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Reduction of socioeconomic inequality in cancer incidence in the South of the Netherlands during 1996–2008

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ABSTRACT

Background: Cancer incidence varies according to socioeconomic status (SES) and time trends. SES category may thus point to differential effects of lifestyle changes but early detection may also affect this.

Patients and methods: We studied patients diagnosed in 1996–2008 and registered in the South Netherlands Cancer registry. Incidence rates and estimated annual percentage changes were calculated according to SES category, age group (25–44, 45–64 and ⩾65) and sex.

Results: People with a low SES exhibited elevated incidence rates of cancer of the head and neck, upper airways (both sexes), gastro-intestinal tract, squamous cell skin cancer, breast (⩾65) and all female genital, bladder, kidney and mature B-cells (all in females only), whereas prostate cancer, basal cell skin cancer (BCC) and melanoma (both except in older females) were most common among those with a high SES. Due to the greater increase in prostate cancer and melanoma in high SES males and the larger reduction of lung cancer in low SES males, incidence of all cancers combined became more elevated among males of ⩾45 years with a high and intermediate SES, and approached rates for low SES men aged 45–64. In spite of more marked increases in the incidence of colon, rectal and lung cancer in high SES women, the incidence of all cancers combined remained highest for low SES women of ⩾45 years. However, at age 25–44 years, the highest incidence of cancer of the breast and melanoma was observed among high SES females. During 1996–2008 inequalities increased unfavourably among higher SES people for prostate cancer, BCC (except in older women) and melanoma (at middle age), while decreasing favourably among low SES people for cancers of the oesophagus, stomach, pancreas and kidney (both in females only), breast (⩾65 years), corpus uteri and ovary.

Conclusions: Although those with a low SES exhibited the highest incidence rates of the most common cancers, higher risks were observed among those with high SES for melanoma and BCC (both except older females) and for prostate and breast (young females) cancer. Altogether this might also have contributed to the recent higher cancer awareness in Dutch society which is usually promoted more by patients of high SES and those who know or surround them.

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1. Introduction

More or less consistent excess risks for tobacco-related and other lifestyle-related cancers (i.e. respiratory cancers, cancers of the head and neck and upper gastro-intestinal (GI) tract, liver and cervix uteri) have been reported for people from the lower social strata, while their risks for cancers of the colon, breast and ovary and malignant melanoma are generally reduced.[1–12]

Studies of time trends in cancer incidence according to the socioeconomic class in Finland from 1971 to 1995 showed decreases in relative differences among socioeconomic status (SES) categories, (albeit not quantified) for cancers of the colon, female breast, vulva, vagina and testis, while such inequalities remained for cancers of the upper GI tract and rectum, liver, gallbladder and pancreas, female genital organs, prostate and penis.[13–15] Socioeconomic inequalities in oral cancer have perhaps been declining over recent decades in a few countries.[16] In contrast, older data from England and Wales suggested such inequalities to be increasing among males for all cancers combined and for cancers of the lung, larynx and stomach and among females for all cancers combined and for cervical cancer.[1] More recently, increased inequalities from 1995 to 2004 were reported for melanoma, prostate and female breast and kidney cancers.[12]

Although health care in the Netherlands is accessible for everyone, also through obligatory health insurance since 2006 (and social insurance for the 70% with a lower income before then) and through broad availability of well trained general practitioners (one per 2000 people on average), social inequalities in cancer incidence have been reported for cancers of the cervix, lung, stomach, oropharynx, oesophagus and breast, being more common in people with a low SES,[17–20] contrasting breast[20] and colon cancer, albeit inconsistently.[21]

None of the Dutch studies was population-based and took information into account on SES of the complete population, which is typically known in Denmark, Sweden and Finland. Without this information, incidence rates of a specific SES group could not be calculated, and reporting proportions of patients with a specific SES group does not necessarily reflect true incidence. The SES of the population according to postal code has recently been made available by Statistics Netherlands and thus enable correct analyses of incidence according to SES. In addition, these previous studies were conducted on a selected sample and were thus not representative of a geographical area. No studies have yet been done of time trends in the association of incidence and SES in the Netherlands, which are likely to be affected by the various mass screening campaigns.[22] This information is also useful to understand potential changes in awareness of cancer, usually elevated in people of higher SES and to assess the need for specific preventive interventions. Therefore we aimed to detect patterns in time trends in the incidence of the major cancers according to SES in the South of the Netherlands.

2. Patients and methods

2.1. Study population

The South Netherlands or Eindhoven Cancer Registry records data on all patients newly diagnosed with invasive cancer in the south-eastern part of the Netherlands, an area with 2.4 million inhabitants (about 15% of the Dutch population) and served by about 10 general hospitals and two large radiotherapy institutes. Trained registry personnel actively collect data on diagnosis, staging, treatment and survival from the medical records after notification by pathologists and medical registration offices. We included all patients newly diagnosed between 1996 and 2008 with invasive cancers including those amenable to lifestyle,[23–25] i.e. cancers of the oesophagus (including cardia of the stomach); larynx; oropharynx; urinary bladder; lung; corpus uteri; kidney; stomach (non-cardia); colon; rectum; pancreas; breast; cervix uteri; acute and precursor leukaemia and lymphomas; melanoma; basal cell carcinomas (BCC) (for which there is a unique registration at the Eindhoven cancer registry[26]) and squamous cell cancers of the skin (including lip, SCC); as well as prostate; ovary; mature B-cell (including Hodgkin's lymphoma). In addition, we conducted analyses of *all* cancers combined, i.e. including those above plus all other cancers diagnosed, but excluding BCC.

2.2. Socioeconomic status

An indicator for SES developed by Statistics Netherlands was used.[27] SES of the patient was defined at the neighbourhood level (based on six-digit postal code of residence area) combining mean household income (in 1998) and mean economic value of the house/apartment (in 2000), derived from individual fiscal data provided at an aggregated level. On average, each postal code area contains 17 households, thus covering a very small geographical area. The use of routinely collected income fiscal data assures the reliability of the estimates of household incomes. Postal codes were assigned to three SES categories: low (1st–3rd deciles), intermediate (4th–7th deciles) and high (8th–10th deciles). This SES measure is assumed to be valid for 10 years before and after the base year (2000).[27] A separate SES category was made for postal codes of care-providing institutions but these were excluded from the analyses because assigning SES to those living in a nursing home or other care-providing institution is very difficult.

For the year 2004, population data at the level of a six-digit postal code, i.e. according to SES, age and sex, were available from Statistics Netherlands, enabling calculation of specific incidence rates for each SES category. Since these source population data were not available for the other years, we corrected the SES-specific population for the changes in the general population (age distribution, sexes). This method appears to be valid because during 1996–2008 the sum of the specific SES populations never deviated more than 10% from the general population. Absolute inequalities, not relative

inequalities, were investigated. Absolute inequalities were assessed through incidence rates.

2.3. Statistics

Incidence rates were calculated for the period 1996–2008; age-adjustment was performed by direct standardization according to the European Standard Population [European Standardised Rates (ESR), per 100,000 person-years]. SES-specific tumour incidence rates were calculated according to sex for each age category separately (25–44, 45–64, ⩾65 years) in order to trace specific trends. The complete population according to SES was only provided for these age groups. Results are shown per age category only for the tumours with varying patterns. For the other tumours results are only presented for all ages together as 3-year moving averages (for 1996 and 2008 as 2-year moving averages). Incidence rates of >10 were rounded off to integer numbers, rates of 1–10 were rounded off to 1 decimal place and rates <1.0 to 2 decimal places. Evaluation of the trend in incidence was performed by calculating the estimated annual percentage changes (EAPC). Incidence and EAPC analyses were performed using SAS 9.1 (SAS Institute, Cary, NC, USA). *P*-values were two-sided and values <0.05 were considered significant.

