RESEARCH REPORT

Educational level as a contextual and proximate determinant of all cause mortality in Danish adults

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Study objective: To examine the educational level in the area of living as a determinant of all cause mortality, controlling for individual and other correlated contextual factors.
Design: Pooled data from two population based cohort studies were linked to social registers to obtain selected socioeconomic information at parish and individual level. A total of 18 344 men and women were followed up from 1980 until October 1999.
Setting: Copenhagen, Denmark.
Main outcome measure: All cause mortality.
Results: During follow up 2614 men and women died. Educational status both at parish (hazard ratio (HR): 0.87 (95% CI 0.77 to 0.98) and individual level (HR: 0.76 (95% CI 0.64 to 0.88) were inversely associated with mortality, when comparing the higest educated groups with the least educated. However, at parish level the effect was only present, when information on subject's income, behaviour (smoking, exercise, alcohol use, and body mass index) and contextual factors (local area unemployment, income share, and household composition) were included in the Cox model.
Conclusion: In this study the educational level of an area influenced subject's mortality, but first after adjustment for behavioural and other contextual risk factors. Neighbourhood education is one of different characteristics of adverse social conditions in an area increasing mortality.

An increasing number of studies indicate that living in an area characterised by poor socioeconomic conditions has negative health effects.[1–3] Besides confounding from individual level socioeconomic factors, some causal mechanisms linking specific characteristics of neighbourhoods to health of the persons who reside in them have been suggested.[1–5] Underinvestment in social infrastructure and lack of material resources (access to health services, decent housing, recreational facilities) in deprived neighbourhoods may adversely affect the sociocultural environment by increasing social disintegration and decreasing public commitment. People's attitudes towards health and behaviour are influenced by the context and could be considered a mediating mechanism between contextual measures and health outcomes. Although, many characteristics of neighbourhoods are correlated, some chararcteristics may be more related to health than others and they may operate through different mechanisms. Recently, Muller[6] showed that the prevalence of people without high school education absorbs the effect of income inequality and is a more powerful predictor of the variation in mortality among US states. The study suggested that lack of high school education affected mortality by economic resource deprivation, risk of occupational injury, and learnt risk behaviour, and in contrast with other context measures such as income inequality and employment status, it also captured the lifetime cummulative effects of adverse socioeconomic conditions.[6] However, because education is typically conceived and measured as a fixed individual attribute,[7] only few cohort studies have examined associations between education measured at neighbourhood level and individual level health outcomes. Two cohort studies from Canada[8] and the Netherlands[9] have examined the effect of neighbourhood educational level on individual's mortality risk. In a six year follow up of 8500 Dutch adults from the City of Eindhoven, subjects living in neighbourhoods, where the percentage of residents with only primary schooling were high, had a slightly higher risk of dying compared with those living in a neighbourhood with a low percentage of the population having only primary school. This effect was no longer significant after controlling for individual level socioeconomic characteristics.[9] Veugelers *et al*[8] followed up 2116 adults from Nova Scotia for 10 years and found that subjects living in neighbourhoods with more than 15% of the population having an education of less than ninth grade, experienced the same risk of dying compared with those living in neighbourhoods with a lower percentage of less educated.

In this population based cohort study we examine whether the educational level in area of living is associated with all cause mortality after stepwise adjustment for spouse and subjects own education and behaviour as well as for some of the contextual factors typically correlated with high levels of education.[6 10]

METHODS

Study population

The study is based on data from two longitudinal population studies conducted in Copenhagen: The Copenhagen City Heart Study (CCHS), and the Glostrup Population Studies (GPS). The original purpose of these studies was to examine cardiovascular risk factors, and they have been described in detail previously.[11 12] Briefly, the CCHS population comprised 14 223 randomly selected, age stratified men and women aged 20 years or more from a defined area of Central Copenhagen, who were examined in 1976–78. In 1981–83 and 1993–94, subjects were re-examined, and 3816 new subjects were included. The GPS have since 1964 followed up different birth cohorts of the population in selected Western suburbs of Copenhagen. All cohorts were sampled randomly, and had an equal distribution of men and women. For this study we used data from the following birth cohorts: 1105 subjects born in 1936 examined in 1976, 1981, and 1987; 3758 subjects randomly sampled from four birth cohorts (1922, 1932, 1942, and 1952) examined in 1982, 1987 and 1992; 1399 subjects (born in 1927, 1937, 1947, and 1957) examined in 1982, and 2010 subjects (born in 1932, 1942, 1952, and 1962) examined

Table 1 Baseline distribution of covariates according to individual, spouse, and area (parish) educational level

