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Educational attainment and risk of stroke and myocardial infarction

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Summary

Background: Prior reports have suggested that low educational attainment could be associated with higher incidence of some of the cardiovascular conditions.

Material/Methods: We evaluated the association of educational attainment (≥12 years or <12 years) with the incidence of fatal strokes, ischemic stroke, intracerebral hemorrhage, and myocardial infarction in a cohort of 21,443 United States adults who participated in either the First National Health and Nutrition Examination Survey (NHANES-I) Epidemiologic Follow-up Study (NHEFS) or the Second National Health and Nutrition Examination Survey Mortality Follow-up Study (NHANES-II). Cox proportional hazards analyses were used to examine the relationships.

Results: During a mean follow-up period of 15.2±4.6 years, the risk for all fatal strokes was increased in persons who reported less than 12 years of education. The increased risk was more prominent in persons aged 50 years or less (relative risk [RR], 2.6; 95% confidence interval [CI], 1.1–6.0) compared with persons aged greater than 50 years (RR, 1.3, 95% CI, 1.0–1.6). A higher risk of myocardial infarction associated with less than 12 years of education was observed in both persons aged 50 years or less (RR 1.7, 95% CI 1.2–2.4) and those aged greater than 50 years (RR 1.3, 95% CI 1.1–1.5). The risk for fatal intracerebral hemorrhages (RR 2.0, 95% CI 1.1–3.5) was higher in persons with less than 12 years of education (no significant interaction demonstrated with age).

Conclusions: Educational attainment has a significant effect on the risk for stroke and myocardial infarction, independent of socioeconomic status and other cardiovascular risk factors.

key words: **educational attainment • stroke, myocardial infarction • cardiovascular risk factors • epidemiologic studies**

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Background

Cardiovascular disease was responsible for 618,289 deaths in the United States in 1998. It is estimated that 1,100,000 persons will have a myocardial infarction and 600,000 persons will suffer from a stroke in the year 2002 [1]. Given the continuing high incidence of cardiovascular disease, the identification of new predisposing risk factors, especially those that can be modified, is of paramount importance. Social conditions have been implicated in influencing the risk of cardiovascular disease [2–5]. We had previously observed that educational attainment explained in part the differences in the risk of intracerebral hemorrhage in white and African-American populations [6]. In the present study, our purpose was to examine the contribution of educational attainment to the long-term risk of cardiovascular disease.

Material and Methods

Study Design and Objectives

We used the pooled data of two national cohorts, the First National Health and Nutrition Examination Survey (NHANES I) Epidemiologic Follow-up Study (NHEFS) and the Second National Health and Nutrition Examination Survey (NHANES II) Mortality Follow-up Study, to determine the effect of educational attainment on the long-term risk of stroke and its subtypes and myocardial infarction [7–10]. The National Health and Nutrition Examination Survey follow-up studies provide cohort data on a large nationally representative sample of the United States population, which presents a unique opportunity for identification of undefined cardiovascular risk factors within the United States population.

NHEFS (NHANES I Epidemiologic Follow-up Study)

NHANES I was conducted by the National Center for Health Statistics, Centers for Disease Control and Prevention, from 1971 through 1975 to collect health-related information on a probability sample of the United States civilian, non-institutionalized population. To increase the sample size in select subgroups, the elderly, persons living in poverty areas, and women of childbearing age were oversampled [11–13]. The objective of the NHEFS was to provide follow-up of the 14,407 examinees in NHANES I who were between the ages of 25 and 74 years at the time of the baseline survey [7]. Data collection for this analysis included tracing all NHANES I participants for morbidity and mortality through 1992 [7,9,14]. Events of ischemic stroke, intracerebral hemorrhage, and myocardial infarction were determined by death certificate diagnoses that included one or more of the following International Classification of Diseases Clinical Modification (ICD–9 CM) codes: 433, 434, 436, 437.0, or 437.1 (for ischemic stroke), 431 to 432 (for intracerebral hemorrhage), and 410 to 414 (for myocardial infarction).