3. Results

Localisation at diagnosis of the 133,690 tumours included in this study according to sex and SES is shown in Table 1. Cancers of the lung were most common in low SES, in contrast to cancers of the breast and prostate as well as BCCs.

3.1. All cancers

Associations of SES and *all* cancer incidences, i.e. all cancers diagnosed, have reversed over time for males, from the highest incidence in low SES groups towards the highest incidence in high SES groups (Fig. 1A). Incidence for

Table 1 – Localization of first tumours according to socioeconomic status diagnosed between January 1996 and 31st December 2008, in the Eindhoven Cancer Registry, The Netherlands (N = 133,690).

Tumour site	Males Socioeconomic status						Females Socioeconomic status					
	Low		Intermediate		High		Low		Intermediate		High	
	N	%	N	%	N	%	N	%	N	%	N	%
Oropharyngeal	397	2	484	2	269	1	221	1	271	1	142	1
Larynx	338	2	386	1	263	1	87	0	77	0	34	0
Oesophagus (incl. cardia stomach)	542	3	853	3	600	2	237	1	268	1	178	1
Stomach, non-cardia	498	2	609	2	445	2	382	2	396	1	246	1
Colon	1379	7	2122	7	1725	7	1708	8	1951	7	1447	7
Rectum	842	4	1495	5	1173	5	720	3	947	3	668	3
Pancreas	325	2	496	2	364	1	364	2	406	1	274	1
Lung (incl. bronchus and trachea)	3818	19	4943	16	2903	12	1788	9	1927	7	971	5
Skin, melanoma	350	2	792	2	741	3	496	2	1053	4	921	4
Skin, squamous cell carcinoma incl. lip	910	4	1283	4	1078	4	625	3	713	2	506	2
Skin, basal cell carcinoma	3428	17	6072	19	5757	23	4165	20	6103	21	5429	25
Breast							4638	23	7849	27	5971	28
Cervix uteri							329	2	410	1	176	1
Corpus uteri							788	4	1065	4	782	4
Ovary							545	3	794	3	568	3
Prostate	3033	15	5096	16	4577	18						
Kidney	385	2	710	2	553	2	344	2	416	1	290	1
Urinary bladder	811	4	1216	4	822	3	302	1	323	1	190	1
Mature B-cell incl. Hodgkin	833	4	1478	5	1142	5	792	4	968	3	774	4
Acute/precursor leukaemia/ lymphoma	178	1	304	1	231	1	162	1	256	1	188	1
Subtotal	18,067	89	28,339	89	22,643	91	18,693	91	26,193	91	19,755	93
Total (=*all* cancers, incl. the cancers above but excl. basal cell carcinoma)	16,798		25,639		19,254		16,421		22,557		15,882	

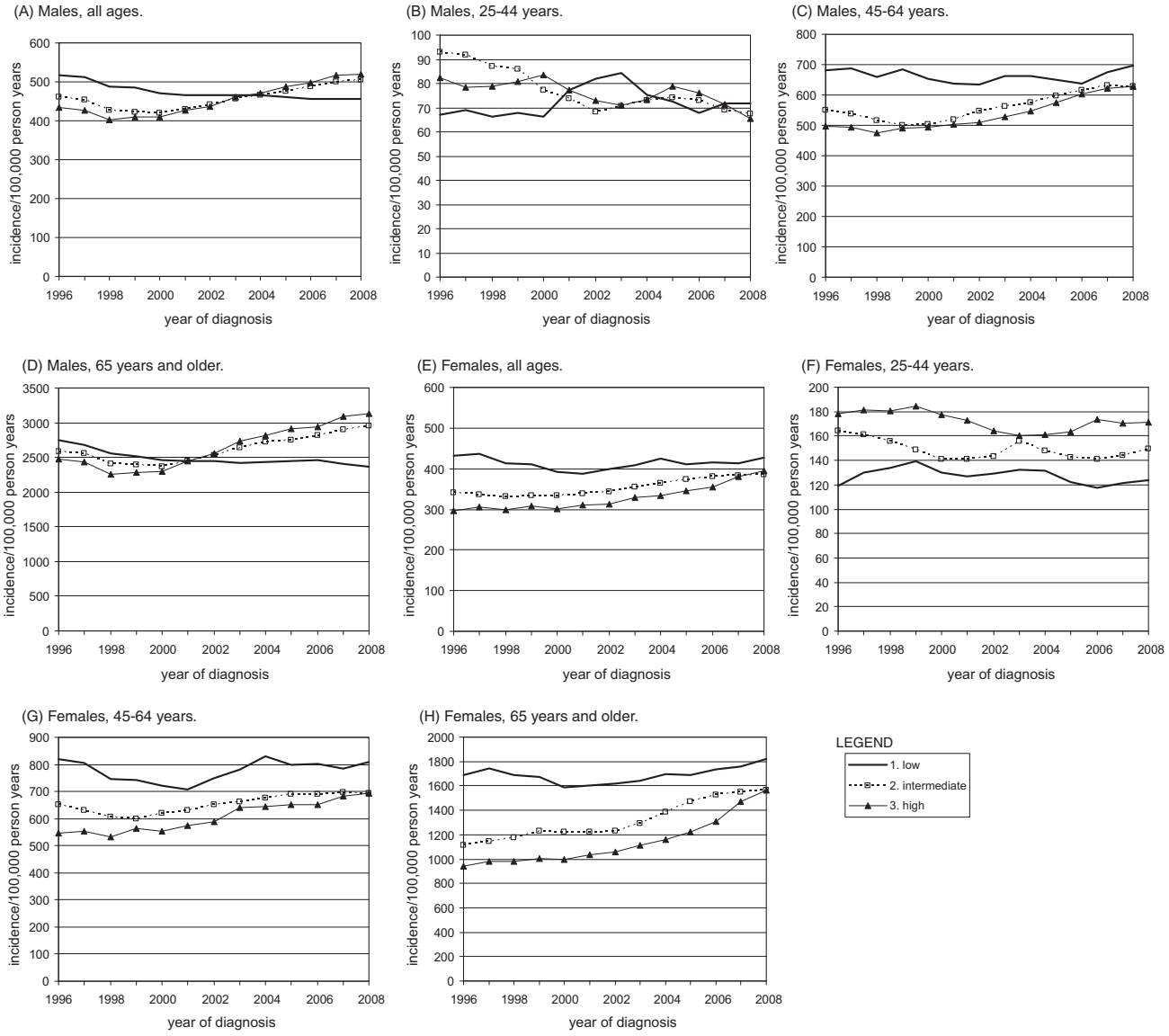

Fig. 1 – Incidence of all cancers, excluding basal cell carcinoma, according to socioeconomic status.

males with low SES has decreased slightly (EAPC –1.0%), while the incidence increased among those with intermediate (1.2%) and high (2.1%) SES (Table 2). In older males a similar shift was observed (EAPCs –1.0%, 1.6% and 2.7% for low, intermediate and high SES) (Fig. 1D). For males aged 45–64 similar trends were observed for those with an intermediate and high SES (1.8% and 2.3%), but the trends for low SES people remained stable (–0.2%) and no shift occurred (Fig. 1C). Although disparities seemed to be reduced for those of 25–44 years, no clear socioeconomic gradient was present (Fig. 1B).

