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Social inequality and incidence of and survival from lung cancer in a population-based study in Denmark, 1994–2003

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ABSTRACT

We investigated the effects of socioeconomic, demographic and health-related indicators on the incidence of and survival from lung cancer diagnosed in Denmark in 1994–2003 with follow-up through 2006 using information from nationwide registers. The analyses were based on data on 21,492 patients with lung cancer in a cohort of 3.22 million persons born between 1925 and 1973 and aged ⩾30 years. There was a general pattern of decreasing lung cancer incidence with increasing social advantage, being married and decreasing urbanicity. The presence of somatic or psychiatric disorders increased the incidence. The most advantaged groups of men had better short-term survival, and a similar tendency was seen for women. The relative 5-year survival after lung cancer was similarly low in most groups, 8% for men and 9% for women, except for groups of patients living in small apartments, with unknown tenure or schizophrenia and for divorced or single men.

1. Introduction

During the 20th century, the incidence of lung cancer increased dramatically in most European countries. In 2003, lung cancer was diagnosed in 3655 persons in Denmark, making this the second most frequent cancer in both men and women, except for non-melanoma skin cancer. Further, lung cancer is the commonest cause of death from cancer in Danish men and the second commonest in women.[1] Lung cancer has been found relatively consistently to be inversely related to socioeconomic position (SEP)[2,3] perhaps due largely to differences in smoking prevalence amongst different socioeconomic groups. Nevertheless, some studies have shown that the inverse association between SEP and lung cancer incidence remains after adjustment for smoking.[4–8] Less is known about social inequality in survival from lung cancer, although factors such as SEP and smoking predict adverse comorbidity, which in turn may influence survival after lung cancer.[9,10] We studied the effects of a range of socioeconomic, demographic and health-related indicators on the incidence of lung cancer diagnosed in 1994–2003 and survival after lung cancer through 2006 in Denmark using register-based information from nationwide Danish administrative registers. The study was carried out as part of a comprehensive, rigorous analysis of the role of socioeconomic position in cancer incidence and survival.

2. Materials and methods

The materials and methods are described elsewhere.[11] Briefly, the study population comprised all 3.22 million Danish residents born between 1925 and 1973 without a previous cancer and who entered the cohort at age 30 (see Fig. 1 in Ref. 11). Information on socioeconomic, demographic and

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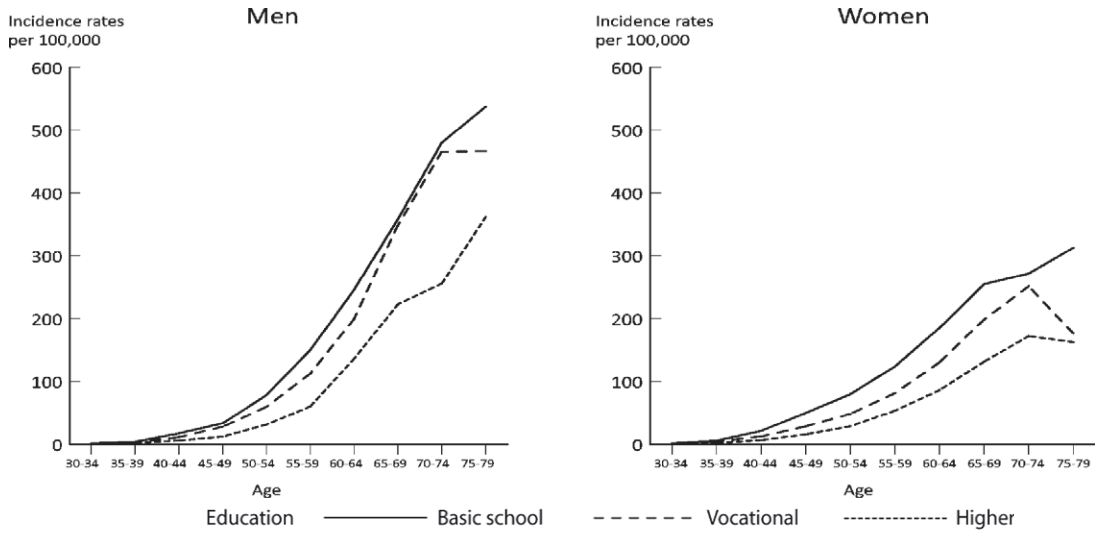

