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The influence of multiple indices of socioeconomic disadvantage across the adult life course on the metabolic syndrome: the Vietnam Experience Study

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Abstract

Few studies have explored the relationship between individual and combined multiple indicators of socioeconomic status across the life course and the metabolic syndrome, or attempted to understand the mechanisms underlying any associations. The present study examined the associations between 4 indicators of socioeconomic status, individually and in combination, and metabolic syndrome risk in a study of male US veterans and examined the influence of health behaviors, intelligence, and psychologic distress on these associations. Participants (N = 4253) were drawn from the Vietnam Experience Study. From military service files, telephone interviews, and a medical examination, occupational, sociodemographic, health behavior, intelligence, psychologic, and health data were collected. The 4 indices of socioeconomic status were as follows: education achieved, early adulthood income, household income in midlife, and occupational prestige in midlife. Metabolic syndrome was diagnosed from the following: body mass index, fasting blood glucose or a diagnosis of diabetes, blood pressure—a diagnosis of hypertension or taking antihypertensives, high-density lipoprotein cholesterol, and triglyceride levels. In models that adjusted for age, men in the lower 2 groups on the combined measure of socioeconomic status experienced a higher risk of metabolic syndrome. This association was accounted for mainly by education achieved, household income in midlife, and occupational prestige in midlife. Intelligence appeared to explain much of this association. Combined socioeconomic status measures across the life course were related to metabolic syndrome but in a threshold rather than dose-response manner. Intelligence appeared to mediate this relationship.

1. Introduction

Metabolic syndrome is a cluster of symptoms (obesity, high triglyceride levels, low levels of high-density lipoprotein [HDL] cholesterol, raised blood pressure, and high levels of fasting blood glucose or a diagnosis of diabetes) that increases the risk of cardiovascular and all-cause mortality [1]. Those with socioeconomic disadvantages have been reported to exhibit an elevated risk of metabolic syndrome compared with those in higher socioeconomic groups [2,3].

The bulk of the research on socioeconomic status and metabolic syndrome risk either has relied on single indices of socioeconomic status, such as education [4] or occupational grade [2], or, where multiple indices have been available, has examined the risk associated with these separately [5,6]. The observed associations between different indices of socioeconomic status and metabolic syndrome suggest that the greatest risk will be borne by those with a combination of

Ethical approval for the study was given by various bodies, including the US Centers for Disease Control.

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disadvantages, such as brief education, low occupational status, and low income; but importantly, this supposition remains largely untested. Similarly, many studies have only measured socioeconomic status indicators at one particular point in the adult life course. It has been suggested previously that accumulated wealth, as an index of socioeconomic advantage across the life course, may be a stronger (in terms of magnitude) predictor of metabolic syndrome than measures that reflect socioeconomic status at a single time point [7]. Furthermore, the presence of risk factors for cardiovascular disease and/or insulin resistance relates not only to current socioeconomic status, but also to prior socioeconomic circumstances [8,9]. Indeed, the importance of an accumulation of indices of poor socioeconomic circumstances throughout the life course has been emphasized in relation to mortality [10-12]. Thus, it is conceivable that an index incorporating various sources of socioeconomic deprivation at various times throughout the life course might predict metabolic syndrome more strongly than individual indices, and that the more indices of deprivation an individual possesses, the greater the association with metabolic syndrome, in a dose-response manner.

Various characteristics of individual persons might contribute to explaining why low socioeconomic status may increase the risk of metabolic syndrome. For example, those in lower socioeconomic groups are more likely to engage in certain unhealthy behaviors such as smoking, low physical activity, and poor diet, which correlate with obesity, high blood pressure, and a poor lipid profile [13]. There is a suggestion that controlling for these factors appears to explain some of the association between low socioeconomic position and metabolic syndrome risk [6,14]. Unhealthy behaviors may be particularly important risk factors for metabolic syndrome in men [5,15], although others have failed to observe an attenuation of the link between socioeconomic status and metabolic syndrome risk when adjusting for health behaviors [2]. That controlling for such behavioral risk factors apparently fails to completely eliminate the socioeconomic status–metabolic syndrome link raises the possibility that there are other, as yet unmeasured, mediators.

