RESEARCH REPORT

Cumulative deprivation and cause specific mortality. A census based study of life course influences over three decades

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Objective: To examine whether increasing cumulative deprivation has an incremental effect on total as well as cause specific mortality.

Design: Census data on housing conditions as indicators of deprivation from 1960, 1970, and 1980 were linked to 1990–98 death registrations. Relative indices of inequalities were computed for housing conditions to measure the cumulative impact of differences in social conditions.

Participants: 97 381 (71.1%) 30–49 year old and 70 701 (80.0%) 50–69 year old inhabitants of Oslo, Norway, in 1990 with census information on housing conditions and recorded length of education.

Main results: Mortality risk was increased when all censuses' housing conditions were summed in both age groups and sex. The cause specific analysis indicated such an effect particularly for coronary heart disease, chronic obstructive lung disease, and smoking related cancers. Violent deaths were essentially associated with housing conditions closer to the time of death in men in both age groups and in young women.

Conclusions: To fully account for socially mediated risk of death, a full life course approach should be adopted. The relative importance of each stage seems to vary by cause of death.

An increasing number of studies have focused on how various factors acting across the life course may influence inequality in adult health status. In this approach specific disease outcomes may be related to exposures acting at particular stages of the life course. For some, such as stomach cancer and haemorrhagic stroke, childhood socioeconomic factors seem to be most important.[1 2] Other causes such as coronary heart disease, chronic obstructive pulmonary disease, and breast cancer have been linked to factors from across the entire life course.[3–6] For further causes, such as lung cancer and accidental/violent deaths, factors in adult life seem most important.[1]

Previous studies with data from across the life course have related current and childhood socioeconomic conditions with adult mortality risk.[7–11] Some of these studies have aimed at assessing how each life stage independently influences mortality risk. Researchers have increasingly recognised that analysis must move beyond a simple dichotomy between childhood and adulthood socioeconomic conditions.[7 12 13] Few studies have longitudinal data with the multiple time point exposure data required for such analyses. Cumulative effects have been reported both in studies of early life to adult life social factors, and with repeated measures only during adult life. To analyse in detail if mortality risk is incremental with respect to lifetime social conditions and study this for major cause of death groups, a large study sample would be needed. Most existing studies looking at cumulative effects have been limited to summary health measures or all cause mortality.[14–18] Recent studies have examined broad cause of death groups[19 20] and have also investigated cardiovascular mortality in detail.[21]

From Norwegian census data only some aspects of housing conditions were available to measure social conditions longitudinally. Various aspects of housing conditions have been used in public health and epidemiological research as an indicator of deprivation.[22–24] Change in housing conditions is a manifestation of fluctuating social circumstances as people move and makes it useful when studying social conditions along the life course.

In this study we wanted to examine whether social deprivation measured by housing conditions at 10 year intervals provides additional explanatory power over single measurements. For this purpose we used census data and mortality statistics. Furthermore, we wanted to explore whether the cumulative influence is expressed differently according to cause of death.

METHODS

A cohort of all inhabitants in two age groups who lived in the municipality of Oslo on 1 January 1990 was chosen as the study population. They were 30–49 and 50–69 years in 1990, and 0–19 and 20–39 years in 1960. A total of 133 329 people were identified in the younger age group and 88,159 in the older. Data were obtained by linking census information from 1960, 1970, and 1980 with the death register, facilitated by the Norwegian identity code and provided by the National Bureau of Statistics. Causes of death were coded in ICD-9 from 1990–1996 and in ICD-10 from 1997–1998.

Completing the census is compulsory by law, and no missing schemes were reported. Included were all people with complete information on housing conditions from all three years and length of education, giving 94 381 (71.1%) people among the younger and 70 701 (80.0%) among the older cohort, were included in this analysis. Those who had not responded to all the questions or did not live in Norway every year were treated as missing data and excluded. In the youngest age group the percentage of missing data was 18.3 (1960), 15.9 (1970), and 18.9 (1980). In the oldest group similar figures were 11.5, 6.2, and 9.9. In the younger age group those included had an age adjusted mortality rate (per 10 000 person years) of 29.0 as compared with 33.0 among the excluded. Similar figures in the older group were 180.6 among included and 226.2 among excluded.

The following housing information was recorded in the three censes: type of dwelling (block, row house, detached house), status of ownership, number of persons per room, having a telephone in dwelling, and having access to toilet or bath inside the dwelling. This information was summarised for each year into an index (table 1). This index gave a minimum value of 6 (bad housing) and a maximum of 14 (good housing). For each person in each sex and age band we summed the value for the three censes years, and produced a score with a range of values from 18 to 42. Because some of the groups with low or high housing index contained few subjects, the housing indices for each separate census and the summed index were each collapsed into variables with five categories of approximately similar size. Housing conditions was unfortunately not recorded in 1990. Length of education was defined as the highest obtained education in 1989 taken from the educational register.