NHANES II Mortality Follow-up Study

The baseline survey of NHANES II was conducted between 1976 and 1980 for a national probability sample of 20,322 persons aged 6 months to 74 years [8,10]. The basic purpose, design, and procedures were similar, with slight modifications, to those of NHANES I. Mortality follow-up was conducted for the cohort of 9252 NHANES II participants who were aged 30 years or older at the time of enrollment. The vital status of each participant was ascertained by matching data obtained from NHANES II with deaths recorded in the National Death Index, which has been shown to accurately record 93 to 98 percent of all deaths [15–17] and the Social Security Administration Death Master File [8]. Information obtained for the Mortality Follow-up Study included the month and year in which an individual was last known to be alive and the ICD-9 CM code for the underlying cause of death. The vital status of each cohort member through December 31, 1992 was obtained. The duration of follow-up (i.e, survival time) for each participant was calculated as the difference between the NHANES II baseline examination date and the last known date alive obtained from the NHANES II Mortality Study. The cause of death was available through death certificate diagnosis using the above-mentioned ICD-9 CM codes.

Pooled NHEFS and NHANES II Mortality Follow-up Study data

The two national health surveys had similar sampling and data collection methods. The cardiovascular risk factors analyzed in the pooled data included age, blood pressure measurements, serum cholesterol levels, cigarette smoking status, and presence of diabetes, and these data were obtained in both surveys. For NHEFS, three blood pressure readings were available for 48% of participants and one blood pressure reading was available for 52% of participants at baseline evaluation. For NHANES II Mortality Follow-up Study, three blood pressure readings were available for 99% of the participants at baseline evaluation. The last blood pressure measurement made was used whenever more than one measurement was available. The sex- and race/ethnicity-specific operating characteristics curves of the NHANES I and NHANES II cohorts were nearly identical in a previous report, which suggested that the demographic characteristics of these persons were equivalent [18]. Data from the two cohorts were combined to increase the size of the sample in the present study. Educational attainment was available at baseline for each national cohort and was categorized into the following two response choices on the basis of self reports of years of education: less than 12 years, or equal to or more than 12 years.

Statistical Analysis

Persons who reported a history of stroke or myocardial infarction during the baseline NHANES I and II surveys were excluded from statistical analysis in our study. Because the interval of follow-up varied among individuals, Cox proportional hazards analyses were used to estimate the relative risks (RR) and 95 percent confidence

Table 1. Demographic and clinical characteristics of participants according to educational attainment.

Characteristic		Educational attainment <12 years (N=9223)	Educational attainment ≥12 years (N=12220)
Age	Mean±SD	56.2±13.6*	46.6±14.3
Gender	Male	4085 (44%)	5006 (41%)
	Female	5138 (56%)*	7214 (59%)
Race/ethnicity	White	7259 (79%)	11109 (91%)
	African-American	1855 (20%)*	944 (8%)
	Other	109 (1%)	167 (1%)
Systolic blood pressure	mm Hg	140±25*	130±21
Diabetes mellitus		526 (6%)*	327 (3%)
Body mass index	kg/m^2	26.5±5.4*	25.3±4.7
Serum cholesterol	mg/dl	227±50*	218±47
Socioeconomic status	Poverty index <1	2106 (23%)*	577 (5%)
Smoking	Current	2333 (25%)	3338 (27%)
	Previous	2493 (27%)	3245 (27%)
	Never	3768 (41%)	5044 (41%)
	Missing	629 (7%)	593 (5%)
Income per year	<10,000	6422 (70%)	4073 (33%)
	10,000–20,000	1957 (21%)*	4977 (41%)
	>20,000	479 (5%)*	2764 (23%)
	Missing	365 (4%)*	406 (3%)