Educational level	n	Men %	Mean age (y)	Smoker %	Inactive %	High alcohol use %	Mean BMI (kg/m²)	Basic education %	Mean* household income	Unemployment %	Area level: Income† share (%)	Households with children %
Neighbourhood: % with vocational education												
Lowest quartile (range 52.7–67.2)	3706	50.2	43.1	58.2	26.3	13.2	24.5	37.5	35.1	9.4	22.7	40.7
Second quartile (range 67.3–69.3)	5141	49.2	44.8	63.1	22.9	13.6	24.8	43.7	32.4	8.8	21.6	32.2
Third quartile (range 69.4–72.9)	4647	46.4	45.2	60.8	21.4	13.5	24.5	40.6	32.6	6.4	23.4	28.3
Highest quartile (range 73.0–79.1)	4850	44.0	47.0	61.3	20.8	12.8	24.9	42.0	32.4	6.0	22.7	24.5
Individual:												
Basic	7699	40.4	47.2	67.1	26.2	13.2	25.3		28.4	8.0	24.3	29.0
High school	969	51.5	37.3	52.0	14.6	11.5	23.0		25.1	8.7	22.8	25.6
Short vocational	7633	51.9	44.4	58.3	20.8	13.9	24.5		35.6	7.0	22.3	33.7
Long vocational	2043	52.6	42.0	49.2	17.3	11.5	23.6		44.3	7.1	22.6	30.1
Spouse:												
Basic	4543	59.2	46.2	66.2	23.4	15.9	25.4	59.4	36.1	7.5	23.1	32.1
High school	386	51.5	36.9	49.8	18.9	13.1	23.0	13.7	40.2	8.0	22.5	29.4
Short vocational	4999	48.1	43.6	57.9	21.6	11.5	24.5	28.9	41.9	6.7	23.6	35.9
Long vocational	1214	42.3	41.0	44.2	16.6	8.6	23.4	12.7	55.0	6.7	23.1	34.1
Single	4952	48.8	46.3	64.6	24.5	16.6	24.7	44.2	18.2	8.5	22.1	24.9

*In 1000; †the proportion of total household income earned by the poorer 50% of the households in the area.

in 1992. The GPS population thus consisted of 8272 subjects. The combined study population consisted of 26 311 subjects, while 7390 were invited but did not participate (participation rate 78%). Register information was obtained for 18 344 participants (9662 women and 8682 men). For 7967 participants this information was missing either because they were born before 1920 (n=5200), or had died before 1980 (n=976) or because they had moved out of the metropolitan area (n=1761). Subjects were followed up from 1 January 1980 or study entry if later and until 31 October 1999 for total mortality.

Data

The study population was linked to registers with socioeconomic information in Statistics Denmark[13] using the person identification number as a key. Information on income and education were obtained for study participants and for their cohabiting partners (married or non-married) for the years 1980, 1985, and 1990. This study used data from the year nearest the baseline examination.

Measures of education

Every person in Denmark born after 1920, who is or has been registered in an educational institution is classified annually in the educational classification module in the Statistics Denmark. This register is based on report from educational institutions and includes data on type and duration of educations. For each participant and cohabiting partner we obtained information on most recently completed education. The data on the highest educational degree earned were divided into four categories: only basic school; completed high school; short vocational educations (<2 years—that is, technician, nursery teacher), and vocational educations of longer duration (⩾2 years—that is, schoolteacher, nurse, college and university degrees).

We calculated the proportion of inhabitants aged 15–49 years with a vocationally oriented education at parish level by aggregating the information from the education register for the entire population (around 1.1 million) in the study area. The 153 parishes had a mean of 7500 (range 600–17 400) inhabitants. The mean proportion was 69.9% (range 45.5%–87.4%).

Other covariates

From the social register we obtained other indicators at parish level: the proportion of households with children, rates of unemployment, and the median share of income estimated as the proportion of total household income earned by the poorer 50% of the households in the area. Furthermore, data on each participants family gross income were included.

Standard risk factors were assessed for each participant at baseline by a self administered questionnaire, health examination with anthropometric measurements and various laboratory tests. Body mass index (BMI) was calculated as weight in kilograms divided by height in metre squared, based on anthropometric data collected by trained nurses. Smoking behaviour was elucidated using questions to categorise smokers according to present tobacco consumption. In this study participants were categorised as non-smokers (never or ex-smokers) and smokers. Alcohol consumption was classified according to total daily intake: <1 drinks, 1–3 drinks, 3–6 drinks, 6–11 drinks; >11 drinks. One drink contained 9–13 g alcohol and an intake above three drinks per day was termed high. Physical activity in leisure time was classified into two categories as sedentary (moderate activity ⩽4 hours per week); and active (moderate activity >4 hours per week).