One possible candidate is intelligence or cognitive function (denoted here as *IQ*). IQ is correlated with socioeconomic position, especially education indices [16]; is associated with the prevalence of metabolic syndrome [17]; and partially mediates the association between low socioeconomic position and a range of health outcomes including cardiovascular mortality [16]. Psychologic distress may be another factor accounting for the link between socioeconomic status and metabolic syndrome. Variations in depression and depressive symptomatology with socioeconomic status [18] are well documented, with greater prevalence of depression among the socioeconomically disadvantaged. Furthermore, various indices of psychologic distress have been shown to relate to metabolic syndrome risk [19]. However, to our knowledge, this is the first examination of the effects of IQ and psychologic distress as potential explanatory factors in the socioeconomic status and metabolic syndrome link.

Consequently, the present analyses aimed to examine the links between socioeconomic status and metabolic syndrome in male Vietnam war–era veterans in a novel way through using a combined socioeconomic status index derived from several measures gathered pre-, during, and postservice, from late adolescence through to middle age. It also examined the links between the metabolic syndrome and these socioeconomic status measures individually. It was hypothesized that the risk for metabolic syndrome would be graded according to one's place on a scale of overall socioeconomic adversity accumulated over time. Secondly, given that socioeconomic status may impact upon the development of metabolic syndrome in men via various pathways including poor health habits, intelligence, or psychologic distress, in combined and separate analyses, we considered the extent to which the link between socioeconomic status and metabolic syndrome can be explained by such factors in addition to other demographic and service-related variables (eg, place of service).

2. Method

Fig. 1 details the sampling at each stage of data collection. Ethical approval for the study protocol was given by the US Office for Technology Assessment, the Department of Health and Human Sciences Advisory Committee, the Agent Orange Working Group Science Panel, and a review panel from the US Centers for Disease Control; and informed consent was obtained from all participants. Inclusion criteria were as follows: entered military service between January 1, 1965, and December 31, 1971; served only one term of enlistment; served at least 16 weeks of active duty; earned a military specialty other than "trainee" or "duty soldier"; and had a military pay grade at discharge no higher than sergeant. These inclusion criteria were used to ensure that the sample included frontline soldiers rather than higher-ranking officers, as anecdotal reports of health problems had occurred among infantry men, whose combat exposure was likely to be more intense than that of the officers. Information on military rank, place of service, and ethnicity was extracted from the military archives in 1983. Ethnic origin was classified as "white," "black," or "other," the latter group comprising Hispanics, Asians, Pacific Islanders, American Indians, and Alaskan Natives. Based on military rank at discharge from the army (mean age, 22.5 years; range, 17.9-36.8), the monthly income of the army personnel based on 1964 pay scales was derived (≤\$144/mo; >\$144/mo) and used as an indicator of early adulthood income. From the subsequent telephone survey, household income in midlife (≤\$20 000/y; >\$20 000/y) and grade from which participants left school (≤12th grade; >12th grade) were determined; and an index

