Father's Education	2	3.89	1.48	10.19		2.62	1.18	5.78	
	1	2.57	0.94	7.05		1.03	0.41	2.59	
	0	ref				ref			
HI in 1974 + Education +	3	9.80	2.97	32.30	1108.7	2.48	1.16	5.33	1514.9
Father's Occupation	2	7.69	2.37	24.98		2.12	1.01	4.46	
	1	3.52	1.01	12.22		1.05	0.44	2.47	
	0	ref				ref			
AHI 1965-1974 + Education	3	5.33	2.37	12.03	1111.2	3.97	1.72	9.18	1497.3
+ Father's Education	2	2.62	1.13	6.09		2.86	1.24	6.61	
	1	1.41	0.56	3.54		0.99	0.38	2.58	
	0	refr				ref			
AHI 1965-1974 + Education	3	7.07	2.47	20.25	1114.5	2.47	1.10	5.55	1512.8
+ Father's Occupation	2	5.29	1.88	14.92		2.47	1.14	5.39	
	1	2.67	0.88	8.10		1.04	0.42	2.57	
	0	ref				ref			

Table 4.8 continued: Bivariate proportional hazards model results by gender in the study of cumulative socioeconomic disadvantage (CSD) measures based on annual HI and 6-year CVD mortality among 2530 adults from the Alameda County Study

		Men				Women			
		HR	95% LCL	95% UCL	AIC	HR	95% LCL	95% UCL	AIC
HI in 1983 + Education +	3	12.42	2.85	54.20	483.69	3.13	1.14	8.60	509.50
Father's Education	2	6.89	1.56	30.48		1.87	0.66	5.30	
	1	3.91	0.83	18.36		0.93	0.28	3.03	
	0	ref				ref			
HI in 1983 + Education +	3	4.55	1.46	14.18	496.11	2.33	0.83	6.54	513.46
Father's Occupation	2	2.66	0.87	8.10		1.72	0.62	4.78	
	1	2.18	0.69	6.92		0.91	0.28	2.98	
	0	ref				ref			
AHI 1965-1983 + Education	3	6.90	1.96	24.30	489.43	2.32	0.89	6.01	508.77
+ Father's Education	2	4.91	1.41	17.09		1.80	0.69	4.66	
	1	2.50	0.66	9.42		0.53	0.15	1.88	
	0	ref				ref			
AHI 1965-1983 + Education	3	3.78	1.34	10.70	495.55	1.62	0.61	4.31	511.25
+ Father's Occupation	2	1.37	0.45	4.17		1.74	0.68	4.43	
	1	2.35	0.84	6.59		0.50	0.14	1.75	
	0	ref				ref			

CVD=Cardiovascular disease; HR=Hazards Ratio; LCL=Lower confidence limit; UCL=Upper confidence limit; HI= Household income; AHI=Average household income.

Table 4.9: Multivariable proportional hazards model results by gender in the study of cumulative socioeconomic disadvantage (CSD) measures based on annual HI and 6-year CVD mortality among 2530 adults from the Alameda County Study

		Men				Women			
		HR	95% LCL	95% UCL	AIC	HR	95% LCL	95% UCL	AIC
HI in 1965 + Education + Father's Education	3	1.16	0.56	2.40	1465.33	1.08	0.46	2.54	1324.53
	2	1.03	0.50	2.09		0.99	0.43	2.30	
	1	0.84	0.39	1.84		1.09	0.45	2.68	
	0	ref				ref			
HI in 1965 + Education + Father's Occupation	3	0.99	0.46	2.12	1465.99	1.69	0.73	3.93	1320.00
	2	1.17	0.59	2.34		1.10	0.48	2.51	
	1	1.08	0.52	2.26		1.00	0.41	2.43	
	0	ref				ref			
HI in 1974 + Education + Father's Education	3	2.00	0.78	5.08	961.41	0.82	0.35	1.92	1292.41
	2	1.68	0.65	4.36		0.99	0.44	2.25	
	1	1.83	0.68	4.95		0.82	0.33	2.00	
	0	ref				ref			
HI in 1974 + Education + Father's Occupation	3	3.74	1.12	12.52	955.17	1.01	0.46	2.21	1292.25
	2	4.10	1.26	13.31		0.82	0.39	1.76	
	1	2.71	0.78	9.46		0.79	0.34	1.87	
	0	ref							
AHI 1965-1974 + Education + Father's Education	3	1.67	0.76	3.69	961.73	1.02	0.42	2.47	1291.41
	2	1.29	0.57	2.89		1.31	0.56	3.07	
	1	1.21	0.50	2.95		0.90	0.36	2.29	
	0	ref				ref			
AHI 1965-1974 + Education + Father's Occupation	3	3.25	1.12	9.43	956.20	1.27	0.55	2.89	1292.23
	2	3.12	1.11	8.76		1.11	0.51	2.44	
	1	2.10	0.70	6.30		0.91	0.38	2.22	
	0	ref				ref			