Causes of death were coded according to the ICD-9 as follows: coronary heart disease (410–414), stroke (430–438), cardiovascular causes (390–459), smoking related cancers (ICD-9 140–149, 150, 157, 160–162, 188–189), breast cancer (174) and other non-smoking related cancers (ICD-9 151–156, 158–159, 167–173, 175–187, 200–208), chronic obstructive pulmonary disease (490–496), and violent causes (800–999). In the youngest age group stroke and coronary heart disease were collapsed into cardiovascular causes because there were few deaths.

To compare risk of death by the housing index at three points in time, a measure called the relative index of inequality (RII) was used. The housing index in 1960, 1970, and 1980 had different proportions of the population in each category. Direct comparison of ratios was therefore not possible. The RII is purposively constructed to avoid this problem. At all three census years, each category of the housing index was assigned a value between 0 and 1 according to the proportion of participants with a higher housing index than the midpoint of each category within the hierarchy in which that person lay, starting with the best off category (category 5). A proportion of 0.19 of all men in the youngest age group in 1960 were in the highest housing index category 5. The midpoint person would have a proportion of 0.19/2 of the population having more favourable conditions, giving an RII score of 0.095 for this group. In the next most favourable category (category 4), there were 21% of the population. All 19% in the better housing index category (category 5) were taken to be in more favourable circumstances than this category, and for the midpoint person a proportion of 0.105 of the population in category 4

Table 1 Percentage distribution (%) and age adjusted all cause mortality rates (rate) 1990–98 (10 000 person years) across all components of the housing index 1960, 1970, and 1980 in both age groups

	Men						Women					
	1960		1970		1980		1960		1970		1980	
	%	Rate	%	Rate	%	Rate	%	Rate	%	Rate	%	Rate
Age 30–49 (1990)												
Type of dwelling												
(0) Block	41	41	41	44	49	44	38	24	43	24	53	26
(1) Row house	30	33	30	32	25	29	30	20	29	20	24	17
(2) Detached house	29	33	29	32	26	30	32	20	28	20	23	16
Rooms per head												
(0) <0.5	22	47	10	46	5	43	22	26	12	27	6	27
(1) 0.5–1	64	35	60	38	44	40	64	20	61	21	46	22
(2) >1	13	28	29	31	51	33	14	23	27	20	48	20
Ownership												
(0) No	64	39	62	40	66	41	62	23	65	24	70	24
(1) Yes	36	32	38	32	34	29	38	19	35	17	30	16
Telephone												
(0) No	53	44	35	43	27	46	52	24	38	23	27	28
(1) Yes	47	29	65	33	73	34	48	19	62	20	73	20
Toilet												
(0) No	32	43	15	45	9	61	35	23	16	27	8	30
(1) Yes	68	33	85	35	91	35	65	21	84	20	92	21
Bath												
(0) No	30	46	17	46	8	68	32	24	19	27	8	29
(1) Yes	70	33	83	34	92	34	68	20	81	20	92	21
Age 50–69 (1990)												
Type of dwelling												
(0) Block	58	252	56	266	52	280	58	148	56	152	52	158
(1) Row house	28	227	31	213	28	206	28	128	31	124	28	118
(2) Detached house	14	232	13	206	20	190	14	127	13	116	20	109
Rooms per head												
(0) <0.5	22	292	9	304	4	291	22	169	9	184	4	159
(1) 0.5–1	61	233	64	243	39	256	61	135	64	137	39	154
(2) >1	17	216	27	221	57	230	17	125	27	136	57	133
Ownership												
(0) No	81	248	77	256	67	267	81	143	77	147	67	151
(1) Yes	19	218	23	199	33	190	19	125	23	115	33	111
Telephone												
(0) No	62	260	27	298	13	314	62	151	27	168	13	181
(1) Yes	38	215	73	223	87	232	38	126	73	132	87	136
Toilet												
(0) No	30	287	10	326	6	360	29	164	10	181	6	191
(1) Yes	70	227	90	233	94	235	71	133	90	136	94	138
Bath												
(0) No	28	294	13	328	6	374	28	175	13	185	6	214
(1) Yes	72	225	87	230	94	234	72	130	87	134	94	136

would be above them (0.21/2). The RII score for this group was therefore 0.19 plus 0.105. This procedure is then continued for the rest of the categories, and the method applied to the housing index for all census years and to the summed housing index. The RII scores were related to mortality in logistic regressions:

$$\text{Log}(P) = a + b\text{Score} + c\text{Agecat}$$

P is the odds of death and Agecat the five year age bands, producing age adjustment. RII is the exponentiated value of b, and is the odds ratio of mortality for the hypothetical person with the lowest score of 0 compared with the hypothetical person with the highest score of 1. This model was expanded by adding education as covariate.