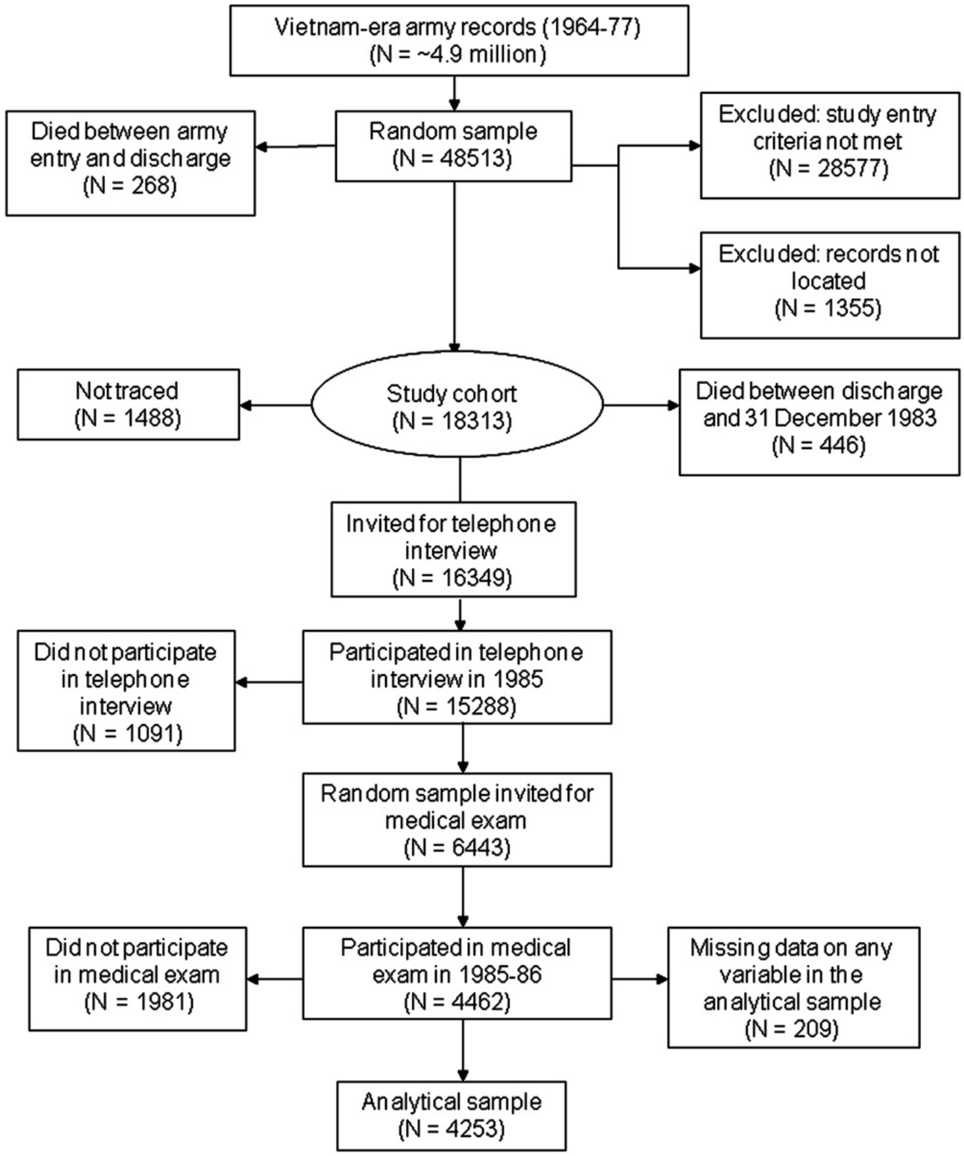

Fig. 1. Sampling in the Vietnam study.

of occupational prestige (≤50th percentile; >50th percentile) was determined using the Occupational Classification Scheme[20]. Frequency of alcohol consumption (units per week), cigarette smoking habits, marital status, and physician-diagnosed diseases were ascertained using standard questions [21]. The final analytic sample size was 4253. This group represents 23% of persons originally enrolled in the study. Although this analytical sample is based on the recruitment of a random sample of surviving men, concerns about selection bias are nonetheless possible, that is, if the reported results differ markedly between persons included in the analyses and those not. Differences between the excluded and included participants were in fact very small: in comparison with the excluded group, men in the analytical sample had higher IQ test scores (means of 101.3 vs 100.4, P = .001); and a greater proportion had service experience in Vietnam (55% vs 51%, P < .001). The fact that these marginal differences reached statistical significance can be ascribed to the large sample size.

