Explaining Educational Differences in Mortality: The Role of Behavioral and Material Factors

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A B S T R A C T

Objectives. This study examined the role of behavioral and material factors in explaining educational differences in all-cause mortality, taking into account the overlap between both types of factors.

Methods. Prospective data were used on 15 451 participants in a Dutch longitudinal study. Relative hazards of all-cause mortality by educational level were calculated before and after adjustment for behavioral factors (alcohol intake, smoking, body mass index, physical activity, dietary habits) and material factors (financial problems, neighborhood conditions, housing conditions, crowding, employment status, a proxy of income).

Results. Mortality was higher in lower educational groups. Four behavioral factors (alcohol, smoking, body mass index, physical activity) and 3 material factors (financial problems, employment status, income proxy) explained part of the educational differences in mortality. With the overlap between both types of factors accounted for, material factors were more important than behavioral factors in explaining mortality differences by educational level.

Conclusions. The association between educational level and mortality can be largely explained by material factors. Thus, improving the material situation of people might substantially reduce educational differences in mortality. (*Am J Public Health.* 1999;89: 535–540)

Since the publication of the "Black Report" in 1980,[1] one of the issues in the debate on the causes of socioeconomic inequalities in mortality has been the possible contributions of behavioral vs material factors. Both types of factors fit within the framework of the causation theory, in which socioeconomic inequalities in mortality are explained by a differential distribution of determinants of health across socioeconomic groups. The behavioral explanation of socioeconomic inequalities in mortality focuses on the behavior and lifestyle adopted by people from different socioeconomic groups. Behavioral factors that might be distributed unequally across socioeconomic groups include smoking, dietary habits, and physical activity. The material explanation of socioeconomic inequalities in mortality emphasizes the role of material factors, such as housing conditions and employment status, that differ among socioeconomic groups.[2]

Most studies on socioeconomic status and cause-specific mortality have focused on behavioral factors in combination with biological risk factors as explanations for the higher mortality in the lower socioeconomic groups. These studies indicated that part of the socioeconomic gradient in either all-cause or cause-specific mortality remains unexplained after adjustment for behavioral and biological risk factors.[3–9] Fewer studies have focused on the role of material factors, either isolated or in combination with behavioral factors; evidence of the relative contribution of behavioral and material factors in explaining the socioeconomic gradient in mortality is very scarce.[3]

When studying the effect of behavioral and material factors on the association between socioeconomic status and mortality, it is important to consider the overlap between both types of factors. Part of the unhealthy behavior in the lower socioeconomic groups is likely to be induced by adverse material conditions. For example, people might smoke to compensate for unfavorable living conditions such as a low income.[3] This implies that the unequal distribution of behavioral factors across socioeconomic groups can be partly ascribed to the unequal distribution of material factors. The independent contribution of behavioral factors to the explanation of socioeconomic inequalities in mortality is therefore easily overestimated.[10]

In this article, we report on the association between educational level and all-cause mortality by using 5-year mortality data from a large longitudinal study on socioeconomic inequalities in health in the Netherlands. We followed the framework of the causation theory to study behavioral and material factors as possible explanations of the association between educational level and mortality. Both their independent effect on the association between educational level and mortality and their overlap are presented.

Subjects and Methods

The subjects were participants in the Longitudinal Study on Socioeconomic Health Differences, which aims to explain socioeconomic inequalities in health in the Netherlands.[11] In 1991, an aselect sample (stratified by age, degree of urbanization, and socioeconomic status) of 27 070 non-institutionalized Dutch persons (aged 15 to 74 years) was drawn from 18 municipal pop-

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ulation registers in the southeastern Netherlands. The study started with a postal survey (response rate 70.1%, n = 18 973). The difference in response rate by socioeconomic status, age, and gender was small.[11]

Data on educational level, confounders, health status at baseline, and behavioral and material factors were collected through the survey. We measured the highest level of education attained, with students classified according to their current training. Four educational categories were distinguished: (1 = high) higher vocational school and university, (2) intermediate vocational school and intermediate or higher secondary school, (3) lower vocational school and lower secondary school, and (4 = low) primary school only. Confounders included in the analyses were age (5-year categories; the 6 youngest categories [15 to 44 years] were combined because the total number of deaths in these categories was only 17), gender, marital status (4 categories), degree of urbanization (4 categories), and religious affiliation (4 categories). We excluded respondents with a lack of data on educational level or confounders (n = 1089, 5.7% of the original sample of 18973).