RESULTS

A stepwise decrease in mortality was seen within most of the individual components of the index and census years (table 1). Frequencies of the variables in the housing index changed during the 20 years of observation. In the youngest age group many more lived in blocks, had more rooms per household head, and had telephone, toilet, and bath. In the oldest age group rooms per head increased, and most of the population had telephone, toilet, and bath in the dwelling. This is probably attributable both to growing individual income during adult life, and to growing prosperity in Norway.

The correlations between each census year's housing index varied from 0.24 to 0.44 in the youngest group and 0.39–0.64 in the oldest, indicating less housing mobility in older age groups (not tabulated). In the young age group correlation between the summed housing index and occupational class was 0.29 and with education 0.41. In the old group this was 0.38 (occupational class) and 0.44 (education).

All cause death appeared to have larger RIIs for the summed housing index compared with the separate years (table 2). RII ranged from 2.39 to 2.46 by census in young men. When all three census years' housing indices were summed for each person, this risk was increased additionally to 3.00. In young women the RIIs of the summed index was 2.29 as compared with 1.63, 2.11, and 2.28 at separate years. In the oldest group the summed RII was 2.62 and 1.94, 2.26, and 2.51 for separate years in men. Women in the oldest age group had 2.18 for the summed estimate and 1.86, 1.84, and 2.12 for separate years. To investigate formally if each census year's housing data had an independent impact on mortality, we mutually adjusted for all three census years. Most of them had a significant independent effect on risk of death by all causes. After adjusting for education most years had independent effect on mortality when mutually adjusting each census year in this model.

For some causes of death, summing all three census years seemed to increase the RIIs (table 3). In the young age group, this occurred for death from cardiovascular causes in both sexes and smoking related cancers in men. In the older age group, an increased effect was seen in deaths from coronary heart disease, stroke, and chronic obstructive pulmonary disease. Violent causes, except in older women, were more associated with the housing index in 1980, a time closer to death. Surprisingly, breast cancer was associated with high RII in the young age group and low RII in the old.

DISCUSSION

In this study we find increased risk of death from all causes when a cumulative measure of deprivation is compared with measuring deprivation at single years. When all three census years of deprivation measures during this period were mutually adjusted, most had an independent influence on risk of death.

The results for some causes of death indicate particular strong cumulative associations (coronary heart disease, stroke, smoking related cancers, and chronic obstructive pulmonary disease). Violent causes have more abrupt onset and differ from this, particularly among men in our study.

Table 2 Age adjusted relative indices of inequality (95% CI) for mortality in 1990–98 by the housing index in 1960, 1970, 1980 and the summed index with and without adjusting for education. Mutually adjusted results for the three separate census periods are also presented.

	Crude		Mutually adjusted		+Education		+Education and mutually adjusted	
30–49 years								
Men (n = 46984)								
1375 deaths								
1960	2.39	(1.97 to 2.90)	1.84	(1.48 to 2.30)	1.42	(1.16 to 1.74)	1.35	(1.08 to 1.69)
1970	2.07	(1.69 to 2.53)	1.22	(0.96 to 1.54)	1.19	(0.96 to 1.47)	0.92	(0.72 to 1.16)
1980	2.46	(2.02 to 3.00)	1.98	(1.61 to 2.45)	1.60	(1.31 to 1.97)	1.55	(1.25 to 1.92)
Summed	3.00	(2.46 to 3.66)			1.60	(1.29 to 1.99)		
Women								
(n = 47397)								
813 deaths								
1960	1.63	(1.28 to 2.09)	1.23	(0.94 to 1.60)	1.23	(0.95 to 1.59)	1.04	(0.79 to 1.37)
1970	2.11	(1.61 to 2.76)	1.60	(1.19 to 2.15)	1.64	(1.24 to 2.17)	1.41	(1.04 to 1.90)
1980	2.28	(1.76 to 2.95)	1.92	(1.46 to 2.52)	1.88	(1.44 to 2.45)	1.73	(1.32 to 2.28)
Summed	2.29	(1.78 to 2.96)			1.72	(1.30 to 2.27)		
50–69 years								
Men (n = 31521)								
6106 deaths								
1960	1.94	(1.75 to 2.16)	1.32	(1.17 to 1.49)	1.40	(1.25 to 1.57)	1.15	(1.02 to 1.30)
1970	2.26	(2.03 to 2.51)	1.31	(1.14 to 1.52)	1.60	(1.43 to 1.80)	1.13	(0.98 to 1.31)
1980	2.51	(2.26 to 2.79)	1.89	(1.65 to 2.17)	1.85	(1.65 to 2.08)	1.66	(1.44 to 1.91)
Summed	2.62	(2.36 to 2.91)			1.87	(1.66 to 2.10)		
Women								
(n = 39180)								
4393 deaths								
1960	1.86	(1.65 to 2.08)	1.41	(1.23 to 1.62)	1.49	(1.32 to 1.69)	1.27	(1.10 to 1.46)
1970	1.84	(1.64 to 2.07)	1.07	(0.91 to 1.26)	1.47	(1.30 to 1.66)	0.97	(0.83 to 1.15)
1980	2.12	(1.88 to 2.38)	1.75	(1.50 to 2.04)	1.75	(1.55 to 1.98)	1.63	(1.40 to 1.91)
Summed	2.18	(1.94 to 2.44)			1.74	(1.54 to 1.98)		