For females we observed decreasing disparities due to an unchanged incidence among low SES over time (EAPC –0.1%) and a rising incidence for intermediate (EAPC 1.4%) and high (2.3%) SES (Fig. 1E). These patterns were similar for those aged 45–64 and 65 and older (Fig. 1G and H), but the association was inverse for females of 25-44 years (Fig. 1F).

3.2. *Tumour specific, males*

3.2.1. *High incidence in low SES*

The association of SES and cancer incidence differed per tumour site (Table 2). Cancers of the head and neck, upper GI tract and airways were generally most common in people of a low SES. But incidence rates for stomach and lung cancer decreased markedly and differentially, the EAPCs for stomach cancer being –5.1% in low SES and –2.8% in high SES. EAPCs for lung were –3.2% for low and –2.2% for high SES (Fig. 2A).

3.2.2. *High incidence in high SES*

Prostate cancer, melanoma and BCC remained generally more common among those with a high SES because of the increasing incidence for people with a high SES, while incidence for people with a low SES remained more or less unchanged, or only slightly increased in case of BCC (Table 2, Figs. 3A–C,

Table 2 – Cancer incidence according to sex and socioeconomic status, 3-year moving averages for 1996, 2002 and 2008.

	Socioeconomic status	Males Incidence (ESR)						Females Incidence (ESR)					
		1996	2002	2008	EAPC	95% CI		1996	2002	2008	EAPC	95% CI	
Total (excl. BCC)													
All ages	1. Low	517	466	457	**−1.0**	−1.7	−0.4	432	399	427	−0.1	−1.1	0.8
	2. Intermediate	460	441	504	**1.2**	0.3	2.1	341	343	385	**1.4**	0.8	1.9
	3. High	434	437	520	**2.1**	1.0	3.1	297	313	394	**2.3**	1.4	3.2
25–44 years	1. Low	67	82	72	0.8	−1.3	2.8	119	130	124	−0.5	−1.9	1.0
	2. Intermediate	93	68	68	**−2.6**	−4.0	−1.2	164	143	150	−1.0	−2.3	0.4
	3. High	82	73	65	−1.4	−3.2	0.3	178	165	171	−0.9	−1.9	0.1
45–64 years	1. Low	683	636	696	−0.2	−1.4	1.1	820	748	808	0.2	−1.1	1.6
	2. Intermediate	549	546	629	**1.8**	0.8	2.7	652	652	695	**1.1**	0.4	1.8
	3. High	496	509	629	**2.3**	1.4	3.2	546	588	693	**2.3**	1.2	3.3
⩾65 years	1. Low	2747	2444	2367	**−1.0**	−1.6	−0.4	1689	1621	1822	0.4	−0.5	1.4
	2. Intermediate	2581	2524	2956	**1.6**	0.6	2.5	1114	1228	1563	**3.1**	2.3	3.9
	3. High	2478	2553	3131	**2.7**	1.6	3.9	943	1060	1564	**4.2**	3.0	5.4
Oropharyngeal	1. Low	12	11	14	−0.4	−3.1	2.3	6.8	6.4	7.9	1.6	−1.9	5.0
	2. Intermediate	8.1	8.9	7.3	0.9	−2.6	4.4	3.6	4.2	4.9	2.0	−1.5	5.5
	3. High	5.5	5.1	7.0	0.7	−2.4	3.7	3.2	2.3	3.7	2.7	−1.3	6.6
Larynx	1. Low	8.6	10	9.1	−0.4	−3.7	3.0	1.9	2.8	2.9	3.2	−2.5	8.8
	2. Intermediate	7.5	8.0	5.6	−1.7	−5.3	1.9	1.3	1.0	1.4	2.8	−1.2	6.9
	3. High	7.1	5.6	6.2	−0.1	−3.0	2.8	0.40	0.80	0.85	1.7	−9.2	12.7
Oesophagus (incl. cardia stomach)	1. Low	12	15	17	2.9	−2.0	7.8	6.1	5.1	4.2	−3.1	−6.4	0.3
	2. Intermediate	13	15	20	**4.0**	1.9	6.1	3.1	4.3	3.9	2.7	−2.4	7.7
	3. High	11	13	17	**3.4**	0.4	6.4	2.9	3.2	4.8	**2.8**	0.1	5.6
Stomach (non-cardia)	1. Low	19	14	11	**−5.1**	−8.5	−1.6	11	8.3	6.2	−2.8	−6.1	0.5
	2. Intermediate	17	11	9.2	**−4.2**	−7.0	−1.4	5.9	5.1	6.5	−1.2	−4.8	2.4
	3. High	13	10	9.3	**−2.8**	−5.1	−0.6	4.6	4.8	5.7	2.6	−2.1	7.4
Colon	1. Low	36	37	43	**1.5**	0.3	2.7	35	34	42	0.7	−1.4	2.8
	2. Intermediate	40	36	45	1.4	−0.7	3.5	26	30	33	**2.5**	1.7	3.3
	3. High	40	41	49	**2.4**	1.1	3.7	25	28	37	**3.3**	1.9	4.6
Rectum	1. Low	24	26	22	−1.4	−3.7	1.0	17	14	19	0.9	−1.5	3.3
	2. Intermediate	25	25	34	**2.3**	0.4	4.2	15	14	15	1.0	−0.8	2.8
	3. High	25	26	28	**1.5**	0.4	2.7	10	12	16	**2.9**	0.3	5.4
Pancreas	1. Low	10	8.4	8	−3.3	−7.3	0.7	9.9	6.4	7.1	−2.5	−5.8	0.9
	2. Intermediate	8.8	8.0	11	**2.3**	0.2	4.3	5.4	6.0	6.4	2.5	−0.1	5.1
	3. High	6.8	7.1	12	3.7	−0.1	7.5	5.2	4.6	7.3	**4.1**	0.6	7.5
Lung, bronchus and trachea	1. Low	138	104	94	**−3.2**	−4.6	−1.9	43	48	57	**3.7**	2.1	5.3
	2. Intermediate	100	86	83	**−1.7**	−2.5	−0.8	23	31	41	**5.9**	4.6	7.1
	3. High	90	69	62	**−2.2**	−4.3	−0.2	13	20	31	**7.1**	5.0	9.1
Skin, melanoma													
All ages	1. Low	11	10	13	1.2	−1.8	4.2	13	14	14	0.7	−1.4	2.8
	2. Intermediate	9.5	11	17	**5.5**	3.7	7.3	17	15	20	1.9	−0.1	3.9
	3. High	14	16	21	**3.1**	1.3	4.9	18	18	26	**3.1**	1.2	5.0
25–44 years	1. Low	8.8	9.7	7.1	−0.5	−6.3	5.4	6.5	16	13	4.8	−0.6	10.1
	2. Intermediate	13	6.9	12	0.1	−5.3	5.6	24	16	21	−1.1	−4.4	2.1
	3. High	9.1	15	13	1.2	−4.1	6.6	30	27	28	−0.3	−3.2	2.6
45–64 years	1. Low	10	12	27	4.9	−2.5	12.4	23	21	25	0.8	−5.7	7.4
	2. Intermediate	17	21	31	**5.3**	3.2	7.5	22	26	34	3.2	−0.7	7.1
	3. High	25	26	33	**2.7**	0.9	4.5	30	28	53	**5.5**	2.2	8.9
⩾65 years	1. Low	41	34	44	2.8	−3.7	9.4	33	35	32	0.0	−4.3	4.3
	2. Intermediate	11	35	52	**12.5**	8.3	16.7	24	24	46	**8.7**	2.6	14.7
	3. High	45	46	79	**7.6**	0.8	14.4	10	28	47	**10.2**	5.3	15.0
Skin, basal cell carcinoma (BCC)													
All ages	1. Low	90	94	111	**1.7**	0.5	2.9	91	94	125	**3.1**	1.9	4.3
	2. Intermediate	90	96	151	**5.1**	3.4	6.8	75	83	131	**5.1**	3.6	6.6
	3. High	99	118	186	**6.0**	4.8	7.2	83	101	164	**6.1**	4.7	7.5
25–44 years	1. Low	13	19	26	**4.5**	1.1	7.9	28	34	44	**5.4**	3.4	7.4
	2. Intermediate	25	24	33	2.2	−0.2	4.6	41	38	61	**3.9**	1.4	6.5
	3. High	37	36	42	**2.8**	0.1	5.4	51	62	79	**4.6**	3.5	5.7