Respondents were asked whether they had any chronic illness at the time of the survey, by means of a checklist of 23 chronic conditions. We excluded those reporting 1 or more of 6 severe chronic diseases at baseline that potentially affect survival (diabetes, heart disease, stroke, chronic obstructive pulmonary disease, severe kidney disease, cancer) (n = 2433, 12.8%). In this way, we excluded respondents who might have undergone changes in behavioral (e.g., stopped smoking) or material factors (e.g., left the labor market) because of the serious disease they had at baseline. Finally, 15451 respondents were left for analyses.

We considered the following behavioral factors in the study (distinguished categories are in parentheses). *Alcohol consumption* was measured by questions on (1) the average number of days per week that the respondent drinks and (2) the average number of units drunk per day (respondents were classified as total abstainers, light drinkers, moderate drinkers, excessive drinkers, or very excessive drinkers). *Smoking* was measured by questions on the current smoking status and the number of cigarettes, cigars, or pipes smoked per day (respondents were classified as never smokers, former smokers, pipe or cigar smokers, less than 20 cigarettes per day, or at least 20 cigarettes per day). *Body mass index* was based on self-reported height and weight and calculated as weight/height^2 (<20 kg/m^2, 20–27 kg/m^2, >27 kg/m^2). *Physical activity* was based on (1) the number of hours per week spent on gardening, cycling, and walking and (2) the number of hours per week spent on physical exercise; the total was calculated with the second type of activity given twice as much weight as the first (no, light, moderate, frequent activity). *Dietary habits* concerned (1) the average number of days per week the respondent eats breakfast (0; 1 to 5; 6 or 7 times), (2) the average number of cups of coffee the person drinks per day (0, 1, or 2; 3 or 4; 5 or 6; at least 7), and (3) a question on whether the respondent eats meat as part of the main meal at least 4 times per week (yes, no).

We measured the following material factors: *Financial problems* were measured by a question on the difficulty the respondent had in paying bills for food, rent, electricity, and so forth during the preceding year (no problems, some problems, many problems). *Adverse neighborhood conditions* were measured by 4 questions about noise (neighbors and traffic), smell, and vandalism in the neighborhood (no, 1, 2, 3, or 4 problems). *Adverse housing conditions* were measured by 3 questions on cold, mold, or dampness in the house (no, 1, 2, or 3 problems). *Crowding* was defined as the number of persons per room, based on self-report. *Employment status* was measured by the respondent's self-reported main activity (working, unemployed, receiving long-term work disability, retired, housewife, or other [e.g., students, soldiers]). Finally, we constructed an *income proxy,* which was based on the type of health insurance (private or public), car ownership (yes or no), and housing tenure (rented house or house owner).[12] We distinguished 5 categories: (1 = high) private insurance, house owner; (2) private insurance, rented house; (3) public insurance, house owner; (4) public insurance, rented house, car; (5 = low) public insurance, rented house, no car.

For each of the behavioral and material factors, respondents with a missing value remained in the analyses as a separate category.

Information on the vital status of respondents on July 15, 1996, and the date of death for the deceased were provided by municipal population registers in and outside the study area. These registers cover the population virtually completely and are maintained continuously with respect to deaths and changes of address. People who moved from the study area were traced through the municipal register of their new residence. For one municipality (n = 810), we used information on respondents' vital status on July 31, 1995.

Cox proportional hazards models[13] were used to analyze mortality by educational level (highest group as reference category) and by single behavioral and material factors, adjusted for confounders. All variables were coded as dummy variables. Statistical significance of the association between each factor and mortality was determined by the reduction in deviance caused by adding a factor to a model with confounders only. Age- and gender-standardized percentages of respondents in each category of the behavioral and material factors by educational level were calculated with the direct method.