Mean age at medical examination was 38.3 years (range, 31.1-49.0). Participants fasted from 7:00 PM on the evening before the examination until blood was drawn the following morning. Serum triglycerides and cholesterol fractions were assessed by an enzymatic method that used an Eastman Kodak (Rochester, NY) cholesterol kit and used the Ektachem test method. High-density lipoprotein cholesterol was measured after dextran sulfate magnesium chloride precipitation of apolipoprotein B–containing lower-density lipoproteins using a Kodak Ektachem 700 autoanalyzer and Kodak clinical chemistry slides. Triglycerides were also measured using Kodak Ektachem test kits and an enzymatic method. Serum glucose level was determined with an adaptation of the glucose oxidase-peroxidase-chromogen–coupled system, also using Kodak Ektachem 700 autoanalyzer. All laboratory assays were conducted between June 1985 and September 1986 on the day the specimen was collected by Loveless Medical Foundation in Albuquerque under contract from and supervision by the Centers for Disease Control. The assays were assured by using bench and blind repeat controls. The blind repeat tests were run for 667 randomly chosen samples; the intraclass correlations between first and repeat samples were 0.98 for HDL and 0.99 for triglycerides. Overall, bench controls yielded coefficients of variation that were all less than 10% [21].

After blood sampling, blood pressure was measured twice in the right arm using a sphygmomanometer; and an average was computed. Resting pulse rate, an indicator of cardiorespiratory fitness and therefore a proxy for regular physical activity [22], was also recorded. Height and weight were then measured to calculate body mass index (BMI, in kilograms per square meter).

After the physiologic measures were taken, psychologic morbidity was assessed using the Diagnostic Interview Schedule (version 3A)[23] as administered by a trained psychologic technician. Study participants were considered positive for generalized anxiety disorder (GAD) and major depressive disorder (MDD) if they reported a pattern of symptoms in the previous 12 months that satisfied the *Diagnostic and Statistical Manual of Mental Disorders, Third Edition* criteria [24]. In the same session, the Army General Technical Test, which consists of 2 subtests, verbal and arithmetic reasoning [17], was administered to assess cognitive ability (hereafter referred to as *IQ*). IQ scores were standardized to z scores for ease of interpretation.

Metabolic syndrome was defined as having at least 3 of the following: BMI greater than 30 kg/m^2 (in the absence of waist circumference data, BMI at this threshold is regarded by World Health Organization as an acceptable substitute in defining metabolic syndrome); triglycerides at least 1.7 mmol/L (150 mg/dL); HDL cholesterol less than 1.036 mmol/L (40 mg/dL); blood pressure at least 130/85 mm Hg, a diagnosis of hypertension, or taking antihypertensive medication; and fasting glucose at least 5.6 mmol/L (100 mg/dL) or a diagnosis of diabetes.

Demographic, service, health behavior, metabolic, and hemodynamic variables were compared between those with and without metabolic syndrome using χ^2 and analysis of variance. The binary indices of socioeconomic status (early adulthood income, education grade achieved, household income in midlife, occupational prestige) were coded such that lower status was assigned a score of 0 and higher status a score of 1. These variables were then summed to form an index of socioeconomic status scored from 0 to 4, thus creating 5 groups where higher scores indicate higher status. First, logistic regression was used to examine the relationship between the socioeconomic status index and metabolic syndrome in a model adjusting for age alone and then in separate models adjusting for other covariates (place of service, ethnicity, marital status), health behaviors (alcohol consumption, smoking, and pulse rate as a proxy for physical activity), IQ, and, finally, psychologic distress (diagnoses of MDD, GAD, posttraumatic stress disorder). Second, to examine which aspect of socioeconomic status was contributing to metabolic syndrome risk, separate age-adjusted analyses were run for each of the original binary socioeconomic status variables. These models were repeated with similar separate adjustment as above.