Table 3 Age adjusted relative indices of inequality of some causes of death (1990–1998) by the housing index in 1960, 1970, 1980 and summed in the two age groups

Causes of death	1960		1970		1980		Summed	
Age 30–49								
Men								
Cardiovascular causes (n = 300)	1.96	(1.31 to 2.92)	2.22	(1.43 to 3.43)	2.37	(1.55 to 3.61)	2.99	(1.98 to 4.58)
Smoking related cancer (n = 102)	2.64	(1.33 to 5.26)	2.59	(1.21 to 5.54)	2.84	(1.37 to 5.88)	3.52	(1.69 to 7.36)
Non-smoking related cancers (n = 142)	1.36	(0.76 to 2.43)	0.78	(0.43 to 1.43)	1.03	(0.57 to 1.87)	1.13	(0.62 to 2.03)
Violent deaths (n = 278)	1.94	(1.27 to 2.95)	2.14	(1.38 to 3.32)	3.34	(2.17 to 5.16)	3.20	(2.07 to 4.94)
Women								
Cardiovascular causes (n = 97)	3.30	(1.61 to 6.76)	2.13	(0.98 to 4.66)	3.33	(1.56 to 7.07)	4.36	(2.03 to 9.35)
Smoking related cancers (n = 91)	0.97	(0.48 to 1.98)	4.30	(1.80 to 10.26)	1.49	(0.69 to 3.20)	1.50	(0.71 to 3.16)
Breast cancer (n = 117)	1.64	(0.87 to 3.10)	1.30	(0.65 to 2.58)	0.99	(0.51 to 1.92)	1.43	(0.74 to 2.74)
Other non-smoking related cancers (n = 165)	1.20	(0.70 to 2.04)	1.52	(0.85 to 2.73)	1.74	(0.99 to 3.05)	1.67	(0.96 to 2.90)
Violent deaths (n = 130)	0.83	(0.45 to 1.53)	1.69	(0.88 to 3.25)	1.82	(0.97 to 3.42)	1.32	(1.71 to 2.44)
Age 50–69								
Men								
Coronary heart disease (n = 1613)	1.81	(1.50 to 2.18)	2.29	(1.91 to 2.76)	2.10	(1.74 to 2.52)	2.37	(1.97 to 2.85)
Stroke (n = 428)	1.87	(1.31 to 2.68)	2.04	(1.44 to 2.90)	2.30	(1.61 to 3.27)	2.47	(1.74 to 3.51)
Smoking related cancers (n = 874)	1.88	(1.47 to 2.41)	2.04	(1.59 to 2.60)	2.24	(1.75 to 2.86)	2.34	(1.83 to 3.00)
Non-smoking related cancers (n = 855)	1.23	(0.96 to 1.58)	1.01	(0.79 to 1.29)	0.96	(0.75 to 1.23)	1.13	(0.89 to 1.44)
Chronic obstructive pulmonary disease (n = 286)	3.67	(2.34 to 5.75)	4.17	(2.68 to 6.49)	3.94	(2.54 to 6.13)	5.34	(3.41 to 8.39)
Violent deaths (n = 246)	1.47	(0.94 to 2.31)	1.47	(0.93 to 2.30)	2.32	(1.48 to 3.65)	1.86	(1.19 to 2.92)
Women								
Coronary heart disease (n = 681)	2.54	(1.92 to 3.37)	2.27	(1.72 to 3.00)	2.41	(1.82 to 3.20)	2.76	(2.09 to 3.66)
Stroke (n = 338)	2.28	(1.53 to 3.39)	2.10	(1.42 to 3.11)	2.32	(1.55 to 3.45)	2.48	(1.68 to 3.68)
Smoking related cancers (n = 552)	1.94	(1.43 to 2.64)	1.65	(1.22 to 2.23)	1.74	(1.28 to 2.36)	2.01	(1.49 to 2.73)
Breast cancer (n = 298)	0.70	(0.46 to 1.05)	0.73	(0.48 to 1.10)	0.76	(0.50 to 1.14)	0.71	(0.47 to 1.07)
Other non-smoking related cancers (n = 712)	1.38	(1.05 to 1.80)	1.48	(1.13 to 1.93)	1.62	(1.24 to 2.13)	1.59	(1.22 to 2.07)
Chronic obstructive pulmonary disease (n = 266)	2.55	(1.63 to 3.99)	2.41	(1.55 to 3.76)	3.24	(2.06 to 5.09)	3.19	(2.04 to 4.99)
Violent deaths (n = 166)	1.59	(0.91 to 2.76)	1.64	(0.95 to 2.85)	1.52	(0.87 to 2.63)	1.96	(1.13 to 3.41)