(*continued on next page*)

Table 2 – (*continued*)

	Socioeconomic status	Males Incidence (ESR)						Females Incidence (ESR)					
		1996	2002	2008	EAPC	95% CI		1996	2002	2008	EAPC	95% CI	
45–64 years	1. Low	148	138	147	0.2	−2.0	2.3	157	165	230	**3.7**	1.5	5.8
	2. Intermediate	128	137	205	**4.7**	2.6	6.7	134	149	227	**5.1**	3.5	6.6
	3. High	147	182	269	**5.1**	3.9	6.4	181	190	296	**4.6**	2.7	6.5
⩾65 years	1. Low	410	473	603	**3.2**	2.2	4.1	415	416	561	**3.0**	1.7	4.4
	2. Intermediate	439	491	835	**6.3**	4.3	8.3	267	319	538	**6.4**	4.4	8.3
	3. High	454	568	1003	**7.8**	6.3	9.3	200	331	636	**9.9**	8.1	11.7
Skin, squamous cell, including lip	1. Low	25	26	29	1.4	−1.6	4.4	9.2	11	19	**7.5**	3.8	11.1
	2. Intermediate	21	23	34	**4.7**	2.8	6.5	8.4	9.2	16	**6.1**	3.5	8.7
	3. High	20	24	43	**6.5**	4.3	8.7	8.4	8.7	16	**7.9**	4.1	11.7
Breast													
All ages	1. Low							132	127	123	−1.2	−2.6	0.2
	2. Intermediate							125	123	131	0.6	−0.3	1.4
	3. High							119	121	140	**1.3**	0.1	2.6
24–44 years	1. Low							42	61	43	−0.7	−3.6	2.3
	2. Intermediate							65	68	66	0.0	−1.4	1.4
	3. High							89	87	81	−0.8	−2.2	0.6
45–64 years	1. Low							299	273	275	−0.9	−2.7	1.1
	2. Intermediate							291	273	281	0.6	−0.7	1.8
	3. High							265	266	294	1.3	−0.3	2.9
⩾65 years	1. Low							389	393	415	−0.7	−2.1	0.8
	2. Intermediate							298	325	388	1.5	−0.3	3.3
	3. High							247	282	406	**3.8**	2.1	5.4
Cervix uteri	1. Low							8.2	8.0	9.2	−0.7	−5.1	3.7
	2. Intermediate							8.4	5.5	6.5	−2.6	−7.2	2.1
	3. High							5.5	2.8	3.4	−3.1	−8.4	2.1
Corpus uteri	1. Low							25	19	20	−1.2	−3.2	0.9
	2. Intermediate							19	14	17	0.3	−2.7	3.3
	3. High							12	17	19	**3.4**	1.1	5.8
Ovary	1. Low							16	16	13	−3.4	−7.5	0.7
	2. Intermediate							17	13	10	**−4.1**	−5.9	−2.3
	3. High							13	12	12	**−1.8**	−3.2	−0.3
Prostate													
All ages	1. Low	80	80	77	0.5	−0.7	1.8						
	2. Intermediate	82	87	109	**3.9**	2.2	5.6						
	3. High	81	107	130	**5.1**	3.2	7.0						
45–64 years	1. Low	71	89	96	**3.9**	2.0	5.8						
	2. Intermediate	60	86	134	**8.9**	6.7	11.2						
	3. High	62	109	162	**10.3**	8.1	12.5						
⩾65 years	1. Low	541	512	483	0.0	−1.4	1.4						
	2. Intermediate	593	595	698	**2.9**	1.2	4.6						
	3. High	579	721	843	**4.1**	2.1	6.2						
Kidney	1. Low	11	10	11	0.4	−1.7	2.5	11	7.3	7.4	−2.0	−5.3	1.3
	2. Intermediate	13	10	16	1.7	−1.5	4.8	6.9	6.5	7.8	1.0	−1.5	3.5
	3. High	12	10	16	**3.2**	0.5	6.0	5.6	6.3	6.5	1.9	−2.1	5.9
Urinary bladder	1. Low	26	22	19	−2.6	−4.7	−0.6	7.8	5.2	8.5	0.8	−4.0	5.6
	2. Intermediate	21	23	22	0.6	−1.1	2.3	4.0	5.0	5.5	**4.1**	1.8	6.4
	3. High	22	19	23	1.1	−0.9	3.1	4.1	4.1	3.5	3.0	−3.6	9.6
Mature B-cell including Hodgkin	1. Low	28	24	25	−0.5	−3.4	2.4	22	22	17	−0.4	−3.1	2.3
	2. Intermediate	28	25	28	0.7	−0.8	2.3	15	14	15	1.6	−0.5	3.7
	3. High	27	26	28	1.2	−0.4	2.7	15	14	19	**2.4**	0.5	4.3
Acute/precursor leukaemia/lymphoma	1. Low	8.1	5.8	4.1	**−5.4**	−10.1	−0.8	6.2	2.7	5.8	1.7	−4.8	8.2
	2. Intermediate	6.1	5.1	5.4	−0.8	−3.9	2.3	3.6	3.3	4.8	0.6	−4.3	5.5
	3. High	5.4	6.9	5.6	−1.8	−7.4	3.7	4.5	3.2	5.7	1.8	−2.7	6.4

95% CI: 95% confidence interval of EAPC; ESR: European Standardised Rate (3-year moving averages); and EAPC: Estimated Annual Percentage Change.

4A, and 5A). In 1996, the incidence of prostate cancer was similar for each of the SES groups, but disparities increased due to strong increases in intermediate (3.9%) and high (5.1%) SES males, but only 0.5% in low SES males and even showed a decrease from 2005 onwards (Fig. 3A). Incidence increased in all SES groups of those aged 45 and older, except

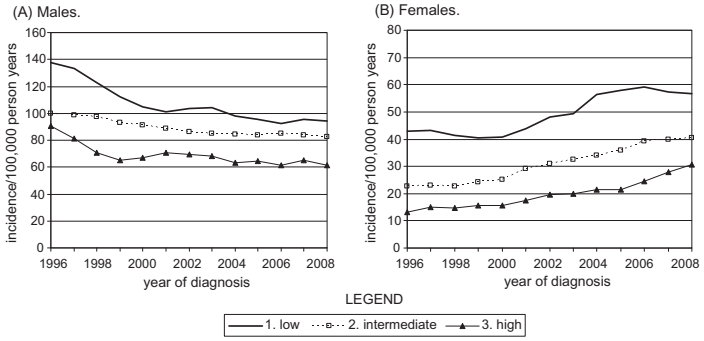

Fig. 2 – Incidence of lung cancer according to socioeconomic status.