*Significant difference according to analysis of variance (ANOVA) for means or chi-square test for frequencies

intervals (CI) for all strokes, ischemic stroke, intracerebral hemorrhage, and myocardial infarction among persons with 12 or more years of education and those with less than 12 years of education. Potential confounding factors considered in the analyses included age, sex, race/ethnicity (African American, white, or other), systolic blood pressure, presence of diabetes mellitus, serum cholesterol level, smoking status, body mass index (weight in kg/height in m2), and socioeconomic status. Diabetes mellitus was determined by self-report. The presence of diabetes mellitus was determined by self-report during a standardized interview at baseline evaluation. Smoking status was categorized as current, previous, never, and undetermined. Socioeconomic status was expressed as poverty index. Poverty index was computed as a ratio of two components [19]. The numerator was the midpoint of the observed family income category. The denominator is the product of the following: [(daily cost for food per person for the specific year x number of family members) x number of days in that year] x 3. The daily cost for food is adjusted annually and it is assumed that one-third of the income will be spent on food. The poverty index allowed income data to be analyzed in a comparable manner across the years of these surveys and previous surveys. A higher poverty index suggests higher income and economic status. Poverty index was categorized as less than 1 or greater than or equal to 1, with values less than 1 designating poor. Systolic blood pressure, body-mass index, and serum cholesterol level were entered in the model as continuous variables.

Interactions between variables entered in the models were tested. The only significant interaction observed was between age and educational attainment in the models for fatal myocardial infarction, stroke, and ischemic stroke. The results were therefore analyzed in two strata of age based on the median age of the population. The strata were greater than 50 years and less than or equal to 50 years. No significant interactions were demonstrated in the models after stratification by age.

The mean follow-up period for the combined cohort was 15.2±4.6 years. The mean follow-up period for NHANES I cohort was longer than the NHANES II cohorts (16.4±5.0 years versus 13.5±3.5 years, $p<0.001$). We tested for any interaction induced by participation in either cohort on the effect of education on cardiovascular endpoints in each of the models. There was no interaction demonstrated suggesting homogeneity of effect between the two cohorts.

RESULTS

Follow-up data were available for 22,838 participants, consisting of 13,586 enrolled in the NHEFS and 9252 enrolled in the NHANES II Mortality Follow-up Study. Of the 22,838 participants, 1220 persons were excluded because a history of stroke or myocardial infarction was reported at the time of baseline evaluation, and 175 persons were excluded because the educational status was not available. A total of 21,443 participants were included in the final analysis. The mean age was 50.8±14.8 years; 9091 were men.

Compared with persons who had 12 or more years of education, those who had less than 12 years of education were more likely to be older and have higher systolic blood pressure and diabetes mellitus (Table 1). A higher proportion of African-Americans and diabetics were observed in the group with less than 12 years of education. Mean values for serum cholesterol level and body mass index were higher in persons with less than 12 years of education. Educational attainment of less than 12 years was associated with lower socioeconomic status (poverty index <1). The proportion of persons with higher annual income was significantly lower among those with educational attainment of less than 12 years. To determine the effect of education on access to health care, we analyzed the association between educational attainment and self-reported visit to physician's office within the last 5 months. The data was only available for a subset of participants (n=6505). The proportion of patients with physician's office visit within the last 5 months was not different among persons with less than 12 years of education compared with persons with 12 or more years of education (1197 of 2992 versus 1452 of 3513 persons, p=0.3).

In the follow-up period, a total of 5693 deaths were observed of which 409 were fatal stroke events and 1527 were fatal myocardial infarctions. A comparison of the frequency of major causes of death among persons according to educational attainment is provided in Table 2. Among the fatal stroke events, 344 were classified as ischemic strokes and 65 were classified as intracerebral hemorrhages.

Table 2. Causes of death among the participants according to educational attaitment.