3. Results

Five hundred eighty-four (14%) of the 4253 men in the analytical sample were identified as having metabolic syndrome. The demographic, health behavior, service-related, metabolic, and hemodynamic characteristics of those with and without metabolic syndrome are presented in Table 1. Study participants with metabolic syndrome were slightly older; were less likely to be divorced, widowed, or separated; were more likely to come from ethnic groups other than white or black; and had somewhat higher pulse rates, a lower IQ, and a higher prevalence of GAD.

As would be expected, the 4 socioeconomic status indices were significantly intercorrelated (*C*s ranged from .17 to .35, $P < .001$).

3.1. Combined socioeconomic status analyses

Age-adjusted logistic regressions showed that the combined life course socioeconomic status score was significantly negatively associated with metabolic syndrome overall, such that those in the lower 2 status groups (scoring 0 or 1) had an increased risk of the metabolic syndrome in comparison with the highest status group (scoring 4). Those in the higher socioeconomic status groups, scoring 2 or 3 on the combined measure, did not differ significantly from the highest status group (scoring 4) in terms of their risk of metabolic syndrome. The outcomes of the age-adjusted analyses for each comparison are shown in Table 2. After adjustment for demographic and service-related variables, it was again men in the lower 2 socioeconomic status groups who experienced the highest risk of the metabolic syndrome. In this model, ethnicity (P = .03) and marital status (P = .001) were also significantly associated with metabolic syndrome, such that those of “other” ethnicity and married were at greater risk. However, it is difficult to pinpoint which of the minority ethnic groups is driving the overall effect of ethnicity; and the ethnicity and marital status effects were unable to attenuate the associations between socioeconomic status and metabolic syndrome.

3.2. Adjustment for potential explanatory factors

Models C, D, and E sought to identify whether particular covariates might explain some of these associations. In model C, health behaviors somewhat attenuated the previous age-adjusted associations with metabolic syndrome; but the prevalence of the metabolic syndrome was

Table 1
Descriptive characteristics of those with and without metabolic syndrome

	Metabolic syndrome (n = 584)		No metabolic syndrome (n = 3669)		P value
	Mean	SD	Mean	SD	
Metabolic syndrome components					
BMI (kg/m^2)	30.7	4.14	25.17	3.04	<.001
Triglycerides (mg/dL; mmol/L)	228.2; 2.6	216.12; 2.43	97.0; 1.1	65.04; 0.73	<.001
HDL cholesterol (mg/dL; mmol/L)	34.8; 0.9	8.16; 0.21	46.3; 1.19	12.28; 0.31	<.001
SBP (mm Hg)	133.3	12.50	121.3	11.10	<.001
DBP (mm Hg)	91.9	9.35	82.9	8.84	<.001
Blood glucose (mg/dL; mmol/L)	106.8; 5.9	30.78; 1.71	92.3; 5.1	12.58; 0.70	<.001
Covariates					
Age at medical examination (y)	38.8	2.52	38.3	2.51	<.001
Units of alcohol/wk	7.3	16.78	7.0	14.01	.71
Pulse rate (beat/min) as index of physical activity	86.4	12.20	80.5	12.00	<.001
Standardized IQ score from medical examination	103.5	20.36	106.6	20.33	<.001
	n (%)		n (%)		P
Metabolic syndrome components					
Obese	346 (59)		203 (6)		<.001
Hypertension diagnosis	435 (74)		646 (18)		<.001
Diabetes diagnosis	333 (57)		386 (11)		<.001
Predictor variables					
Education achieved					
≤12th grade	312 (53)		1763 (48)		.016
>12th grade	272 (47)		1906 (52)		
Army rank at discharge (income)					
≤$144/mo	360 (62)		2271 (62)		.907
≥$145/mo	224 (38)		1398 (38)		
Household income in midlife					
≤$20 000	184 (32)		1016 (28)		.057
>$20 000	400 (68)		2653 (72)		
Occupational prestige					
<50th percentile	320 (55)		1799 (49)		.010
>50th percentile	264 (45)		1870 (51)		
Covariates					
Place of service					
Ever in Vietnam	339 (58)		2009 (55)		.33
Other overseas	142 (24)		952 (26)		
US only	103 (18)		708 (19)		
Ethnicity					
White	472 (81)		3016 (82)		.030
Black	61 (10)		434 (12)		
Other	51 (9)		219 (6)		
Marital status					
Married	459 (79)		2671 (72)		.005
Divorced/separated/widowed	78 (13)		687 (19)		
Never married	6247 (8)		311 (9)		
Smoking status					
Nonsmoker	147 (25)		938 (26)		.97
Exsmoker	165 (28)		1042 (28)		
Current smoker	272 (47)		1689 (46)		
MDD	46 (8)		231 (6)		.15
GAD	77 (13)		333 (9)		.002