Factors that were statistically significantly related to mortality and that varied by educational level were added separately to a model with educational level and confounders. The percent change in relative hazards for educational groups after addition of each factor was then evaluated. The effect of simultaneously adding all significant behavioral factors, as well as all significant material factors, to a model containing educational level and confounders was evaluated. The final model contained educational level, confounders, and both behavioral and material factors. The following models were fitted:

1. Educational level + confounders + behavioral factors
2. Educational level + confounders + material factors
3. Educational level + confounders + behavioral factors + material factors

TABLE 1—Number and Percentage of Respondents, Number and Percentage of Deaths, and Relative Hazard of All-Cause Mortality by Level of Education: Southeastern Netherlands, 1991–1996

Educational Level[a]	No. of Respondents	Respondents, %	No. of Deaths	Deaths, %	Relative Hazard[b] (95% Confidence Interval)
1 (High)	3012	19.5	40	1.3	1.00
2	3551	23.0	54	1.5	1.28 (0.85, 1.93)
3	5964	38.6	131	2.2	1.48 (1.02, 2.13)
4 (Low)	2924	18.9	123	4.2	1.64 (1.13, 2.40)
Total	15 451	100	348	2.3	

[a]1 (High) = higher vocational school and university; 2 = intermediate vocational school and intermediate or higher secondary school; 3 = lower vocational school and lower secondary school; 4 (Low) = primary school.
[b]Adjusted for age, gender, marital status, religious affiliation, and degree of urbanization.

TABLE 2—Association Between Behavioral and Material Factors and All-Cause Mortality, With Relative Hazard (RH) and 95% Confidence Interval (CI) Adjusted for Confounders[a]: Southeastern Netherlands, 1991–1996 (n = 15 451)

Behavioral Factor	RH	95% CI	Material Factor	RH	95% CI
Alcohol consumption			Financial problems*		
Total abstainer	1.32	0.96, 1.88	No	1.00	
Light	1.04	0.77, 1.41	Some	1.14	0.86, 1.50
Moderate	1.00		Many[b]	2.48	1.62, 3.81
Excessive	1.08	0.62, 1.87	Missing value	0.63	0.23, 1.70
Very excessive[b]	2.01	1.22, 3.29			
Missing value	1.15	0.68, 1.92			
Smoking*			Adverse neighborhood conditions		
Never	1.00		No problems	1.00	
Former smoker	1.06	0.77, 1.45	1 problem	1.01	0.77, 1.32
Pipe/cigar smoker	1.62	0.96, 2.73	2 problems	0.94	0.63, 1.41
<20 cigarettes[b]	1.66	1.21, 2.27	3 or 4 problems	0.85	0.44, 1.65
≥20 cigarettes[b]	2.54	1.67, 3.86	Missing value	0.94	0.39, 2.28
Missing value	0.77	0.24, 2.47			
Body mass index*			Adverse housing conditions		
<20 kg/m^2 [b]	1.81	1.16, 2.83	No problems	1.00	
20–27 kg/m^2	1.00		1 problem	1.20	0.90, 1.61
>27 kg/m^2 [b]	1.58	1.25, 2.00	2 problems	1.21	0.76, 1.90
Missing value	0.48	0.21, 1.08	3 problems	1.37	0.67, 2.77
			Missing value	0.89	0.37, 2.17
Physical activity*			Crowding	0.99	0.90, 1.09
Frequent	1.00				
Moderate[b]	1.76	1.28, 2.42			
Light[b]	2.55	1.73, 3.75			
No[b]	4.95	3.27, 7.50			
Missing value	1.29	0.60, 2.74			
Breakfast frequency			Employment status*		
Never	1.00		Working	1.00	
1–5 times/week	1.06	0.57, 1.94	Unemployed	1.10	0.47, 2.57
6–7 times/week	0.95	0.59, 1.54	Long-term work disability[b]	3.75	2.47, 5.68
Missing value	1.20	0.40, 3.55	Retired	1.51	0.98, 2.35
			Housewife	1.36	0.84, 2.20
			Other	1.04	0.34, 3.16
			Missing value[b]	2.14	1.05, 4.38
Coffee consumption			Income proxy*		
0–2 cups/day	1.00		Private insurance, house owner	1.00	
3 or 4 cups/day	0.84	0.61, 1.14	Private insurance, rented house	1.02	0.70, 1.49
5 or 6 cups/day	1.16	0.85, 1.58	Public insurance, house owner	1.24	0.87, 1.76
≥7 cups/day	1.26	0.89, 1.78	Public insurance, rented house, car[b]	1.65	1.21, 2.23
Missing value	1.35	0.42, 4.31	Public insurance, rented house, no car[b]	1.63	1.12, 2.36
			Missing value	1.04	0.41, 2.60
Meat with meal, per week					
<4 times	1.00				
≥4 times	1.35	0.94, 1.95			
Missing value	0.39	0.10, 1.57			