	Education <12 years (n=9223)		Education ≥12 years (n=12220)		OR (95% CI)*	
All causes	3546	(38%)	2147	(18%)	2.9	(2.8–3.2)
All cardiovascular diseases (390–398, 402,404–429, 430–438)	1664	(18%)	893	(7%)	2.8	(2.6–3.0)
Ischemic heart disease (410–414)	990	(11%)	537	(4%)	2.6	(2.3–2.9)
Stroke (431–437)	280	(3%)	129	(1%)	2.9	(2.4–3.6)
Malignant neoplasms (140–208)	850	(9%)	647	(5%)	1.8	(1.6–2.0)
Chronic obstructive pulmonary diseases and allied conditions (490–496)	158	(2%)	91	(1%)	2.3	(1.8–3.0)
Accidents and adverse effects (E800–E949)	28	(0.3%)	30	(0.5%)	1.2	(0.8–2.1)
Pneumonia and influenza (480–487)	125	(1.3%)	60	(0.5%)	2.8	(2.0–3.8)
Diabetes mellitus (250)	75	(0.8%)	39	(0.3%)	2.6	(1.8–3.8)
Human immunodeficiency virus infection (042–044)	–		–		–	
Suicide (E950–E959)	1		–		–	
Chronic liver disease (571)	41	(0.4%)	26	(0.2%)	2.1	(1.3–3.4)
All other causes	604	(7%)	361	(3%)	2.3	(2.0–2.6)

OR – Odd ratio; CI – Confidence interval.
Symbols used: *– derived from chi-square test.
ICD-9 CM codes are provided with cause of death

Table 3. Effect of educational attainment on risk for all fatal strokes, fatal ischemic strokes, and fatal intracerebral hemorrhage in the pooled analysis of the First National Health and Nutrition Examination Survey Epidemiologic Follow-up Study and the Second National Health and Nutrition Examination Survey Mortality Follow-up Study.

	Sample size	Event rate		Age-adjusted RR (95% CI)		Multivariate adjusted RR (95% CI)	
All strokes							
Age ≤50 years							
Educational attainment ≥12 years	7450	10	(0.1%)	Reference		Reference	
Educational attainment <12 years	3034	20	(0.7%)	4.1	(1.9–8.8)	2.6	(1.1–6.0)
Age >50 years							
Educational attainment ≥12 years	4770	119	(2.5%)	Reference		Reference	
Educational attainment <12 years	6189	260	(4.2%)	1.4	(1.2–1.8)	1.3	(1.0–1.6)
Ischemic strokes							
Age ≤50 years							
Educational attainment ≥12 years	7450	5	(0.1%)	Reference		Reference	
Educational attainment <12 years	3034	14	(0.5%)	5.3	(1.9–14.8)	2.6	(0.8–8.1)
Age >50 years							
Educational attainment ≥12 years	4770	104	(2.2%)	Reference		Reference	
Educational attainment <12 years	6189	221	(3.6%)	1.4	(1.1–1.8)	1.2	(0.9–1.6)
Intracerebral hemorrhage							
All ages							
Educational attainment ≥12 years	12220	20	(0.2%)	Reference		Reference	
Educational attainment <12 years	9223	45	(0.5%)	2.0	(1.2–3.7)	2.0	(1.1–3.5)

Analyses in Table 3 were conducted after adjusting for age, sex, race/ethnicity, systolic blood pressure, diabetes mellitus, serum cholesterol level, smoking status, body mass index (weight in kg/height in m^2), and socioeconomic status.
RR – relative risk; CI – confidence interval