SBP indicates systolic blood pressure; DBP, diastolic blood pressure.

still elevated in the lowest status group. In this model, higher pulse rate, as a marker of cardiorespiratory fitness, was significantly associated with metabolic syndrome (P < .001). The addition of IQ to the age-adjusted model (model D) attenuated all previous associations to nonsignificance (Table 2). IQ was negatively associated with metabolic syndrome prevalence (P = .02). However, psychologic distress, as entered in model E, did not attenuate the previous associations shown for the lower 2 socioeconomic groups, although a diagnosis of GAD was significantly related to increased metabolic syndrome risk (P = .01) as reported previously [19].

Table 2
Analyses of the prediction of metabolic syndrome prevalence by the combined and individual socioeconomic status indicators

Model		OR (95% CI)	*P*	OR (95% CI)	*P*	OR (95% CI)	*P*	OR (95% CI)	*P*	OR (95% CI)	*P*
		A		B		C		D		E	
Combined SES index	4 High	1.0 (ref)		1.0 (ref)		1.0 (ref)		1.0 (ref)		1.0 (ref)	
	3	0.97 (0.73, 1.30)	.86	0.99 (0.74, 1.33)	.94	0.95 (0.70, 1.27)	.71	0.92 (0.69, 1.24)	.59	0.98 (0.73, 1.31)	.98
	2	1.14 (0.86, 1.53)	.35	1.17 (0.88, 1.57)	.28	1.13 (0.83, 1.51)	.43	1.03 (0.76, 1.39)	.88	1.14 (0.85, 1.52)	.38
	1	1.42 (1.06, 1.90)	**.02**	1.48 (1.10, 1.99)	**.009**	1.32 (0.98, 1.79)	.07	1.20 (0.87, 1.66)	.27	1.38 (1.03, 1.86)	**.03**
	0	1.54 (1.11, 2.15)	**.01**	1.72 (1.22, 2.41)	**.002**	1.47 (1.05, 2.06)	**.03**	1.25 (0.86, 1.82)	.24	1.48 (1.06, 2.07)	**.02**
Individual indices	High	1.00 (ref)		1.00 (ref)		1.00 (ref)		1.00 (ref)		1.00 (ref)	
Education	Low	1.30 (1.09, 1.55)	**.004**	1.31 (1.10, 1.56)	**.003**	1.26 (1.05, 1.51)	**.012**	1.14 (0.94, 1.39)	.18	1.28 (1.07, 1.53)	**.007**
Early adulthood income	Low	1.07 (0.89, 1.28)	.48	0.92 (0.76, 1.10)	.35	0.95 (0.79, 1.15)	.60	1.03 (0.86, 1.25)	.73	0.95 (0.79, 1.14)	.56
Household income in midlife	Low	1.27 (1.05, 1.54)	**.01**	1.41 (1.15, 1.72)	**.001**	1.23 (1.01, 1.50)	**.04**	1.15 (0.94, 1.40)	.18	1.23 (1.01, 1.49)	**.04**
Occupational prestige	Low	1.35 (1.13, 1.61)	**.001**	1.35 (1.15, 1.65)	**.001**	1.30 (1.08, 1.56)	**.005**	1.21 (1.00, 1.47)	**.05**	1.32 (1.11, 1.58)	**.002**

Model A—age adjusted. Model B—age + place of service, marital status, ethnicity. Model C—age + health behavior adjusted. Model D—age + IQ. Model E—age + psychologic distress. OR indicates odds ratio; CI, confidence interval; SES, socioeconomic status. Values in bold are statistically significant.