[a]Adjusted for age, gender, marital status, religious affiliation, and degree of urbanization.
[b]The categories of behavioral and material factors that showed a statistically significantly elevated risk of mortality (compared with each specific reference category).
*P value reduction in deviance < .001.

The independent contribution of behavioral factors (i.e., independent of material factors) was determined by the percent reduction of the relative hazards for educational level due to the inclusion of behavioral factors (model 3) to a model already containing material factors (model 2). The overlap between material and behavioral factors was then calculated by subtraction of the independent contribution of behavioral factors from the total contribution of behavioral factors (compare model 1 with the difference between models 2 and 3). This overlap is defined as the indirect effect of material factors through behavioral factors. The direct effect of material factors was then calculated by subtraction of the overlap from the total contribution of material factors (model 2 minus the calculated overlap).

Results

Table 1 shows a higher relative hazard of mortality in each of the lower educational groups as compared with the highest educational group (adjusted for confounders). Data on men and women were combined ($P = .8521$ for interaction between gender and educational level).

Table 2 shows the association between behavioral and material factors and mortality. For the next step in the analyses, we selected factors that were statistically significantly related to mortality (smoking, body mass index, physical activity, financial problems, employment status, income proxy) and factors for which respondents in at least 1 category showed a significantly elevated mortality risk (alcohol consumption).

The percentages of respondents in the above-mentioned categories of behavioral and

TABLE 3—Baseline Prevalence of High-Risk Categories of Behavioral and Material Factors by Educational Level, With Age- and Gender-Standardized Percentage: Southeastern Netherlands, 1991 (n = 15451)

	Educational Level[a]				
	1 (High)	2	3	4 (Low)	Total
Alcohol consumption					
Very excessive	1.8[b]	2.7	3.2	4.1	2.7
Smoking					
<20 cigarettes/day	18.3	24.4	30.0	34.5	26.7
≥20 cigarettes/day	4.5	5.3	7.5	10.3	6.5
Body mass index					
<20 kg/m^2	11.3	11.2	8.0	6.9	9.4
>27 kg/m^2	10.2	14.4	18.7	24.0	16.9
Physical activity					
Moderate	46.1	45.4	50.1	57.2	49.3
Light	8.5	9.6	11.4	12.4	10.6
No	1.8	3.6	4.7	6.6	4.1
Financial problems					
Many	1.9	2.4	3.3	7.5	3.5
Employment status					
Long-term work disability	2.5	3.7	5.7	11.4	5.4
Income proxy					
Public insurance, rented house, car	8.8	17.3	28.4	38.7	24.3
Public insurance, rented house, no car	5.3	6.0	9.1	18.7	9.9
Total no. of respondents	3012	3551	5964	2924	15451

[a]1 (High) = higher vocational school and university; 2 = intermediate vocational school and intermediate or higher secondary school; 3 = lower vocational school and lower secondary school; 4 (Low) = primary school.
[b]The percentage of respondents reporting the specific risk category per educational group; for example, 1.8% of those in the highest educational group reported excessive alcohol consumption.