Incidence rate	Men			Women		
	Basic school (*n* =5799)	Vocational (*n* =4479)	Higher (*n*=1154)	Basic school (*n* =6142)	Vocational (*n* =2176)	Higher (*n* =714)
Crude	130	83	45	111	53	26
Standardised	110	96	57	86	61	40
Difference	53	39	0	46	21	0

Persons with unknown level of education not included

Fig. 1 – Age-specific incidence rates per 100,000 person-years for lung cancer by education amongst persons born in 1925–1973, Denmark, 1994–2003. Supplementary table shows the crude incidence rate and the incidence rate standardised by age (5-year age groups) and period (two 5-year periods) with the total study population as the standard and the incidence rate difference with higher education as the reference.

health-related indicators was obtained from various Danish registers based on administrative data.[11] Crude, age-specific and age-standardised incidence rates are presented for lung cancer (ICD-10 C33–34) diagnosed in the cohort in 1994–2003. The incidence rates were standardised by age (in 5-year age groups) and period (in two 5-year periods), with the total study population as the standard.[12] Further, we used log-linear Poisson regression to model incidence rate ratios (IRRs), first adjusted for period (in 5-year periods) and age (as two continuous variables: age and age^2 in years) and second by adding education and disposable income to the models. For each level of each indicator, we conducted relative survival analyses, adjusting for population mortality amongst the incident cancer cases in 1994–2003 with follow-up through 2006.[11] Population mortality rates were stratified by age, period and the respective indicator. Except for the analyses of ethnicity, all analyses included only residents born in Denmark to at least one Danish-born parent with Danish citizenship.[11]

3. Results

Lung cancer was diagnosed in 21,492 persons in the study cohort over the period 1994–2003, constituting 61% of the total number of lung cancers diagnosed in Denmark in that period. Amongst Danish persons, the male:female ratio was 1.27, and the age- and period-standardised incidence rate was 94 per 100,000 person-years for men and 76 per 100,000 person-years for women. The 1-year relative survival was 30% for men and 34% for women, and the cumulated relative survival 5 years after diagnosis was 8% for men and 9% for women.

3.1. *Incidence of lung cancer*

The age- and period-standardised incidence rate of lung cancer decreased in a stepwise manner with increasing length of education for both men and women, the incidence rate differences between those with higher education and those with basic school education amounting to 53 per 100,000 in men and 46 per 100,000 in women (Fig. 1).

The IRRs for the socioeconomic and demographic variables adjusted for age, period, education and income showed a general pattern in both men and women of decreasing lung cancer incidence with increasing social advantage, such as longer education, more income, closer affiliation to the work market, better housing tenure and larger housing (Table 1). The IRR for lung cancer by social class was reduced for the creative core and creative professionals and for the service class and the agricultural class compared to the manual class.[13] 'Bohemians' had a high incidence rate, but the result was based on few cases. In comparison with married persons, people of each sex who were cohabiting, single, widowed or divorced had a higher incidence of lung cancer. The IRRs increased with increasing degree of urbanicity; further, being

Table 1 – Incidence rate ratios (IRRs) with 95% confidence intervals (95% CIs) for lung cancer in Danish persons born 1925–1973 and aged ⩾30 years, by socioeconomic, demographic and health-related variables, Denmark, 1994–2003