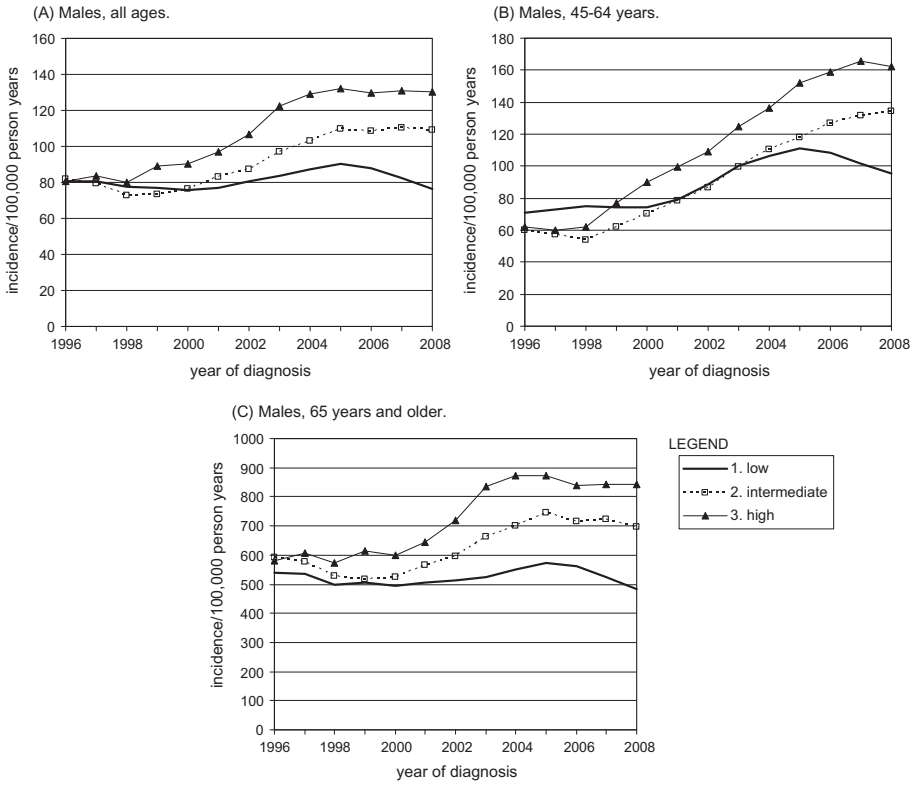

Fig. 3 – Incidence of prostate cancer according to socioeconomic status.

low SES males of 65 and older, being most marked for those with a high SES, especially at middle age (Fig. 3B and C). In the oldest males a plateau seemed to be reached around 2004 for intermediate and high SES (Fig. 3C). Incidence of melanoma increased especially for people with an intermediate and high SES, in those aged 45 and older, but mostly in the high SES groups (Fig. 4A, C and D), except for males of 25–44 years (Fig. 4B). People with a high SES generally exhibited the highest incidence of BCC of the skin and disparities increased mainly after 2001 (EAPC 6.0% for high compared to 1.7% for low SES males) (Fig. 5A). Similar patterns were seen for males of 45 and older as well as of 25–44 years, but with larger variations (Fig. 5B–D).

3.2.3. *Shifting or inconsistent associations*

Incidence of colon cancer became slightly higher for people with a high SES after 2000 (Fig. 6A). Similar associations were observed for squamous cell cancer (SCC) of the skin and kidney cancer (Table 2). There were no such associations for cancers of mature B-cells and acute and precursor leukaemia and lymphomas (Table 2). No increase in low SES compared to intermediate and high SES was observed for rectal cancer (Fig. 7A). The shift from highest towards lowest incidence of cancer of the pancreas in people of low SES was of borderline significance (Table 2).

3.3. *Tumour specific, females*

3.3.1. *High incidence in low SES*

Generally, the females of low SES retained the highest incidence for cancers of oropharynx, larynx, lung, SCC of the skin, cervix uteri and urinary bladder. Disparities among SES groups were reduced for cancers of the oesophagus, stomach, pancreas, colon, rectum, corpus uteri, ovary, kidney

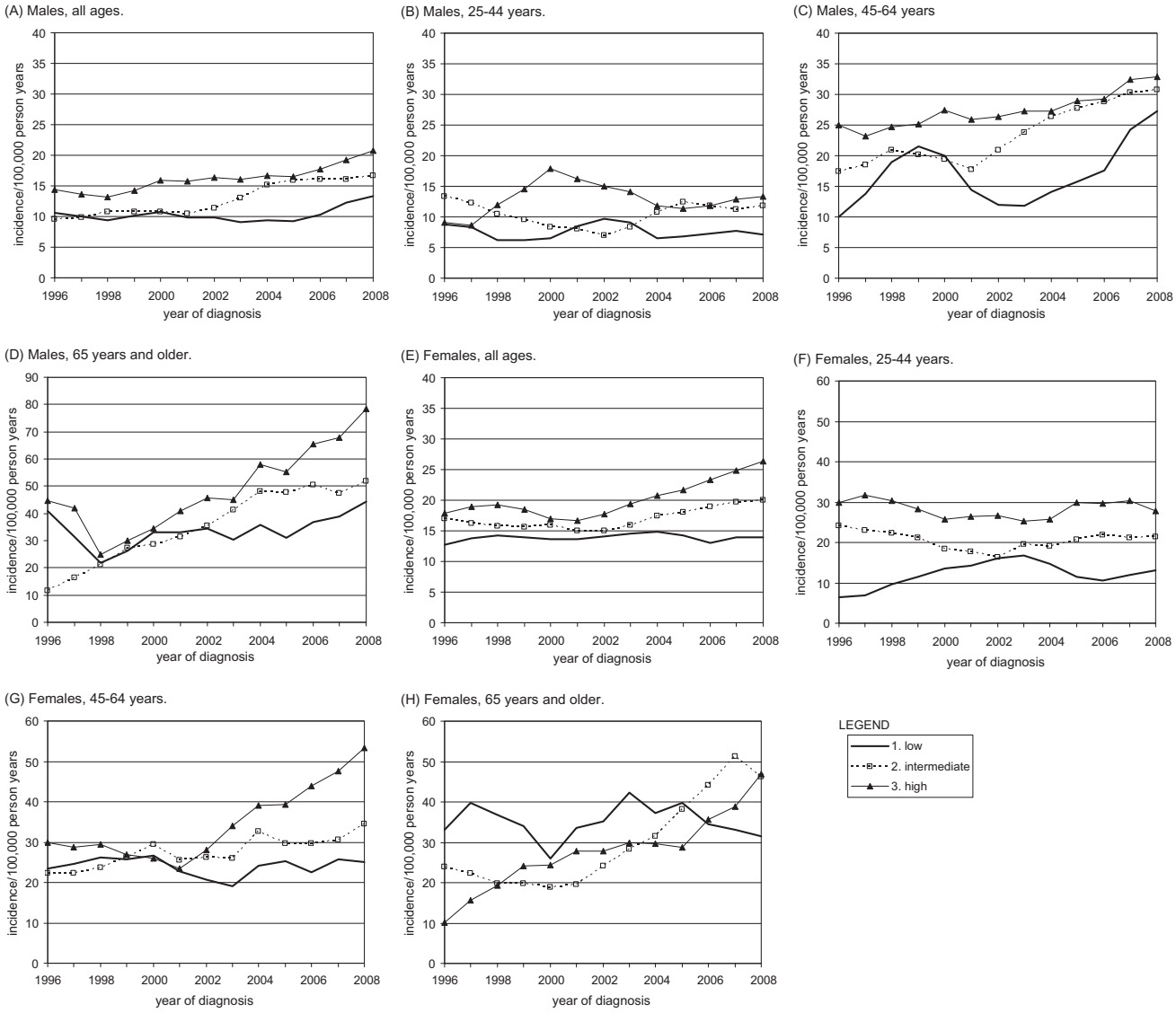

Fig. 4 – Incidence of melanoma according to socioeconomic status and sex.

and mature B-cells (Table 2). Lung cancer incidence increased more for women with a high SES, the EAPC for low SES women being 3.7%, intermediate 5.9% and high SES 7.1% (Fig. 2B). Furthermore, colon and rectal cancer incidence remained highest in women with a low SES, but disparities diminished due to marked increases in those with a high and intermediate SES since 1996 (EAPC colon low 0.7%, intermediate 2.0% and high SES 3.3%, for rectal 0.9%, 1.0% and 2.9%, respectively) (Figs. 6B and 7B).