TABLE 4—Effect of Adjustment for Behavioral and Material Factors on the Association Between Educational Level and All-Cause Mortality, With Relative Hazard (RH) and 95% Confidence Interval (CI) for Educational Categories and Percent Change in RH[a]: Southeastern Netherlands, 1991–1996 (n = 15 451)

	Educational Level[b]			
Adjusted For	1 (High)	2 RH (95% CI)	3 RH (95% CI)	4 (Low) RH (95% CI)
Confounders[c]	1.00	1.28 (0.85, 1.93)	1.48 (1.02, 2.13)	1.64 (1.13, 2.40)
Confounders +				
Alcohol	1.00	1.25 (0.83, 1.89)	1.42 (0.98, 2.06)	1.54 (1.05, 2.27)
% Change		11	12	16
Smoking	1.00	1.27 (0.84, 1.92)	1.44 (1.00, 2.08)	1.57 (1.07, 2.30)
% Change		4	8	11
Body mass index	1.00	1.23 (0.82, 1.87)	1.43 (0.99, 2.07)	1.59 (1.09, 2.32)
% Change		18	10	8
Physical activity	1.00	1.21 (0.80, 1.83)	1.34 (0.93, 1.94)	1.42 (0.97, 2.08)
% Change		25	29	34
Financial problems	1.00	1.26 (0.83, 1.90)	1.44 (1.00, 2.09)	1.54 (1.05, 2.26)
% Change		7	8	16
Employment status	1.00	1.19 (0.79, 1.80)	1.34 (0.92, 1.94)	1.40 (0.95, 2.06)
% Change		32	29	37
Income proxy	1.00	1.18 (0.78, 1.80)	1.25 (0.84, 1.87)	1.29 (0.84, 1.99)
% Change		36	48	55

[a]Percentage change calculated by (RH model A) − (RH model B)/[(RH model A) − 1]; model A = educational level + confounders; model B = educational level + confounders + behavioral or material factor.
[b]1 (High) = higher vocational school and university; 2 = intermediate vocational school and intermediate or higher secondary school; 3 = lower vocational school and lower secondary school; 4 (Low) = primary school.
[c]Adjusted for age, gender, marital status, religious affiliation, and degree of urbanization.

material factors for which we found an elevated mortality risk are presented in Table 3 by educational level. For all but 1 of these categories, the percentage of people in the high-risk category was higher in the lower educational groups. The only exception was a body mass index below 20 kg/m^2, which was more common in the higher educational groups.

In the next step of the analyses, the behavioral and material factors that were related to both mortality (Table 2) and educational level (Table 3) were added to a model with educational level and confounders. Table 4 shows that of the 4 behavioral factors, physical activity caused the largest change in relative hazards for the educational groups. Simultaneous adjustment for the 4 behavioral factors resulted in reductions of 54%, 48%, and 53% of the relative hazards for educational groups (Table 5).

Of the 3 remaining material factors, the income proxy caused the largest change in relative hazards for educational level (Table 4). When the 3 material factors were added simultaneously to a model with educational level and confounders, the resulting percent changes in relative hazards for the educational groups were 46%, 52%, and 67% (Table 5).

Simultaneous adjustment of the association between educational level and mortality for the 4 behavioral and 3 material factors that had remained in the analyses resulted in reductions of 75%, 77%, and 92% of the relative hazards for the second highest to the lowest educational group (Table 5).

In Table 5, the total effect of behavioral and material factors is divided into the independent contribution of behavioral factors, the indirect effect of material factors (through behavioral factors), and the direct effect of material factors. Behavioral factors independently reduced the hazard ratios for educational groups by 29%, 25%, and 25% from the second highest to the lowest educational group. The remainder of the total reduction caused by behavioral factors can be defined as the overlap between behavioral and material factors or the indirect effect of material factors (25%, 23%, and 28%). Consequently, the total reduction caused by material factors (46%, 52%, and 67%) is the result of an indirect effect of material factors (25%, 23%, and 28%) and a direct effect of material factors (21%, 29%, and 39%).