3.3. Individual socioeconomic status indicator analyses

In separate age-adjusted models for each socioeconomic status variable, early adulthood income was not associated with metabolic syndrome. However, those with less education, lower occupational prestige, and smaller household incomes in midlife were at increased risk and remained so in the models adjusting for other demographic and service-related variables. Household income in midlife appeared to be the weakest of the 3 significant predictors; and occupational prestige in midlife, the strongest. When health behaviors were added to the models, these significant associations with metabolic syndrome were marginally attenuated but remained significant. In model D, the addition of IQ attenuated all of the associations to nonsignificance, with the exception of occupational prestige, which remained marginally significant. With the addition of psychologic distress in model E, the previous socioeconomic status associations reemerged.

4. Discussion

A combined socioeconomic status score derived from army income, education, household income in midlife, and occupational prestige was significantly associated with the occurrence of metabolic syndrome, such that those at the 2 lowest levels of socioeconomic status were at increased risk of metabolic syndrome in comparison with those at the highest level. These associations appeared to be generated by the contributions of lower educational attainment, smaller household incomes in midlife, and lower occupational prestige. The negative relationship between socioeconomic status and metabolic syndrome in the male veterans was still evident after adjustment for other potential confounding variables (with the exception of IQ), a result that contrasts with some previous reports of robust associations only found in women [25-27]. The relationship with metabolic syndrome did appear to be graded by socioeconomic status score as reflected in the size of the odds ratios; but there also appeared to be a threshold of deprivation such that a significantly increased risk of the metabolic syndrome was only observed in the lowest 2 socioeconomic groups, that is, those with lower than 12th grade education, and lower than the median household income in midlife and poor occupational prestige, or those who only scored above the median on one of these indices or had education beyond 12th grade only. It is possible that after one has accumulated a certain number of socioeconomic disadvantages and their health sequelae, any further accretion cannot add to the health burden. Alternatively, the initial speculation regarding a graded association was based on associations with mortality; but it may be that with different morbidities, there are threshold effects, such as observed here, which contribute to an overall graded association with mortality. However, it should be conceded that, although this is mathematically feasible, it remains to be demonstrated that a socioeconomic threshold effect characterizes other morbidities.

The absence of an individual effect for early adulthood income seems to suggest that income later in life may be more important than income earlier on, although the other earlier-life index, education, was significantly inversely associated with metabolic syndrome risk. A study directly comparing socioeconomic status indicators from different life phases found that, when both adult and childhood socioeconomic indices were considered together, only adult socioeconomic status was related to metabolic syndrome [15]. Furthermore, household wealth accumulated throughout the life course has been shown to predict metabolic syndrome over and above childhood indicators of socioeconomic status, including education [7]. In contrast, others have argued that metabolic syndrome risk can stem, in the large part, from the influence of early and continuing disadvantage throughout life [28]. For example, in one study, the association between adult social class and metabolic syndrome was mainly accounted for by childhood social class, indexed through parental occupation and education, although only for women [28]. However, it is possible that certain early life indices of socioeconomic status may be more pervasive than others, perhaps dependent on the social barriers against amelioration later in life. This would fit with the present data where income was measured at 2 time points, during army service and in midlife, but only income in midlife is significantly associated with metabolic syndrome. Thus, it may be that, in terms of income, relatively proximal means become more important for health than relatively distal circumstances. However, it is also possible that later measures only supersede earlier ones where these are amenable to improvement, such as household occupational status, amenities [15], and wealth [7]. It is worth noting (Table 1) that the proportion of individuals in the lower income category decreases between measurement during service and in midlife. In contrast, education is generally completed earlier in life and thus remains constant for most people. On the other hand, it is possible that the effects of earlier socioeconomic indicators other than education are more protracted for women than men.