3.3.2. *High incidence in high SES*

Melanoma remained and BCC became more common in persons with intermediate and high SES (EAPCs 1.9% and 5.1%, and 3.1% and 6.1%, respectively) (Figs. 4E and 5E). Remarkably, incidence rates for people with a high SES were highest only at age 25–64 years, in contrast to the highest incidence rates among older women with a low SES until 2005 (Figs. 4E–H and 5E–H).

3.3.3. *Age-dependent and inconsistent associations*

Incidence of breast cancer according to SES remained fairly similar for all SES groups at middle age (Fig. 8C), but among younger women the highest incidence was observed in women with a high SES (Fig. 8B). In 1996 rates were highest in older women of low SES, but the pattern changed due to more markedly increased rates for intermediate and high SES women and in 2008 incidence did not differ by SES anymore (Fig. 8A and D). No association was observed for acute and precursor leukaemia and lymphomas (Table 2).

4. Discussion

In this study in the South of the Netherlands, people with a low SES retained the highest incidence rates for most (including smoking-related) cancers. However, prostate cancer became more common among those with a high SES and these patterns became more pronounced for BCC and

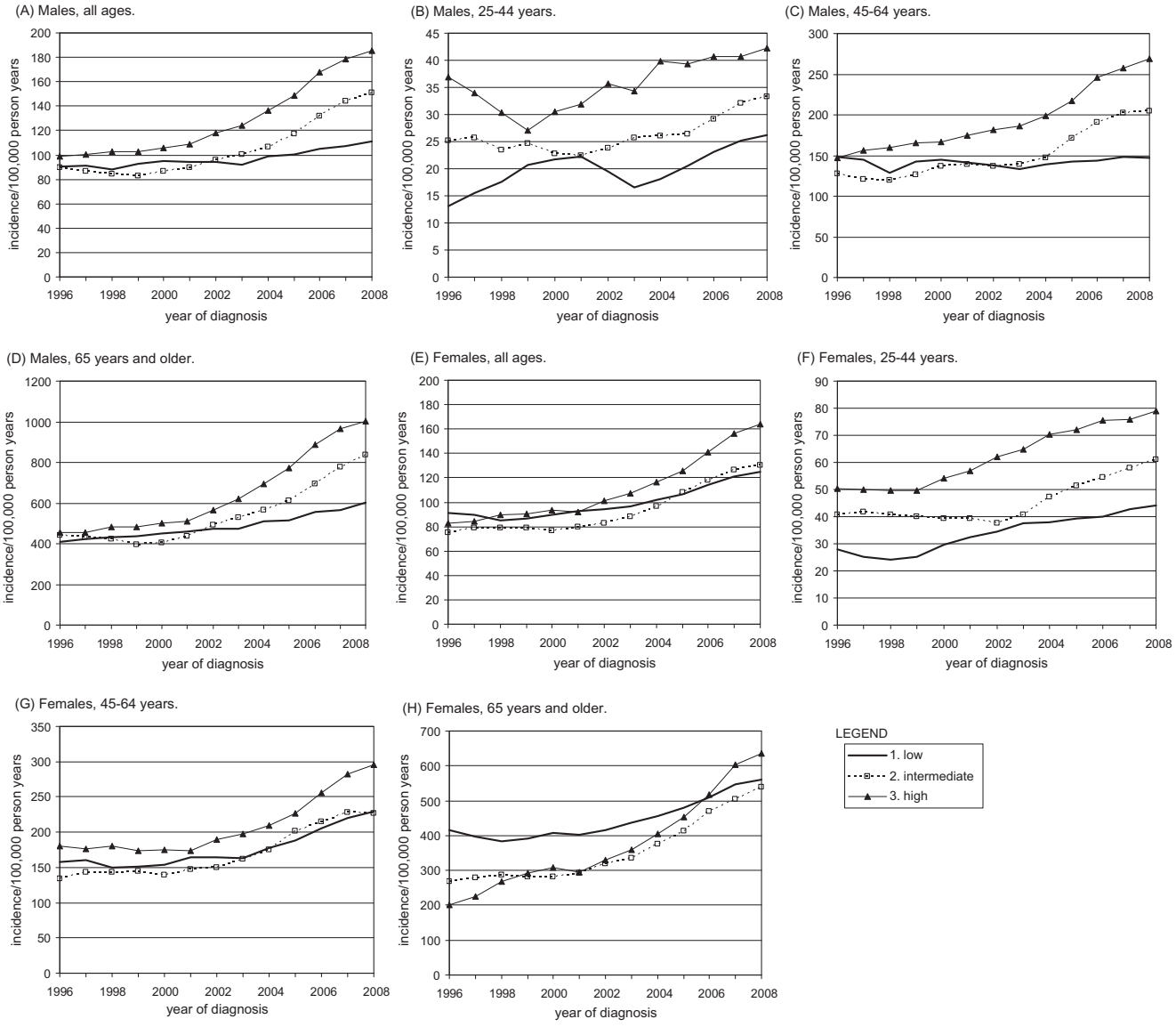

Fig. 5 – Incidence of basal cell carcinoma according to socioeconomic status and sex.

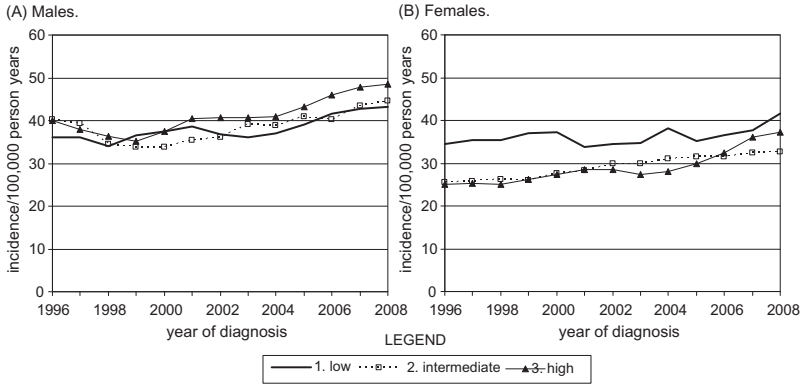

Fig. 6 – Incidence of colon cancer according to socioeconomic status.

melanoma (both except older females). These trends contributed to decreasing disparities in incidence of all cancers combined in those of 45 and older and even to a shift towards higher risks among older males with a high SES. People with a high SES retained the highest incidence of all cancers combined in females of 25–44 years, largely breast cancer, while a

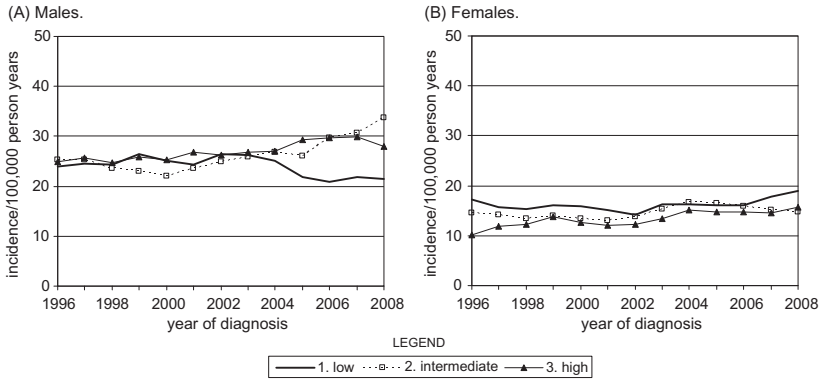

Fig. 7 – Incidence of rectal cancer according to socioeconomic status.

decrease in the inequalities was observed for males of this age without a clear gradient being present.