Discussion

The association between educational level and all-cause mortality was largely

TABLE 5—Effect of Adjustment for Behavioral and Material Factors on the Association Between Educational Level and All-Cause Mortality, With Relative Hazard (RH) and 95% Confidence Interval (CI) for Educational Categories and Percent Change in RH[a]: Southeastern Netherlands, 1991–1996 (n = 15 451)

Educational Level[i]	Confounders (Model 0[b]) RH (95% CI)	Confounders + Behavioral Factors (Model 1[c]) RH (95% CI)	Confounders + Material Factors (Model 2[d]) RH (95% CI)	Confounders + Material and Behavioral Factors (Model 3[e]) RH (95% CI)	Independent Effect Behavioral Factors[f]	Indirect Effect Material Factors[g]	Direct Effect Material Factors[h]
1 (High)	1.00	1.00	1.00	1.00			
2	1.28 (0.85, 1.93)	1.13 (0.75, 1.72)	1.15 (0.76, 1.76)	1.07 (0.70, 1.64)	75−46 = 29%	54−29 = 25%	46−25 = 21%
% Change		54	46	75			
3	1.48 (1.02, 2.13)	1.25 (0.86, 1.82)	1.23 (0.82, 1.84)	1.11 (0.74, 1.67)	77−52 = 25%	48−25 = 23%	52−23 = 29%
% Change		48	52	77			
4 (Low)	1.64 (1.13, 2.40)	1.30 (0.88, 1.93)	1.21 (0.78, 1.86)	1.05 (0.68, 1.64)	92−67 = 25%	53−25 = 28%	67−28 = 39%
% Change		53	67	92			

[a]Percent change calculated by (RH model 0)−(RH model 1, 2, or 3)/[(RH model 0)−1].
[b]Model 0 = adjusted for age, gender, marital status, religious affiliation, and degree of urbanization.
[c]Model 1 = educational level + confounders + alcohol consumption + smoking + body mass index + physical activity.
[d]Model 2 = educational level + confounders + financial problems + employment status + income proxy.
[e]Model 3 = educational level + confounders + alcohol consumption + smoking + body mass index + physical activity + financial problems + employment status + income proxy.
[f]Percentage reduction of relative hazards for educational groups due to inclusion of behavioral factors (model 3) to a model already containing material factors (model 2): % model 3−% model 2.
[g]Calculated by subtracting the independent contribution of behavioral factors from the total contribution of behavioral factors (model 1): % model 1−independent effect of behavioral factors.
[h]Calculated by subtracting the overlap from the total contribution of material factors: % model 2−overlap.
[i]High (1) = higher vocational school and university; (2) = intermediate vocational school and intermediate or higher secondary school; (3) = lower vocational school and lower secondary school; low (4) = primary school.

explained by a differential distribution of behavioral and material factors across educational groups, where material factors were more important than behavioral factors. In a previous study[10] on socioeconomic inequalities in self-reported health, conducted in the same population as the current study, the method used in the present study to measure the contribution of both behavioral and material factors was developed and illustrated. The results of that cross-sectional study suggested that the contribution of material factors to the explanation of socioeconomic inequalities in self-reported health was at least as large as the contribution of behavioral factors.[10] In the current study, we were able to draw firmer conclusions on the association between both groups of explanatory factors and mortality. First, the present study was longitudinal, which implies that the studied explanatory factors were more likely to have a causal effect on the outcome. Furthermore, mortality was the measure of outcome, which is an *objective* outcome measure, as opposed to *perceived* general health in the previous study.

We excluded the respondents with severe chronic disease at baseline from our analysis to eliminate possible selection effects. For example, the risk of mortality for ex-smokers was only slightly higher than that for current smokers, which indicates that the elimination of selection was indeed successful. Still, we may not have adjusted sufficiently for health status at baseline by using data on self-reported severe chronic conditions. Underreporting of chronic conditions is higher in the lower educational groups, as well as in our study population,[14,15] so the population included in our analyses likely contains a subgroup of respondents with an unreported severe chronic condition. Because we expect higher mortality among these respondents, and because underreporting is more common in the lower educational groups, the mortality differences by educational level as presented in this paper might be overestimated.