Table 4.9 continued: Multivariable proportional hazards model results by gender in the study of cumulative socioeconomic disadvantage (CSD) measures based on annual HI and 6-year CVD mortality among 2530 adults from the Alameda County Study

		Men				Women			
		HR	95% LCL	95% UCL	AIC	HR	95% LCL	95% UCL	AIC
HI in 1983 + Education + Father's Education	3	3.87	0.80	18.68	451.30	0.78	0.26	2.35	450.20
	2	2.48	0.53	11.67		0.87	0.30	2.52	
	1	2.42	0.50	11.69		0.61	0.18	2.11	
	0	ref				ref			
HI in 1983 + Education + Father's Occupation	3	2.03	0.66	6.31	453.48	1.13	0.39	3.32	448.65
	2	1.25	0.41	3.81		0.71	0.24	2.12	
	1	1.45	0.46	4.58		0.59	0.17	2.01	
	0	ref				ref			
AHI 1965-1983 + Education + Father's Education	3	2.59	0.65	10.34	452.85	0.81	0.29	2.31	448.86
	2	1.97	0.53	7.37		1.03	0.39	2.68	
	1	1.58	0.39	6.34		0.49	0.13	1.84	
	0	ref				ref			
AHI 1965-1983 + Education + Father's Occupation	3	1.98	0.69	5.69	450.45	1.15	0.42	3.19	447.87
	2	0.76	0.25	2.32		0.93	0.35	2.49	
	1	1.43	0.50	4.09		0.45	0.12	1.60	
	0	ref				ref			

CVD=Cardiovascular disease; HR=Hazards Ratio; LCL=Lower confidence limit; UCL=Upper confidence limit; HI=Household income; AHI=Average household income. Each model was adjusted for age, race/ethnicity and marital status.

Chapter 5

Conclusions

Summary of findings

This dissertation was written with the intent to understand how various measures of socioeconomic position (SEP) and cumulative socioeconomic disadvantage (CSD) based on household income vary in their associations with cardiovascular disease mortality (CVDM) and the presence of multiple depressive symptoms (MDS) within gender. SEP can be measured with several constructs, such as income, occupation, and education, but the interrelationships between these variables is complex, and may vary substantially in their associations with different health outcomes. In these analyses, household income (HI) was analyzed for associations as a recent measure in 1994, average household income (AHI) from 1965 to 1994, and household income trajectory groups (HITG) based on HI data from 1965-1994. Associations between HI in 1994 and CVDM as well as MDS provide evidence in favor of a critical period life course model to describe the relationships between SEP based on HI and these outcomes. The presence of relationships between AHI and HITG with CVDM and MDS provide evidence to support the social mobility and accumulation life course frameworks as theories by which social conditions over the life course may affect these health outcomes. Among men and women, the magnitudes of association were varied and potentially indicated different life course models to be of strongest magnitude in relation to CVDM and MDS.

Results from Chapter 2 indicated that the role of HI in the presence of CVDM varied by measure of HI within gender. The hypothesis that lower HI in 1994 would be inversely associated with CVDM risk was supported in these analyses in both bivariate and confounder-adjusted models for men but only in bivariate models for women. The hypothesis that AHI would be more strongly associated with CVDM than HI in 1994 was not supported in these analyses for men or women. The hypothesis that HITG would be most strongly associated with CVDM hazard was supported in the bivariate analyses for both men and women. Results among men indicated membership in the lower quartiles of the most recent measure of HI (HI in 1994) was associated with increased hazards of CVDM both with and without confounder adjustment. Based on unadjusted models, the magnitudes of association were greatest between HITG and CVDM for men. Unadjusted analyses for women showed that higher average and recent HI based on both continuous measures and quartiles was associated with increased hazards of CVDM. Membership in the second highest HITG was associated with decreased hazards of CVDM for women. The magnitude of association was greater for the HI measure from 1994 compared to that of AHI among women. Among categorical measures, the magnitude of associations were greatest with membership in the second highest HITG, then for membership in lower quartiles of HI in 1994 and AHI. With adjustment for confounders, no associations remained significant among women.