Statistical analysis

Association between risk factors and mortality was analysed using Cox's proportional hazards regression models with age

as the underlying time scale, and using a model for delayed entry (left truncation). The proportional hazards assumption was evaluated for all variables by comparing estimated -ln(-ln) survivor curves over the different categories of the variables being investigated versus ln(analysis time) and by tests based on the generalisation of Grambsch and Therneau.[14] Continuous variables were evaluated for linearity by visual inspection of graphs of estimated coefficients compared with midpoints of centiles and quartiles. Categorisation giving the best model fit was chosen. Because the number of participant in each area varied and those belonging to the same area are more likely to be alike, data were analysed using a robust estimator of variance.[15] Test for interaction between area and individual's educational level was done using the likelihood ratio test. The initial survival analyses were carried out for women and men separately. This showed no significant gender differences in determinants of mortality and consequently we combined the analyses for men and women in order to increase power. All statistical analyses were performed using STATA for Unix version 7.

RESULTS

Table 1 shows how the covariates relate to the three educational measures. Study participants living in parishes with the highest proportion of adult inhabitants with a vocational education were more often women, were older, and less often sedentary during leisure. These areas also had lower unemployment rates and more households with children compared with those living in parishes with a lower proportion of educated adults. For the individual level of education, we found that those with a long vocational education had higher mean incomes, were less often smokers, and physical inactive.

In the crude analyses, living in a parish with a high educational level was not associated with mortality (hazard ratio (HR) 0.97; 95% confidence intervals (CI): 0.85 to 1.10), while spouse and individual's educational level were inversely related to mortality (table 2). The association between the educational level of the parish and mortality was nearly unchanged after control for spouse and subjects own education (model 2), but when individual's income, smoking, exercise, alcohol use, and BMI were included the estimate strengthened (model 3). When unemployment rates, income share and the percentage of households with children, which were all correlated with parish educational status (r=–0.42, r=–0.17, r=–0.35, respectively), were included in the model, the effect of a high education at parish level increased but remained insignificant (model 4). In the full model (model 5), there was a significant association between education and mortality both at parish (HR: 0.87 (95% CI 0.77 to 0.98) and individual level (HR: 0.76 (95% CI 0.64 to 0.88), when comparing the highest educated group with the least educated.

Key points

- The educational level of an area affects mortality risk after adjustment for individual's education, behaviour, and other correlated contextual factors.
- Education, unemployment, and household composition were correlated and may represent the same dimension of social deprivation.
- The distinction between confounding and mediating factor in multilevel studies is complicated, for example, behaviour might differ between areas as a result of different sociodemographic profiles (confounding) and because of variation in facilities and normative attitudes (mediators).

DISCUSSION

This population based study suggests that the educational level of the parish influences individuals mortality, after adjustment for behavioural and other contextual factors. Furthermore, the study confirms the well known finding that subjects with high education have lower mortality compared with the least educated.[7] While ecological studies have shown that the educational level of an area strongly correlates with local mortality rates,[6 16] our and two previous cohort studies have found a modest[9] or no effect[8] of the educational level of neighbourhoods on individuals mortality risk.

The effect of different neighbourhood characteristics in predicting individual's mortality risk are most often smaller or absent in comparison with the relations obtained in ecological studies in particular when individual socioeconomic are accounted for. Thus it has been suggested that neighbourhood level effects are just proxies for unmeasured aspects of individual socioeconomic status.[1 3] In this study, which

Table 2 Hazard rate ratio estimates (95% confidence intervals) of all cause mortality (2614 deaths). Results from Cox's proportional hazards analysis with age as underlying time scale