The effect of explanatory factors on the association between educational level and mortality might not be the same among respondents excluded because of severe chronic disease as it was among those remaining in the analyses. To determine whether this was the case, we compared the results from the analyses presented in this paper with the results from analyses that included the respondents with a severe chronic disease. This comparison indicated that excluding from the analysis respondents with a severe chronic disease at baseline did not substantially affect the estimates of the relative contribution of single behavioral and material factors (results not shown).

The measurement of behavioral and material factors in this study may be criticized in several ways. Most information was obtained by asking one or a few simple questions. For example, detailed information on dietary habits (behavior) was not available for this sample, and only some very broad indicators of a possible underlying food consumption pattern were known. Furthermore, we did not gather information on lifetime exposure to adverse behavioral and material factors.

Also, some explanatory (material) factors, such as adverse physical working conditions, were not included in the study. Although we included the most important explanatory factors (both behavioral and material) in our analyses, a different set of factors might have resulted in different estimates of the relative contribution of both behavioral and material factors to the explanation of mortality differences by educational level.

We hypothesized that the overlap between material and behavioral factors can be defined as the effect of material factors on behavioral factors. One might argue that this overlap also can be defined as the effect of behavioral factors on material factors. For example, financial problems might result from the large amount of money a person spends on alcohol. Although this might be true for a small percentage of our study population (e.g., excessive drinkers), we believe that the mechanism hypothesized in this article is much more important in explaining socioeconomic inequalities in mortality.

Our analyses are thus based on the assumption that behavioral factors are par-

tially embedded in material factors—that is, people may engage in health-damaging behavior (such as smoking) to cope with adverse material circumstances (such as a low income),[16,17] or a lack of money may prevent people from engaging in health-promoting behavior (such as a healthy diet).[18] Our findings suggest the need for an in-depth study of the underlying reasons why people, given their material circumstances, engage in health-damaging behavior or do not engage in health-promoting behavior.

In this study, the most powerful behavioral determinant of the association between education and mortality was physical activity. A protective effect of physical activity for all-cause mortality has been reported repeatedly in other studies in which initial health status was taken into account.[19–21] A proxy of income, composed of information on type of health insurance, car ownership, and housing tenure, was the most powerful material determinant of mortality. The association between these factors and mortality also has been reported before; mortality is lower in people who have private insurance, who own houses, and who own cars.[6,22,23]

We have shown that material factors also have a direct effect on mortality by education: those who have many financial problems, who have a relatively adverse income situation, and who are not working because of a disability have relatively high mortality after 5 years of follow-up. The mechanisms through which adverse material conditions influence mortality negatively, such as the effect of stress caused by negative circumstances, should be further explored.

Possible explanations of the association between educational level and mortality other than behavioral and material factors should be considered in future studies. Of importance are, for example, psychological characteristics, psychosocial stress, and the effects of one's relative position in the social hierarchy.[24] Analogous to the overlap we found between behavioral and material factors, it is very likely that there is overlap between, for example, psychosocial stress and behavioral and material factors.

The results from this study show that the association between educational level and all-cause mortality is largely determined by material factors. This suggests that improving the material situation of people might substantially reduce educational differences in mortality, both directly and through behavioral factors. We identified several specific conditions that could be the target of policy measures—income, financial problems, and employment status. To tackle these types of conditions, policy measures should be directed toward changes in the social structure (e.g., guarantee a minimum income for all Dutch citizens, which would also affect the prevalence of financial problems in the low socioeconomic groups). The importance of the employment status factor indicates that policy measures should also be aimed at improving the working conditions of high-risk groups to prevent them from leaving the labor market because of a long-term work disability.

Finally, the results of our study show that behavioral factors have an independent effect on the association between educational level and mortality. Therefore, health-promoting activities aimed at risk factors such as smoking and lack of physical activity might also contribute to a reduction of mortality differences by educational level. □

Contributors

Each of the 4 authors contributed to the conception and design of the study. C. T. M. Schrijvers analyzed the data, and all 4 authors interpreted the results. C. T. M Schrijvers wrote the paper with the assistance of the other authors. Each author approved the final version.

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