Compared with persons with 12 or more years of education, those with less than 12 years of education were at significantly higher risk for all fatal strokes after adjusting for other confounding factors. The increased risk was more prominent in persons aged 50 years or less (RR, 2.6; 95% CI, 1.1–6.0) compared with persons aged greater than 50 years (RR, 1.3, 95% CI, 1.0–1.6) (Table 3). For persons aged 50 years or less, the relative risk of fatal ischemic stroke was 2.6 times higher among persons with less than 12 years of education compared with those with 12 or more years of education, but this difference did not achieve statistical significance. The risk for fatal intracerebral hemorrhages (RR 2.0, 95% CI 1.1– 3.5) was higher in persons with less than 12 years of education (no significant interaction demonstrated with age). Persons with less than 12 years of education were at a significantly higher risk for fatal myocardial infarction than those with 12 or more years of education (Table 4) after adjusting for other confounding factors. A higher risk of myocardial infarction was observed in both persons aged 50 years or less (RR 1.7, 95% CI 1.2–2.4) and those aged greater than 50 years (RR 1.3, 95% CI 1.1–1.5).

Table 4. Effect of educational attainment on risk for all fatal myocardial infarction in the pooled analysis of the First National Health and Nutrition Examination Survey Epidemiologic Follow-up Study and the Second National Health and Nutrition Examination Survey Mortality Follow-up Study.

	Sample size	Event rate	Age-adjusted RR (95% CI)	Multivariate adjusted RR (95% CI)
Age ≤50 year				
Educational attainment ≥12 years	7450	76 (1.0%)	Reference	Reference
Educational attainment <12 years	3034	72 (2.4%)	1.9 (1.4–2.6)	1.7 (1.2–2.4)
Age >50 years				
Educational attainment ≥12 years	4770	461 (9.7%)	Reference	Reference
Educational attainment <12 years	6189	918 (14.9%)	1.4 (1.3–1.6)	1.3 (1.1–1.5)

Analyses in Table 4 were conducted after adjusting for age, sex, race/ethnicity, systolic blood pressure, diabetes mellitus, serum cholesterol level, smoking status, body mass index (weight in kg/height in m^2), and socioeconomic status.
RR – relative risk; CI – confidence interval

DISCUSSION

Salient Findings of the Study

In our analysis using pooled data from two national cohorts, we observed that persons who reported attaining less than 12 years of education were at higher risk for fatal stroke and myocardial infarction than those who reported 12 or more years of education. The increased risk was independent of age, sex, race/ethnicity, systolic blood pressure, diabetes mellitus, cigarette smoking, serum cholesterol level, body mass index, and socioeconomic status. The effect of education on myocardial infarction and stroke was not consistent through out all age groups and appeared to be more prominent in persons aged 50 years or less. When analysis was performed according to stroke subtype, an increased risk was observed for intracerebral hemorrhage among persons with educational attainment less than 12 years. Our results strongly suggest that educational attainment may affect an individual's risk for developing cardiovascular diseases and that this risk is independent of previously defined cardiovascular risk factors.

Review of Previous Studies

The role of educational attainment as a risk factor for cardiovascular disease has been evaluated in selected populations. Table 5 provides a summary of pertinent studies [3,4,20–25]. It should be noted that most studies performed in United States are representative of men. Our study population includes appropriate representation of women and other ethnic populations in proportions similar to population of United States. Therefore, the study design is less likely to be biased by factors specific to certain geographic sites or organizations that limit the generalization of the derived results. Our study also provides data on the effect of educational attainment on stroke and stroke subtypes, which has not been reported previously. Hinkle et al. [3] reported the results of a 5-year prospective survey evaluating the relationships among occupation, education, and coronary artery disease in 270,000 men employed by the Bell System Operating Companies. These investigators observed that men who entered the organization with a college degree had lower rates of heart attack, death, and disability related to coronary artery disease. Liu et al. [4] studied the relationship of education to cardiovascular risk factors at baseline and long-term mortality from coronary artery and cardiovascular diseases in three cohorts of middle-aged white men employed in Chicago. An inverse relationship was observed between education and blood pressure status. Furthermore, an inverse relationship was observed between cigarette smoking status and level of education. A subset analysis of 8047 men demonstrated a graded inverse relationship between education and age-adjusted mortality rates from coronary artery and cardiovascular diseases in the 21-year follow-up period. These associations were statistically significant, although less so after adjustments for other cardiovascular risk factors such as systolic blood pressure and smoking were made. Low educational attainment has been identified as a risk factor for stroke in other studies [20,26,27]. Siegel et al. [20] analyzed data from the Systolic Hypertension in the Elderly Program pilot project. A total of 551 men and women 60 years of age and older with pretreatment systolic blood pressure greater than or equal to 160 mmHg and diastolic blood pressure less than 90 mmHg were prospectively studied, and the incidence of cardiovascular events and death was determined. In the multivariate analysis, age, lower level of education, history of a cardiovascular event, and cigarette smoking were significant predictors of a cardiovascular event.