	Men			Women		
	Obs	IRR[a] (95% CI)	Adjusted IRR[b] (95% CI)	Obs	IRR[a] (95% CI)	Adjusted IRR[b] (95% CI)
Level of education						
Basic or high school	5799	1.00	1.00	6142	1.00	1.00
Vocational education	4479	0.88 (0.84–0.91)	0.92 (0.89–0.96)	2176	0.72 (0.68–0.75)	0.76 (0.72–0.79)
Higher education	1154	0.52 (0.49–0.55)	0.65 (0.61–0.70)	714	0.45 (0.42–0.49)	0.54 (0.50–0.59)
Unknown	207	1.14 (0.99–1.31)	1.53 (1.33–1.75)	118	1.28 (1.07–1.54)	2.09 (1.74–2.51)
Disposable income[c]						
Lowest (1st quartile)	4784	1.26 (1.21–1.31)	1.21 (1.16–1.27)	3440	1.12 (1.07–1.17)	1.06 (1.01–1.12)
Middle (2nd–3rd quartile)	5110	1.00	1.00	4320	1.00	1.00
Highest (4th quartile)	1745	0.60 (0.56–0.63)	0.66 (0.63–0.70)	1390	0.63 (0.59–0.67)	0.71 (0.67–0.75)
Affiliation to work market[d]						
Working	5034	1.00	1.00	3255	1.00	1.00
Unemployed or other	1536	1.68 (1.58–1.78)	4.69 (4.41–4.99)	1470	1.34 (1.26–1.43)	3.03 (2.81–3.26)
Early retirement pensioner	1621	2.38 (2.25–2.52)	8.56 (8.03–9.12)	2127	2.19 (2.07–2.32)	4.52 (4.19–4.88)
Social class[e]						
Creative core	297	0.40 (0.36–0.45)	0.74 (0.64-0.85)	46	0.49 (0.37–0.66)	2.08 (1.53–2.84)
Creative professional	1265	0.54 (0.51–0.57)	0.74 (0.69-0.79)	463	0.45 (0.41–0.51)	0.96 (0.85–1.09)
Bohemian	56	1.38 (1.06–1.80)	7.20 (5.52-9.39)	11	2.53 (1.40–4.58)	18.4 (10.1–33.4)
Service	2646	0.77 (0.74–0.81)	0.87 (0.83-0.91)	4712	0.66 (0.62–0.71)	0.68 (0.64-0.73)
Manual	5862	1.00	1.00	1096	1.00	1.00
Agricultural	457	0.50 (0.45–0.55)	0.61 (0.55-0.67)	83	0.36 (0.29–0.45)	0.63 (0.50–0.79)
Unknown	1056	0.80 (0.75–0.86)	0.93 (0.87-1.00)	2739	0.74 (0.69–0.80)	0.72 (0.67–0.77)
Housing tenure						
Owner-occupied	6781	1.00	1.00	4784	1.00	1.00
Rental	4708	1.76 (1.69–1.83)	1.67 (1.61–1.74)	4238	1.62 (1.55–1.69)	1.57 (1.50–1.64)
Unknown	150	1.49 (1.27–1.76)	3.11 (2.64–3.66)	128	2.13 (1.79–2.54)	4.45 (3.73–5.31)
Size of dwelling (m^2)						
0–49	509	1.83 (1.67–2.00)	2.12 (1.93–2.33)	198	1.90 (1.65–2.20)	2.95 (2.55–3.41)
50–99	5131	1.54 (1.48–1.61)	1.45 (1.39–1.52)	4752	1.54 (1.47–1.61)	1.47 (1.40–1.54)
100–149	4100	1.00	1.00	2944	1.00	1.00
⩾150	1899	0.73 (0.69–0.77)	0.81 (0.77–0.86)	1256	0.74 (0.69–0.79)	0.85 (0.80–0.91)
Cohabiting status						
Married	7852	1.00	1.00	5162	1.00	1.00
Cohabiting	803	1.38 (1.29–1.49)	1.68 (1.56–1.80)	570	1.43 (1.31–1.56)	1.94 (1.78–2.12)
Single	921	1.19 (1.11–1.27)	1.21 (1.13–1.30)	371	0.97 (0.87-1.08)	1.55 (1.40–1.73)
Widow or widower	624	1.27 (1.17–1.38)	1.46 (1.35–1.59)	1653	1.40 (1.32–1.49)	1.46 (1.37–1.55)
Divorced	1439	1.71 (1.61–1.80)	1.72 (1.63–1.83)	1394	1.67 (1.58–1.77)	1.79 (1.68–1.90)
Type of district						
Capital area	3652	1.00	1.00	2983	1.00	1.00
Provincial city	5951	0.94 (0.90–0.98)	0.84 (0.81–0.88)	4751	0.96 (0.92–1.01)	0.85 (0.81–0.89)
Rural area	1329	0.86 (0.81–0.92)	0.84 (0.79–0.90)	957	0.86 (0.80–0.93)	0.87 (0.81–0.94)
Peripheral rural area[f]	707	0.99 (0.92–1.08)	1.05 (0.97–1.14)	459	0.90 (0.82–0.99)	1.02 (0.92–1.13)
Ethnicity[g]						
Danish	11,639	1.00	1.00	9150	1.00	1.00
Immigrant or descendant from western country	194	0.98 (0.85–1.13)	3.15 (2.72–3.64)	207	0.96 (0.84–1.10)	2.40 (2.09–2.76)
Immigrant or descendant from non-western country	228	1.08 (0.95–1.23)	1.52 (1.32–1.76)	74	0.60 (0.48–0.75)	0.96 (0.73–1.26)
Charlson comorbidity index[h]						
None	7954	1.00	1.00	6555	1.00	1.00
1	2338	1.67 (1.60–1.76)	1.73 (1.65–1.82)	1628	2.27 (2.15–2.40)	2.43 (2.30–2.57)
⩾2	1347	1.91 (1.80–2.02)	2.01 (1.90–2.14)	967	2.39 (2.23–2.56)	2.69 (2.51–2.88)
Depression						
No	11,349	1.00	1.00	8679	1.00	1.00
Yes	290	1.45 (1.29–1.62)	2.15 (1.91–2.41)	471	1.67 (1.42–1.97)	2.01 (1.83–2.21)
Schizophrenia or other psychosis						
No	11,496	1.00	1.00	8997	1.00	1.00
Yes	143	1.67 (1.42–1.97)	3.03 (2.57–3.58)	153	1.54 (1.31–1.81)	2.51 (2.14–2.94)