4.1. *Incidence of all cancers combined*

In this study higher incidence rates of all cancers combined were reported for males with a low SES in line with those reported in literature,[1,11,12,28–30] except for the shift towards highest rates for men with a high SES. However, such results could not easily be compared because age- and SES-specific incidence rates have never been reported[1,11,12,28–30] and for another period.[1,29] Could we be signalling a new trend and might this have implications for implementation of prevention?

Incidence of all cancers combined increased most markedly in males with a high SES, followed by intermediate SES, while it remained stable or was even reduced in the low SES group. These patterns are probably explained by cancers of the lung and prostate and melanoma.

In contrast to males, increased risk[12,28] as well as (non-significant) decreased risks[29,31] of all cancers were reported for low SES females, which in Italy seemed to depend on the SES indicator.[11] Incidence remained highest for females of 25–44 years with a high SES, which was largely determined by breast cancer and possibly melanoma. For females of 45 and older, the low SES group had more or less the highest incidence of all cancers combined but inequalities decreased over time due to strongly increasing incidence in the high SES group, probably largely influenced by breast, colon, rectal and lung cancer.

4.2. *Males – incidence of cancer at specific subsites*

Increasing inequalities in prostate cancer incidence were observed due to increases in the high SES groups, similar to those in England.[12] Most other European studies did not report such changes albeit high SES males indeed exhibited high incidence before 1998[14,29,31] and 2004.[32] Prostate cancer incidence in the Netherlands remained constant from 1995 to 2000, but rose from 2000 to 2006,[33] most likely caused by PSA testing which is more common among high SES males.[34,35] It seems likely to explain the differential trends since 2000, i.e. small increases in low SES groups, moderate increases in intermediate and marked increases in high SES groups. Remarkable decreases in prostate cancer incidence among low SES have been observed after 2005, which we could not explain. Possibly the prevalent pool of prostate cancer may become exhausted similar to the United States (US) situation,[36] but this probably applies to all SES groups. Although PSA testing continued to increase for all males of 40 and older,[37] it may have hardly increased or even decreased in low SES groups. Since 2003–2004 remarkable plateaus were observed among intermediate and high SES males of 65 and older, possibly related to awareness of overdiagnosis in this age group as experience with prostate cancer screening in the Netherlands was having effects. In the following years we will observe whether these trends will persist or perhaps even decrease.

Incidence of melanoma and BCC increased markedly, especially in high SES males. Previously, incidence of melanoma was lowest among the lower SES groups[1,12,29,32,38] and an increasing incidence of BCC was found especially among the high SES group.[39] Health awareness and sun tanning behaviour (especially at young age) on sunny holidays may have been responsible for this trend.[39] During the last two decades the availability has also increased for those with a lower SES and we therefore expect the incidence to increase in this group.

4.3. *Females – incidence of cancer at specific subsites*

For females of 25–44 years breast cancer incidence remained the highest for those with a high SES, probably due to better health awareness and older age at first birth.[40] In contrast, no inequalities were observed for women aged 45–64. This probably relates to the free breast cancer mass screening programme that started in 1991 and was fully implemented in 1996 for all women of 50–69 years, although we found higher participation in high SES females (87% versus 79% of low SES, Aarts 2010). In 1998 the upper age limit of the screening programme was extended to 75. This likely had more effect on attendance of females with a high SES and thus may have reduced socioeconomic disparities in breast cancer incidence rates which were no longer highest in low SES groups in 2008.

For females, remarkable trends in melanoma, BCC, colon and rectal cancers were observed, as reported for melanoma and BCC (without distinction according to age).[1,8,12,29,38] Up to 65, increases in melanoma and BCC were largest in high SES females (as observed for males), while older women with

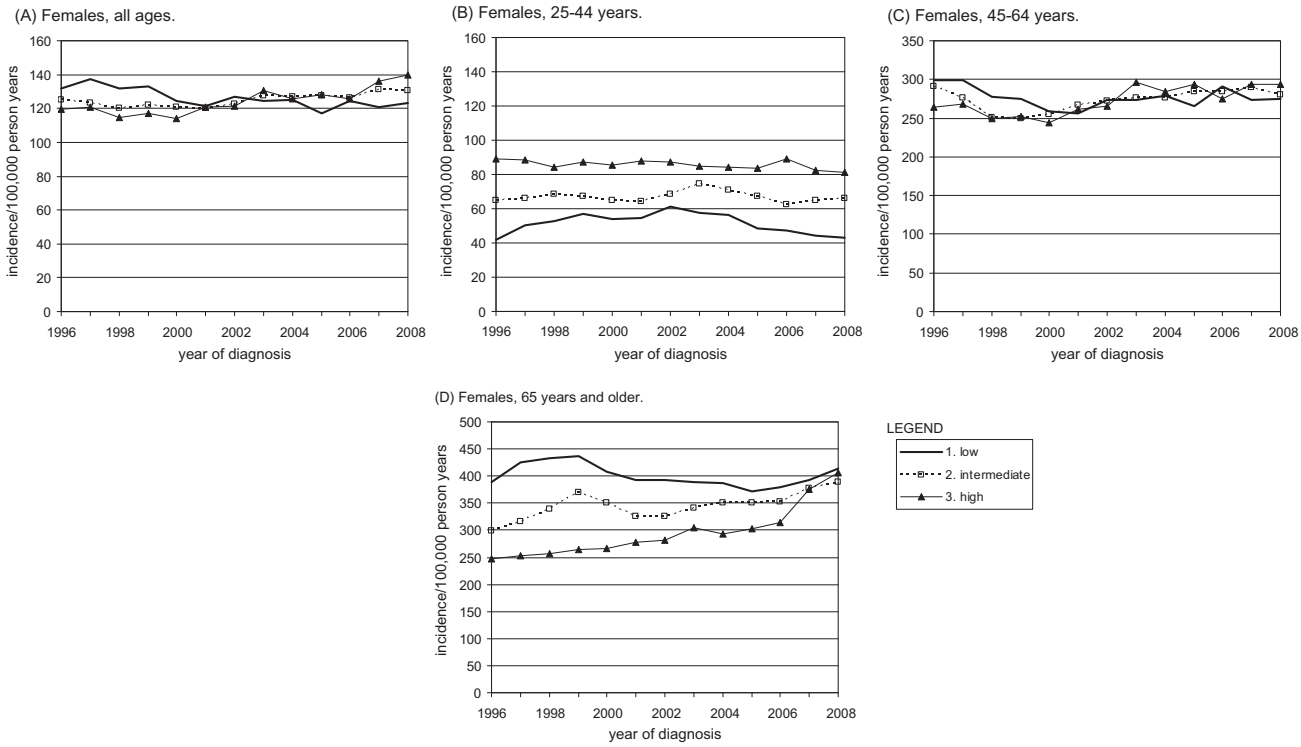

Fig. 8 – Incidence of breast cancer according to socioeconomic status.