Educational level	Model 1	Model 2	Model 3	Model 4	Model 5
Neighborhood:					
Lowest quartile	1	1	1	1	1
Second quartile	1.06 (0.87 to 1.29)	1.02 (0.89 to 1.17)	0.94 (0.84 to 1.06)	0.95 (0.85 to 1.05)	0.89 (0.81 to 0.98)
Third quartile	0.98 (0.84 to 1.14)	0.98 (0.86 to 1.11)	0.96 (0.84 to 1.08)	0.95 (0.83 to 1.09)	0.93 (0.83 to 1.06)
Highest quartile	0.97 (0.85 to 1.10)	0.95 (0.85 to 1.12)	0.90 (0.80 to 1.01)	0.92 (0.80 to 1.04)	0.87 (0.77 to 0.98)
Individual:					
Basic	1	1	1		1
High school	0.80 (0.51 to 1.06)	0.78 (0.58 to 1.04)	0.94 (0.68 to 1.31)		0.95 (0.87 to 1.32)
Short vocational	0.77 (0.70 to 0.85)	0.82 (0.75 to 0.90)	0.93 (0.85 to 1.02)		0.95 (0.86 to 1.05)
Long vocational	0.53 (0.46 to 0.62)	0.57 (0.50 to 0.66)	0.75 (0.63 to 0.88)		0.76 (0.64 to 0.88)
Spouse:					
Basic	1	1	1		1
High school	0.99 (0.69 to 1.43)	1.19 (0.81 to 1.73)	1.04 (0.84 to 3.09)		1.01 (0.91 to 1.13)
Short vocational	0.81 (0.69 to 0.88)	0.88 (0.80 to 0.97)	0.96 (0.87 to 1.07)		0.97 (0.87 to 1.10)
Long vocational	0.60 (0.45 to 0.79)	0.74 (0.57 to 0.98)	0.91 (0.68 to 1.21)		0.92 (0.68 to 1.22)
Single	1.34 (1.20 to 1.50)	1.39 (1.25 to 1.55)	1.47 (0.99 to 2.18)		1.45 (0.98 to 2.16)

Model 1: one single education variable and gender in model. Model 2: neighbourhood, individual, spouse education, and gender in model. Model 3: neighbourhood, individual, spouse education, smoking status (non-smoker, smoker), physical activity (sedentary, active), body mass endex (BMI) (in four categories), daily alcohol intake (<1 drinks (low), 1–3 drinks (moderate) and over 3 drinks (high)), family income, and gender in model. Model 4: neighbourhood education and: percentage households with children, unemployment rate, income share, and gender. Model 5: Neighbourhood, individual, spouse education, smoking status (non-smoker, smoker), physical activity (sedentary, active), BMI (in four categories), daily alcohol intake (<1 drinks (low), 1–3 drinks (moderate) and over 3 drinks (high)), family income, percentage households with children, unemployment rate, income share, and gender in model.

comprised both individual and contextual education, the effect of neighbourhood education increased especially when behavioural factors were included in the model. Behavioural factors might be considered as confounders or mediating factors in the contextual mechanism. The distinction is not easy. If, for example, the prevalence of sedentary lifestyle differs between areas as a result of a different demographic profile it should be regarded as a confounder. However, if sedentary lifestyle is a result of lack of facilities and normative attitudes in the low educated areas it would be a part of a causal pathway, and should not be controlled for in the statistical analyses. In addition, many characteristics of neighbourhoods are correlated, and this was also the case in this study. We found that the educational level of the parish was associated with household composition, and unemployment rates. When these contextual measures, which were also related with individual's mortality risk were included in the statistical model the effect of parish level of education changed slightly but remained insignificant. Other studies have also shown neighbourhood income, unemployment and education are correlated. In Muller's ecological study[6] income inequality did not account for the effect of formal education on mortality at state level, but no other contextual measures were included in this analysis. A multilevel study from Sweden, identified three important components of deprivation by use of factor analysis on 21 socioeconomic indicators.[10] One of the components, which was positively associated with low education, low income, and rates of unemployment (reflecting low labour market mobility), increased the risk of myocardial infarction. It might be discussed, whether other contextual factors should be controlled for when they are correlated and might capture the same dimension of the socioeconomic structure of an area. On the other hand, such an approach does not permit discrimination between the effects of different neighbourhood characteristics.

Our data also had a hierachical structure and it would have been more appropriate to use multilevel analysis to quantify the effect of the variables in the model on the variation in mortality between areas. However, this was not possible in this study, as we are not aware of such methods for survival analyses that permit delayed entry. The latter is important for this study, because the study population included different cohorts sampled at different points in time and ages.

Another important issue to consider in studies of social context is the level of aggregation, as it might influence the pathways through which the contextual determinants are actualised into an individual morbidity risk. The level of aggregation used in our and the other cohort studies[8 9] were comparatively small. In this study, parish level was used as a measure of the social environment close to the individual, as the data were derived from public registers and the level of aggregation had to be based on existing administrative units. Indeed, focus on old church districts, is a potential limitation because of a somewhat artificial nature of boundaries. Thus, we cannot exclude that some of the largest parishes comprised several small areas within them that could have quite different educational levels, and that this might dilute the potential effect. On the other hand, the level of aggregation could also be too small to allow the educational level of the area to exert an effect independent of individual's education.

In conclusion, the results from our study suggest that neighbourhood education is only one of different characteristics of adverse social conditions in an area increasing mortality.

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