a Adjusted for calendar period (in 5-year intervals) and age modelled as age and age^2 in years.

b Adjusted for calendar period and age (as above) and additionally for the level of education and disposable income.

c Household income after taxation and interest, adjusted for number of persons in household; categorised by gender-specific distribution of household disposable income per person.

d For pensioners, work market affiliation before pension date was assigned and follow-up to age 69.

e Based on theory of creative class (13): the creative core (e.g. researchers, designers, architects), creative professionals (e.g. managers, business and finance, lawyers, doctors), bohemians (e.g. artists, models), the service class (e.g. nurses, hairdressers, caterers), the manual class (e.g. construction workers, transport and production workers) and the agricultural class (e.g. farmers, fishermen).

f More than 40 km to a local centre with adequate possibilities for employment and not sharing a border with a centre municipality.

g Included as a separate indicator, but ethnic groups were excluded from the study population in all other analyses presented in Table 1, e.g. education and income.

h The presence of disorders, as defined in the Charlson index, was defined as an in- or outpatient contact with one of the diagnoses listed in Table 1 in Ref. 11 between 1978 and 2 years before the cancer diagnosis. Grouped according to the accumulated sum of scores.

Table 2 – 1-year and 5-year relative survival[a] (%) with 95% confidence interval (95% CI) by socioeconomic, demographic and health variables in patients aged ⩾30 years born in 1925–1973, with lung cancer diagnosed in Denmark between 1994 and 2003 and followed through 2006