Underlying Mechanism for Association Between Educational Attainment and Cardiovascular Diseases

The underlying mechanism by which persons with lower educational attainment are at higher risk for cardiovascular diseases is not fully understood. In our study, the increased risk was observed for fatal stroke, intracerebral hemorrhage, and myocardial infarction. Educational attainment is an important risk factor for cigarette smoking and the development of hypertension, obesity, and high levels of serum cholesterol. In our study and that by Liu et al. [4] the increased risk of cardiovascular diseases was independent of other cardiovascular risk factors. Moreover, in our study, cardiovascular disease risk was also independent of socioeconomic status. Persons of lower socioeconomic status are

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Table 5. Summary of pertinent studies that have evaluated the effect of educational attainment on cardiovascular disease.

Study	Study population	Design	Educational attainment categories	Potential confounders in multivariate model	Results
Hinkle et al. [3] (1968)	Bell systems employed men (n=269,755) aged 35–59 years	Retrospective analysis of cohort (3 year follow-up)	College education	None	Lower rate of CHD among college educated
Liu et al. [4] (1982)	CHA (n=8047) Men aged 40–59 years	Prospective cohort (5 year follow-up)	High school graduate, some college, college graduate	Age, DBP, cigarette smoking, cholesterol, weight, ECG	Graded inverse relationship between CVD mortality
Liu et al. [4] (1982)	PG-WE (n=2980) Men aged 40–55 years and white men aged 40–59 years	Prospective cohort (20–21 year follow-up)	High school graduate, some college, college graduate	Age, DBP, cigarette smoking, cholesterol, weight, ECG	Inverse relationship between CVD mortality but not graded
Siegel et al. [20] (1987)	SHEP pilot program (n=551). Persons with ISH aged ≥60 years (82% white)	Prospective cohort (average follow up of 34 months)	High school graduate or less, some college or more	Age, sex, race, cigarette smoking, BMI, ECG, SBP, DBP, heart rate, pulse pressure, antihypertensive treatment	Education predictive of first cardiovascular event
Mittleman et al. [21] (1997)	Determinants of myocardial infarction study (1623 patients with MI)	Case-crossover study	Less than high school, completed high school, some college	Stratified data analysis	Risk of having MI triggered by anger declined with increasing level of education
Din-Dzietham et al. [22] (2000)	ARIC study (n=10,091) aged 45–64 years	Cross-sectional study	Grade school, high school without graduation, high school graduation, vocational school, some college, graduate/professional school	Age, height, SBP, diastolic diameter, pulse pressure, ethnicity, gender, cigarette smoking	Direct association between increasing education and common carotid elasticity (represents early atherosclerotic changes)
Kilander et al. [23] (2001)	50 year old men (n=2301) in Uppsala, Sweden	Prospective cohort (22–25 year follow-up)	Low (≤7 years of schooling), high (high school or university)	Age, sex, SBP, DBP, serum glucose, cigarette smoking, cholesterol, triglycerides, BMI, physical activity, serum fatty acids and antioxidants	Higher risk of CVD mortality associated with low education lost in multivariate analysis
Jenum et al. [24] (2001)	Subjects aged 40 years (n=14220) in Oslo, Norway	Matched to mortality data obtained 3–10 years later	Low (person aged ≥16 years with only 9 years of formal education)	Correlation with age adjusted mortality	Low education positively correlated with CVD mortality
Pitsavos et al. [25] (2002)	CARDIO2000 included 750 patients with MI and 869 controls	Retrospective case-control	Not passed senior high school, no university education, university education	Age, sex, occupation, cigarette smoking, income, hypertension, diabetes, BMI, physical activity, hypercholesterolemia, family history	Higher risk of non fatal coronary syndromes in persons who have not passed senior high school