Occupational prestige appeared to be driving much of the association between socioeconomic status and metabolic syndrome. This supports the notion that, in affluent societies, relative position is as important for health as absolute position [29]. For example, several studies have shown that measures of income distribution predict life expectancy among developed countries and mortality among states in the United States to a far greater extent than gross domestic product [30].

Health behaviors, other demographic variables, and psychologic distress had only minor effects on the association between the combined index of socioeconomic status and metabolic syndrome. Although others have observed the same outcome for health behaviors [2], there are previous reports that the link between socioeconomic status and metabolic syndrome was moderated by health behaviors, such as physical activity [6,15]. In the present study, pulse rate had to serve as a proxy for physical activity. However, pulse rate was significantly negatively associated with metabolic syndrome risk, and in the individual analyses; nevertheless, its effect on the association between socioeconomic status and metabolic syndrome was trivial. We should concede, in this context, that pulse rate is an imperfect proxy for physical activity. Nevertheless, not all studies with more direct assessment of physical activity have found that it attenuates the association between socioeconomic status and metabolic syndrome [2]. Nonetheless, future investigations would benefit from more direct and comprehensive assessment of health behaviors and include factors such as diet and sleep. Psychologic distress has been mooted as a possible mediator of the associations between socioeconomic status and health outcomes [31]. Although it is clear that psychologic distress is linked to health outcomes such as metabolic syndrome [19], it would not appear to mediate its present association with socioeconomic status.

IQ attenuated the associations between socioeconomic status and metabolic syndrome. This was perhaps unsurprising, given the strong relationship between IQ and health outcomes [17] and socioeconomic status [32]. As such, this study provides further evidence that IQ strongly contributes to socioeconomic inequalities in health. Given that IQ tests capture general learning and reasoning ability and are stable over time, it is possible that IQ partially although not wholly mediates the effect of socioeconomic status on health outcomes, possibly via a lowered ability to successfully manage one's own health [17]. Given that the correlation between IQ and the indicator of socioeconomic exposure herein, and in other cohorts, is not perfect, it is unlikely that IQ is an indicator of socioeconomic position. For a fuller discussion of these issues, please see a previous article [32].

The present study is not without limitations. Not all of the socioeconomic indices were gathered before the assessment of the components of metabolic syndrome. Nevertheless, the present study can boast a range of socioeconomic status indices at different points in the life course. Second, this raises the issue of reverse causality between ill health (metabolic syndrome) and lower socioeconomic status. However, in this particular sample, those already ill would not have been drafted into army service; hence, it is unlikely that ill health led to a downward drift in socioeconomic status. Furthermore, as mentioned above, it was not possible to measure all potential explanatory variables including cardiorespiratory fitness and other important factors such as inflammatory markers. However, these analyses considered a variety of potentially important mediators including IQ, psychologic distress, and health behaviors. Finally, as the sample was exclusively male, there is the issue of generalization. However, middle-aged men are an important constituency in this context given that they have a higher prevalence of metabolic syndrome than middle-aged women [33]. Similarly, when data on metabolic syndrome were collected, the men were relatively young. It is possible that with the increased risk of metabolic syndrome with age [34] and the pervasive effects of socioeconomic status, stronger associations would be evident if such data were gathered in an older sample. However, it should be acknowledged that others have demonstrated no influence of the individual components of education and income in older men [35], whereas in other studies with a greater age range, associations between socioeconomic status and the metabolic syndrome have survived correction for age [2].

In conclusion, male army veterans with 3 or more indications of unfavorable socioeconomic circumstances are at an increased risk of developing metabolic syndrome in middle age, regardless of health behaviors and psychologic distress. This suggests that interventions should pay particular heed to those with multiple indices of disadvantage. Finally, differences in IQ account for much of the association between socioeconomic status and metabolic syndrome; it is possible that socioeconomic status may, in part, be a proxy for cognitive ability, which per se has major implications for health.

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