	Men					Women				
	1-year survival			5-year survival		1-year survival			5-year survival	
	No.	%	95% CI	%	95% CI	No.	%	95% CI	%	95% CI
Level of education										
Basic or high school	5702	28	27–30	7	6–8	6057	33	32–34	9	8–10
Vocational education	4416	30	29–32	8	7–8	2149	36	34–38	9	8–10
Higher education	1146	34	32–37	10	8–12	704	34	30–37	10	8–12
Unknown	201	28	22–35	7	4–12	115	37	28–47	10	6–18
Disposable income[b]										
Lowest (1st quartile)	4697	27	26–29	7	6–7	3382	32	30–34	9	8–10
Middle (2nd–3rd quartile)	5038	30	29–32	8	7–9	4263	33	32–35	8	8–9
Highest (4th quartile)	1730	33	31–36	8	7–9	1380	36	33–39	10	8–12
Affiliation to work market[c]										
Working	4990	37	35–38	10	9–11	3233	41	39–42	11	11–12
Unemployed or other	1511	29	27–32	8	6–10	1449	38	35–41	11	10–13
Early retirement pensioner	1580	23	21–26	8	7–10	2088	35	33–38	10	8–12
Social class[d]										
Creative core	296	29	24–35	8	6–12	46	36	26–52	14	7–30
Creative professional	1249	31	29–34	8	7–10	457	37	32–42	9	7–12
Bohemian	55	30	20–45	10	5–18	10	24	24–24	0	–
Service	2612	31	29–33	8	7–9	4651	35	33–36	9	8–10
Manual	5762	29	28–31	7	7–8	1078	34	32–37	9	7–11
Agricultural	455	30	26–34	9	7–13	82	29	21–41	5	2–14
Unknown	1036	27	24–30	6	5–8	2701	31	29–33	8	7–10
Housing tenure										
Owner-occupied	6700	31	30–33	8	7–8	4736	34	33–36	9	9–10
Rental	4617	28	26–29	7	7–8	4162	33	32–35	9	8–9
Unknown	148	17	12–24	3	1–8	127	28	21–37	6	3–12
Size of dwelling (m^2)										
0–49	490	18	15–22	4	2–6	193	25	20–33	6	3–11
50–99	5040	28	26–29	7	6–8	4673	34	32–35	9	8–9
100–149	4059	32	31–34	8	7–9	2917	33	31–35	9	8–10
⩾150	1876	33	31–35	9	7–10	1242	37	34–40	11	9–13
Cohabiting status										
Married	7756	32	31–33	8	8–9	5099	34	33–36	9	9–10
Cohabiting	792	32	29–36	7	5–9	564	33	29–37	8	6–11
Single	903	22	19–25	4	3–6	367	25	21–30	7	4–10
Widow/widower	609	19	16–22	5	4–8	1623	34	31–37	9	7–11
Divorced	1405	24	22–26	6	5–8	1372	34	32–37	8	6–9
Type of district										
Capital area	3583	29	28–31	7	6–8	2931	33	32–35	9	8–10
Provincial city	5867	30	29–31	8	7–8	4702	34	33–35	9	8–10
Rural area	1316	27	25–30	7	6–9	942	33	30–36	8	7–10
Peripheral rural area[e]	699	32	28–35	8	7–11	450	35	31–40	11	9–15
Ethnicity[f]										
Danish	11,465	30	29–31	8	7–8	9025	34	33–35	9	8–10
Immigrant or descendant from western country	191	33	26–40	10	6–16	205	35	29–42	8	5–13
Immigrant or descendant from non-western country	227	37	31–45	13	9–19	72	41	31–55	14	8–27
Charlson comorbidity index[g]										
None	7861	30	29–31	8	7–8	6475	34	33–36	9	9–10
1	2294	29	27–31	7	6–9	1606	32	30–35	9	7–10
⩾2	1310	27	25–30	7	5–9	944	31	28–34	7	6–10
Depression										
No	11,183	30	29–31	8	7–8	8563	34	33–35	9	8–10
Yes	282	29	24–35	6	4–10	462	34	30–39	10	7–13
Schizophrenia or other psychosis										
No	11,323	30	29–31	8	7–8	8876	34	33–35	9	8–10
Yes	142	21	15–29	5	2–10	149	29	22–38	6	3–12

a Ratio of observed survival of cancer patients and survival that would have been expected if the patients had had the same age-, period-, socioeconomic, demographic or health-related indicator-specific mortality as the total study population; for 'social class' and 'ethnicity', expected survival is adjusted only for age, not period, because of low power.

b Household income after taxation and interest, adjusted for number of persons in household; categorised by gender-specific distribution of household disposable income per person.

c For pensioners, work market affiliation before pension date was assigned and follow-up to age 69.

d Based on theory of creative class (13): the creative core (e.g. researchers, designers, architects), creative professionals (e.g. managers, business and finance, lawyers, doctors), bohemians (e.g. artists, models), the service class (e.g. nurses, hairdressers, caterers), the manual class (e.g. construction workers, transport and production workers) and the agricultural class (e.g. farmers, fishermen).

e More than 40 km to a local centre with adequate possibilities for employment and not sharing a border with a centre municipality.

f Excluded from the study population in all other analyses presented in Table 2.

g The presence of disorders, as defined in the Charlson index, was defined as an in- or outpatient contact with one of the diagnoses listed in Table 1 in Ref. 11 between 1978 and 2 years before the cancer diagnosis. Grouped according to the accumulated sum of scores.