CHA – Chicago Heart Association Detection Project; PG – Peoples Gas Company; WE – Western Electric; SHEP – Systolic hypertension in elderly program; ARIC – Atherosclerosis Risk in Communities; CVD – cardiovascular diseases; MI – myocardial infarction; DBP – diastolic blood pressure; ECG – electrocardiogram; SBP – systolic blood pressure; BMI – body-mass index

substantially less likely to have access to health care [27], which may also affect the risk for cardiovascular diseases. We were unable to demonstrate any difference in the proportion of patients with physician visit within the last 5 months among a subset of the present cohort. Although, it must be recognized that the frequency of physician visit is affected by variables other than access to health care such as presence and severity of medical co-morbidities. Hinkle et al. [3], proposed that observed differences in cardiovascular disease risks were not a result of the educational process itself but rather a result of biological differences in acquired habits, such as in diet and activity, which are formed during childhood and youth and persist into adulthood. We also observed that the effect of educational attainment on myocardial infarction and stroke was more prominent in persons aged 50 years or less. This observation suggests that the adverse consequences of low educational attainment are more likely to manifest in younger age groups. In older persons, perhaps the classical risk factors have a larger impact in determining an individual's risk for cardiovascular diseases.

Issues Related to Data Interpretation

This study is subject to a number of limitations. One limitation is the use of ICD-9 CM codes from death certificates to identify the incidence of cases of stroke and myocardial infarction. Broderick et al. [28] reported a positive-predictive value of 83% by using ICD-9-CM codes for primary diagnoses of strokes and transient ischemic attacks. Iso et al. [29] reported the validity of death certificate diagnoses of stroke and stroke types as the underlying cause of death in a sample of in-hospital deaths from the Minnesota Heart Survey. Relative to diagnoses made by physicians, positive-predictive values for death certificate diagnoses were 100% for all types of stroke, 82% for intracranial hemorrhages, and 97% for nonhemorrhagic strokes. Boyle and Dobson [30] reported a sensitivity of 79% and a positive-predictive value of 66% for hospital diagnostic coding of non-fatal myocardial infarction. Both sensitivity (90%) and positive-predictive values (96%) were higher than hospital abstracts for death certificate data for myocardial infarction. Probably most important, the possibility of misclassification by using ICD-9 CM diagnoses is not different between persons with educational attainment of 12 or more years and less than 12 years. Educational attainment was graded in two broad categories. Such categorization does not allow for the specific technical aspects of the knowledge that has been imparted, which precludes a detailed insight into the educational process. A further limitation is that data regarding stroke risk factors were limited to information collected during the NHANES I and II baseline interviews. Changes in risk factor status during the follow-up period were not considered. Finally, the analysis is likely to underestimate the contributions of risk factors with measurement errors such as those for blood pressure [31] and cholesterol [32]. Because of this under estimation, we may overestimate the magnitude of the adjusted differences in the risk of cardiovascular diseases according to educational attainment.

CONCLUSIONS

Despite these limitations, this present study reports on data obtained from two large national cohorts. The present study is one of the first studies to examine the effect of educational attainment on the incidence of cardiovascular diseases including stroke and its subtypes and myocardial infarction. Our results provide evidence that educational attainment may influence an individual's long-term risk of disease, suggesting a strong effect of education on health. Further studies are required to elucidate the mechanisms by which higher educational attainment effects the risk of cardiovascular disease.

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