This is consistent with the notion that various causes of death have different distributions of important risk factors across the life course.[2] The cause specific pattern has implications on how social inequality in cause specific risk is studied. Coronary heart disease and chronic obstructive pulmonary disease have been suggested as conditions whose determinants should be sought along the entire life course. Our study lends support to this. It implies that when researchers want to investigate models of disease aetiology along the life course, they should take this varying cause specific pattern into account.

Are these findings true or spurious? For the all cause pattern, a large number of deaths contribute with statistical power to support the hypothesis. For the cause specific groups with fewer deaths, this must be interpreted with caution. In many causes the tendency of increased independent risks needs confirmation. The excluded people had slightly greater age adjusted mortality rates than the included. This could lead to our results underestimating the true magnitude of inequalities.

The analysis rests on the assumption that the index measured with a 10 year interval is a reasonable approximation of cumulative socioeconomic influence. Estimating RIIs after taking age into account makes it possible to compare the contribution of change in relative social inequality across the life course. The RII is constructed to capture relative deprivation despite overall absolute changes in housing conditions. Table 1 shows some changes in housing conditions in our cohort from 1960 to 1980. It is known that people improve housing conditions through their life course.[25]

Previously in the same population and material we have compared housing conditions with education and occupation and found similar effects on all cause mortality of RII by each indicator, both alone and when they were mutually adjusted.[26] In our analysis we adjusted by education, which substantially reduced the size of RIIs (table 2). The summed RIIs remained significantly associated with all cause mortality risk indicating a cumulative effect even after adjusting for a social indicator that does not fluctuate. And also it suggests that even if the housing index and length of education tap into different constructs to some degree, our housing index captures reasonably well what is thought of as social living conditions in general. The housing index is, as expected, correlated with education and occupation.

The improvement in housing conditions in Oslo, in particular after 1980, makes us believe that today the census variables used here would not be as strongly linked to other indicators of social conditions as they were.[27 28]

Data on some of the population that moved into the city during this period includes housing information from outside Oslo, which is probably less reliable as a marker of social inequality, and has probably diluted the association. The study population is defined as all inhabitants in Oslo in 1990, and thus the population only includes people that had survived until then. The associations are probably weakened as a consequence of this if those who had died were more deprived. Inequality in Oslo is comparable in size with other settings, such as the UK.[29]

We have investigated in two age groups the cumulative increase in mortality risk with 10 year intervals, and we have found an incremental change in both the young and old age groups. This has important implications for future epidemiological studies because it highlights the need to have adequate information on socioeconomic conditions with enough detail from all along the life course in order to account for its full variability. At the policy level it could imply that measures against social inequality in premature mortality risk should focus on every stages of the life course.[30]

Key points

- Social conditions have a cumulative effect on all cause mortality risk across the life course even when only measured at 10 year intervals.
- Various causes of death are affected differently by this cumulative influence.
- In this study a cumulative effect was particularly found for coronary heart disease, stroke, chronic obstructive lung disease, and smoking related cancers.

Policy implications

- Measures aimed to ameliorate social inequality in premature mortality risk should focus on every stage of the life course. Tackling inequality in health should address the fact that the effect of cumulative deprivation differs between causes of death.

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