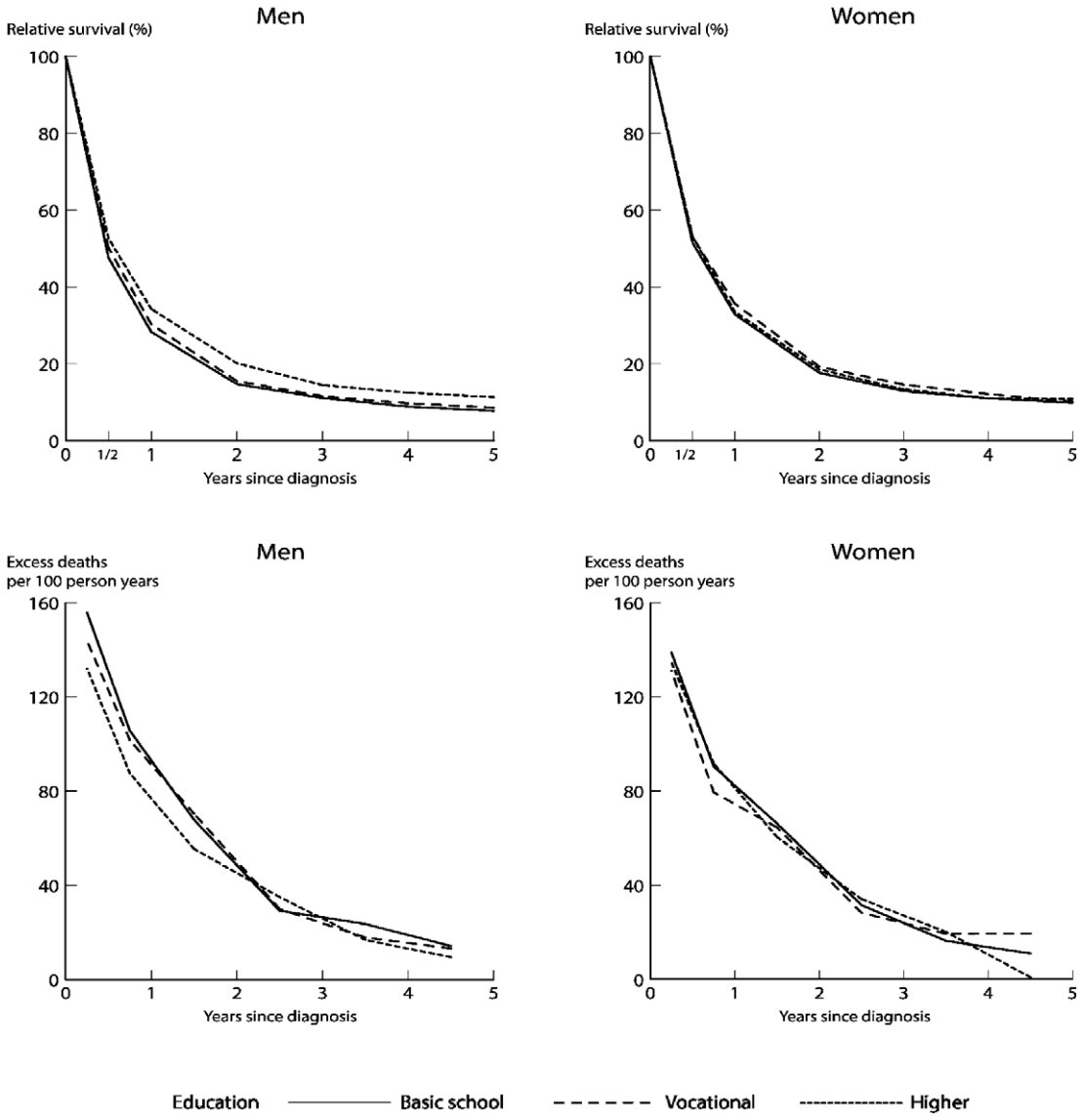

Fig. 2 – Age-standardised relative survival and excess mortality rates per 100 person-years by level of education in patients born in 1925–1973, with lung cancer diagnosed in Denmark 1994–2003 and followed through 2006. Relative survival is the ratio of the observed survival of the cancer patients and the survival that would have been expected if the patients had had the same age-, period- and education-specific mortality as the total study population. Excess mortality is excess to the same population mortality and estimated in intervals since diagnosis. Estimates were standardised for age on the basis of the age distribution of all patients with lung cancer in the study cohort.

an immigrant or descendant from either a western or a non-western country increased the IRR for lung cancer amongst men but only partly amongst women. The presence of either somatic or psychiatric disorders resulted in increased IRRs for lung cancer. The education- and income-adjusted IRR was increased by eightfold and fourfold for male and female early retirement pensioners, respectively (Table 1).