From chapter 3, the role of HI in the presence of MDS varies by gender. The hypothesis that there were associations between each measure of household income and odds of MDS were supported in these analyses. Higher continuous HI in 1994 to be more strongly associated with decreased odds of MDS compared to AHI among men. The association between HI in 1994 and MDS remained when models were adjusted for a history of depressive symptoms within men. Evidence favoring the hypothesis of stronger associations between HITG compared to HI in 1994 and AHI was provided as well for men. Membership in the lowest HITG was most strongly associated with increased odds of MDS, followed by membership in the lowest HI in 1994 and AHI quartiles relative to the highest groups. With further adjustment for a history of depressive symptoms, the associations and relations between the measures followed the same trend. Models for women indicated membership in the lowest quartiles of HI in 1994 and the lowest HITG had increased odds of experiencing MDS. Associations were of greatest magnitude for HI in 1994 compared to HITG. Adjustment for having a history of depressive symptoms completely attenuated the significance of these associations among women.

Results from chapter 4 showed differences in the associations between socioeconomic disadvantage over the life course and the hazards of cardiovascular disease mortality between men and women. Women consistently had higher hazards of CVDM regardless of the CSD measure used when they have increased CSD. Among men, however, only bivariate models based on CSD measures that included father's education were significantly associated with CVDM, but there were no associations between any of the CSD measures and CVDM after controlling for any confounders. When history of depression in 1994 was included in the models, associations were minimally affected in confounder-adjusted models, but with inclusion of CVDM risk factors, a protective effect of decreased disadvantage remained among three of the CSD measures. Reviewing the magnitudes of the associations under study, there appeared to be minimal variability in these values between the multiple CSD measures among women, which suggests that the measures are capturing similar facets of disadvantage when the life course perspective of social disadvantage was considered. Slightly stronger associations among measures that included father's education were present for women, although the type of household income measure was not related to the magnitude of the association.

Strengths and Limitations

Generalizability

One of the strengths of the analyses presented here is that the data used was longitudinal in nature and captured information for a population-based sample of thousands of individuals over a 35-year period. However, the ACS was designed to collect information about adults from households of this particular county in 1965, which, although it represented a large metropolitan area of California, may not be generalizable to larger or other populations without similar demographic distributions of Alameda County in 1965.

Assessments of SEP

The primary strength of these analyses was in the creation of multiple measures of SEP based on household income that considered multiple points across the life course and compared the roles of static and long term measures of household income in the long-term development of health outcomes. Chapters 2 and 3 included a static measure of household income-household income in 1994- and also included two long-term measures of household income- reported household income from each wave averaged from 1965-1994, and household income trajectories. Chapter 4 looked at cumulative measures of socioeconomic disadvantage based on household income in 1994, average household income from 1965-1994 and the household income trajectory classes, the individuals' education, as well as the father's education and father's occupation to create six measures (one household income measure, education, and one parental SEP measure) in an effort to determine whether different combinations of SEP measures over the life course were more strongly related with CVDM compared to others. We were able to examine whether household income from earlier and later points in the life course were more or less associated with CVDM compared to the other measures. This examination was necessary as the variability in the research of measures of HI to capture SEP is wide but obscure in the differences in associations with multiple health outcomes. Although these measures were strengths of the study, and covered a large portion of the life course in our analyses, there were only four waves of data from which the SEP measures were constructed. As a result, there were several years for which data was not collected, and they did not capture the entire life course, and did not reflect the same life course periods for the entire sample. More specifically, household income during the 1965-1994 period reflected different periods of income earnings for people of different ages. Persons who were 18 in 1965 were just entering the period of their lives to begin earning income, while those adults who were in their sixties were beginning to earn less income. Future works with increased sample sizes and cases of CVDM and MDS when compared to these analyses should incorporate stratification by age groups to investigate whether the gender differences seen in these analyses remain, but was not plausible in this work.