a low SES had the highest incidence until around 2004 but patterns became inconsistent during the last years. In a previous study we observed that elderly women with a low SES mainly had BCCs at extremities, head and neck, i.e. related to chronic exposure, while high SES males had the highest incidence rates for all subsites and all age groups.[39] This points to more chronic exposure of elderly women and sun tanning exposure of males; the shift around the mid-2000s may result from differences in sun tanning behaviour or from better awareness of skin cancers a few decades ago.[41]

Females with a high SES had the highest risks of colon and rectal cancer, while only a slightly higher incidence rate of colon cancer was observed for high SES males, in agreement with other European studies.[42] Poor diet and low physical activity levels have become more common in low SES working men in the past few decades. However, in association with greater health awareness, opportunistic screening may be more common in high SES groups in the Netherlands which is reflected in the largest increases in high SES males, although only small differences in stage distribution were present (data not shown). In view of the upcoming screening programme it is important to provide equal access to achieve early detection.[42]

4.4. *European context*

Despite different levels and types of SES indicators, other European studies performed in the same period have shown results fairly similar to ours in the overlapping period (1996–2004). For all cancers combined males exhibited similar inequalities (i.e. 0–20% increased for low SES) to England, Italy, Iceland and Denmark, while inequalities for females from these countries and Norway were smaller (varying from 20% reduced to 20% increased in low SES) than we observed (20–50% increased risk in low SES).[11,12,29,32,43,44] This seems to be associated with large inequalities in risks of tobacco-related and alcohol-related cancers in the Netherlands compared to Italy, Iceland, Denmark and (inconsistently) England.[2–4,11,12,32,45] In addition, inequalities in breast cancer risk were absent in our study (for all ages combined), while decreased risks for low SES were reported in Norway, Sweden, Denmark, Iceland, England and Italy.[9,12,29,43,45,46] Furthermore, although we observed a strong socioeconomic gradient in melanoma risk, inequalities were larger in England, Italy and Iceland (the last only in males),[12,29,45] while inequalities were similar to Denmark and Iceland (females), and slightly smaller than in Norway.[8,32,43]

4.5. *Lifestyle and early detection*

The higher risks and generally more marked increases among the high SES groups seem largely to result from early detection, i.e. for BCC, melanoma (both except females of 65 and older) and prostate cancer. Detection rates probably rose more markedly in high SES groups due to their greater awareness and knowledge of cancers and willingness to seek medical advice.[47–50] In other studies, this was reflected by earlier stages of disease,[51–54] as we also observed for breast (low versus high SES: 38% versus 42% pathological stage 1), cervix uteri (47% versus 55%) and prostate (66% versus 72% clinically localised disease). In addition, relative survival rates for cancer patients with a low SES are usually worse.[1,42,55] Prognosis of early detected cancers is generally good, largely because of this early stage diagnosis. However, the improvement of sur-

vival due to early detection could partly be attributed to bias, e.g. lead time bias (an artifactual increase in time from diagnosis to death) and length bias (an artifactual decrease in hazard rates because some early detected cancers progress too slowly to kill). The proportion of early detected cancers will increase more in people of high SES and thus contribute to their already high life expectancy, while no or only little improvement will be present in the low SES group. As a consequence inequalities in survival will increase, although early detection mainly applies to tumours with good prognosis and thus these increasing inequalities will be relatively small. Due to increasing disparities in cancer incidence resulting from e.g. screening, survival inequalities are likely to increase to the disadvantage of the low SES groups.[56]

On the other hand, incidence rates of lifestyle-related cancers were generally highest in low SES, e.g. lung cancer. In males, smoking prevalence has been decreasing since 1960s[57] and prevalence shifted around that time from highest towards lowest prevalence in high social classes.[58] In females, this shift occurred approximately 10 years later, and prevalence has been increasing until early 1970s,[57] in line with the increasing incidence rates we observed (due to the latency time). Smoking explains 40–50% of inequalities in lung cancer incidence, compared to 23% for physical exercise while diet plays only a small role.[18,59] Although low SES had also increased risks of other tobacco-related cancers (i.e. oropharynx, oesophagus, bladder), incidence rates were not necessarily reducing due to decreasing smoking prevalence. Besides, risk of obesity-related cancers like corpus uteri were indeed more common (but inconsistently) in low SES, while associations for breast cancer were inconsistent due to the screening programme.

Inequalities in cancer risk and prognosis can be addressed by changing lifestyle behaviours, e.g. by addressing smoking. For Denmark several differences in smoking prevalence have been modelled, and all models will reduce the absolute differences in incidence rates of lung cancer between the SES groups, but none will reduce relative inequalities.[60] As it is difficult to change lifestyle behaviours, extra attention should be paid to increase cancer awareness and to ensure early detection, especially in the low SES groups. Thereby prognosis of the low SES individuals will approach those of high SES and socioeconomic disparities will diminish in the long term. However equal access to early detection should then be realised, e.g. by introducing cancer screening programmes. For breast cancer we indeed observed an improved stage distribution (mainly observed for in situ cancers, which were excluded in this study) and survival of all SES groups, but low SES clearly benefited less from the introduction of the screening programme. Thus, socioeconomic inequalities in survival rates even increased,[61] possibly resulting from inequalities in screening participation.[62] In view of the upcoming colorectal cancer screening programme, a high participation rate needs to be realised of low SES individuals.

The following limitations of this study should be mentioned. Firstly, we used an indicator of SES based on the postal code of a residential area and not on individual data on income, education, etc. Since this aggregate covers a relatively small geographical area (on average 17 households), it is likely to represent a reliable approximation of individual SES. Furthermore, routinely collected income tax data have been found to provide reliable estimates of household income.[63] Previous studies in the Netherlands have proven that socioeconomic differences based on neighbourhood data tend to reflect socioeconomic differences accurately at the individual level.[63–65] Secondly, we assumed that the SES indicator did not change during the 10 years before and after 2000. Similar results for survival were obtained with another SES indicator during the period 1983–2002.[61] Thirdly, there were no data on early cancer detection (for example, screening) or on lifestyle changes, such that causal inferences to explain the observed trends could not be directly evaluated. However, uptake in both breast cancer screening and PSA testing was highest in high SES in the Netherlands.[35,62] Fourthly, higher life expectancy may explain part of the higher risk in high SES,[66] but we could not address this issue because the exact age distribution of the population was unknown. However, 16% of the male population with low SES was in the oldest group compared to 10% in high SES; for females these percentages were 21% and 13%, respectively.

Nevertheless, calculation of SES-specific incidence rates would better reflect the socioeconomic inequalities than the proportional distribution of the SES categories among the patients which is used in most studies, with the exception of Denmark, Finland and Sweden, which have SES data at the individual level. Furthermore, selection is unlikely to have influenced the results of this population-based study.

Thus, people with a low SES ultimately exhibited the highest incidence of the most common cancers, but over time, higher risks were observed among high SES people for frequent cancers like BCC, melanoma (both except females $\geqslant$65), breast (females 25–44 years) and prostate cancer. Whether cause or consequence, this may to some extent explain the higher cancer awareness in high SES groups which further increases due to high detection rates. Paradoxically, socioeconomic inequalities in cancer risk may reduce by improving cancer awareness.

Conflict of interest statement

None declared.

Acknowledgements

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