3.2. *Relative survival from lung cancer*

Fig. 2 shows the cumulated age-standardised relative survival curves by time since diagnosis in patients in whom lung cancer was diagnosed during 1994–2003 according to level of education, and the corresponding excess mortality rates in intervals since diagnosis. The relative survival curve was very steep within the first 6 months after diagnosis, masking any difference by educational group. From then onwards, a slight difference by education was observed for men, with only a slight difference after 5 years, whilst the survival of women was slightly better for those with vocational education in years 1–4, with no difference after 5 years. The excess mortality curves show that the small difference in 5-year relative survival amongst men stemmed from a lower excess rate for those with higher education in the first 2 years. For women, slightly lower excess mortality was seen in the first year amongst those with vocational education, but there was no difference in relative survival after 5 years (Fig. 2).

Despite the very poor survival after lung cancer, there were some indications of socioeconomic gradients in age-standardised relative survival when measured as a range of socioeconomic, demographic and health-related indicators. Short-term survival tended to be poorer in the less advantaged groups. In general, the 5-year survival estimates were similarly low in all groups, although lung cancer patients living in the smallest apartments, with unknown housing tenure or with schizophrenia, and men who were divorced or single had even lower relative survival rates. Persons living in peripheral rural areas and immigrants or their descendants had slightly higher relative survival than the corresponding population groups (Table 2).

4. Discussion

Consistent with the results of other studies, we found that the incidence of lung cancer in the study cohort increased with decreasing social advantage. Even after adjustment for education and disposable income, social gradients in lung cancer risk remained as measured by factors related to occupation and affiliation to the work market, housing, civil status and degree of urbanicity. The presence of chronic disorders, both somatic (as represented by the Charlson comorbidity index) and psychiatric, resulted in increased incidence rates of lung cancer, possibly reflecting a high prevalence of smoking in these groups. This might also explain the many-fold increase in IRR for early retirement pensioners, many of whom would have chronic disorders that prevented them from holding a job. In line with this, population-based studies from Holland have reported a high prevalence of serious comorbid disorders in non-small cell lung cancer patients, especially in men; however, the effect of comorbidity on prognosis was, again similar to our study, small.[14,15] In regard to social inequalities, a recent study on smoking at educational level in 11 European countries reported that the relative risk estimate for current daily smoking indicated a disadvantage for men (1.33; 95% CI, 0.64–2.74) and women (1.77; 95% CI, 0.91–3.44) with lower education in Denmark.[16]

Survival after lung cancer in this study was, in general, poor. In the EUROCARE-4 study in 22 European countries, the 5-year survival of Danish patients in whom lung cancer was diagnosed in 1995–1999 was lower than the average.[17] After standardisation to a common age distribution in that study, the overall 5-year survival was 7.9%, whilst the European average was 10.2%. Survival after lung cancer was lowest in Denmark compared to other western and northern European countries, although survival was only slightly better in the United Kingdom.[17] The results of this study show that although there was an apparent initial social gradient in relative survival from lung cancer, regardless of how it was measured, the differences between socioeconomic and demographic groups were almost negligible by 5 years after diagnosis. Thus, although men with higher education had a short delay in time of death after lung cancer, their 5-year relative survival was not much different from that of men with vocational education or basic schooling. We could not include information on tumour stage in our analyses; however, an unfavourable stage distribution amongst Danish lung cancer patients at the time of diagnosis has been suggested to contribute to the lower survival from lung cancer in Denmark.[18] It is possible that more affluent lung cancer patients benefit more from, e.g. new treatment options, smoking cessation or lung cancer awareness campaigns, which might result in a differential stage distribution by social position, which would explain the differences in short-term survival observed.

The potential for reducing social inequalities in the incidence of lung cancer is enormous. If all men and women with basic schooling had the same risk factor profile as persons with higher education, the resulting lung cancer incidence in that very large population group would be halved. As it is to be hoped that the survival from lung cancer will improve in Denmark, as it has in other European countries, it will be important to ensure that the gain in survival is similar in all socioeconomic groups.

Conflict of interest statement

None declared.

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