Measurement error

In these analyses, multiple sources of measurement error were present, many of which strongly related to the self-reported nature of the majority of the data collected. Household income data was originally measured in bracketed ranges, which was then used to impute specific household incomes for each person, and although this provided additional information that allowed our analyses, it was clearly based on an individuals' self-reported category, which could have been incorrectly estimated by the subject at data collection, resulting in underestimates of the effects of each SEP measure. However, since we were interested in comparing the magnitude of associations between genders and measures that were based on the same household income reports, the amount of error would be consistent among each comparison group. Information about the depressive symptoms experienced were also self-reported, and may have been inaccurately reported for both men and women, although the proportions of men and women with depression in the US in 2005-2006 were similar to those presented in these analyses [92].

The wide range of ages in this sample inevitably suggests the presence of age cohorts and potentially a healthy survivor effect. The bias resulting from this issue arises from the inclusion of healthier people who are of older ages, and underestimates the association between CSD and CVDM. One particularly useful way to handle the patterning of socioeconomic measures and CVDM by age would have been to stratify the sample into age groups and repeat these analyses, although this was not feasible due to the limited frequency of outcomes. An additional problem is the limited number of CVDM cases in the data, which could underestimate the true association between CSD and CVDM, and can be resolved in future analyses with increased sample sizes or additional follow-up of subjects.

Another issue in our analyses was in 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 but also individuals who did and did not die of CVD. Works that aim to study similar issues in the future should have greater numbers of cases in an effort to address and create trajectory classes that accurately reflect the patterns of household income within gender in addition to being able to understand which of the overall patterns that individuals fall into, especially when considering gender differences in the associations like those studied here.

The recall of information pertaining to the parental education and occupation may have been limited in accuracy, and with information directly from the parents, this perhaps could have been more accurate. Father's education and occupation were intended to provide information about the childhood social conditions and to indicate something about the individual's access to resources early in life. Incorrect recall of these measures, in addition to the incorrect reporting of household income, could have contributed to the incorrect classification of the individuals' level of cumulative socioeconomic disadvantage, and therefore underestimates of the effects of CSD.

In the attainment of CVDM data, the correct listing of cause of death on state death certificates is an issue that has been discussed in the use of death certificate data in the literature [89]. Despite the plausible issues with this information, death certificate data is often the most widely available death information for large samples of individuals, as with the ACS, and the results presented should be interpreted with this in mind.

Major contributions and conclusions

The work presented here provides an in depth view into the differences in multiple measures of SEP that are based on household income and how static compared to long term measures of household income are differentially associated with CVDM and MDS within genders. In these analyses, a novel method for modeling life course HI, latent trajectory class modeling, allowed for the stud of patterns of income throughout the life course which has infrequently been done in the health literature.

In the current literature, various articles utilize different approaches to SEP based on what is available in their data with respect to education, income, or occupation and adjusts for the other measures of SEP to understand the effect of that specific SEP measure. This analysis suggests differences in association when considering different measures of a single SEP indicator, and that the choice of measure for such an indicator reflects different life course effects of SEP. Furthermore, I was able to show that cumulative socioeconomic disadvantage based on multiple points throughout the life course was indeed more pronounced among women than men. Additionally, this analysis incorporated the use of latent trajectory class modeling in the examination of household income, which allowed for the study of patterns over the life course using measures beyond the traditional approaches, such as the creation of average household income.

The role of SEP over the life course in the development of health outcomes requires in depth study and observation of the behaviors people have, the social environments to which they are exposed, and the health conditions that ultimately develop within populations of individuals. To obtain this information, studies must collect very complex and intricate data about familial and intergenerational practices that are more reliable. The gathering of such data for the entire life course from infancy to death is ideal for studies that aim to explore life course matters and health, but also a quite difficult task to complete. As we realistically progress in the study of the life course and health outcomes, surely more of the needed data will be collected.

In the United States, the primary cause of death among both men and women continues to be cardiovascular disease. In addition, among individuals who reported having moderate or severe depressive symptoms, approximately 80% experienced some level of difficulty in functioning, and more than half of people with mild depressive symptoms reported problems with daily function attributable to their symptoms [119]. The role of SEP in the presence of these conditions has been heavily investigated, documenting inverse associations between SEP and risk of CVDM and MDS. However, the variation within measures of an individual SEP construct varies in relation to these outcomes. Analyses that explore such associations between SEP and health outcomes must provide clear and unified results to provide evidence of the need for health policy changes that include social restructuring. The lack of attainment of this goal among researchers is ultimately a hindrance to efforts to develop health policies intended to reduce the burden poor social conditions on health.

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