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Cancer risks in Nordic immigrants and their offspring in Sweden

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Abstract

Numerous migrant studies on cancer have been carried out, but little data are available on cancer incidence upon inter-European migration. We used the nationwide Swedish Family-Cancer Database to analyse cancer risk among Nordic immigrants and their offspring in Sweden. The parental population had entered Sweden in their 20s and they had become parents in Sweden. Finns were the largest immigrant group including approximately 183,000 parents and 278,000 offspring. We calculated the standardised incidence ratios (SIRs) and 90 or 95% confidence intervals (CIs) for 26 cancer sites using native Swedes as a reference. Cancers in the first generation immigrants followed the rates in the countries of origin, reaching high SIRs for tobacco-related, cervical and testicular cancer among Danes and for stomach cancer among Finns. Only a few cancers, such as cervical cancer was increased in the second generation. At many sites, particularly among the Finns, protection was observed in the first generation. At three sites, breast, ovary and urinary bladder, where plausible evidence for protection was found even among offspring, this was not reinforced among the offspring of compatriot parents, which is inconsistent with heritable effects. Protection against melanoma was strongest among the offspring of compatriots, but the contribution of cultural factors cannot be excluded. As the parents immigrated to Sweden in their 20s, their cancer pattern, including habits and life style, appeared to be set before that age because the differences to Swedes persisted even in cancers that predominate in old age. Immigrant populations would appear to be attractive subjects to study etiological factors of cancer at sites where causes remain poorly understood, such as testicular cancer.

Keywords: Environmental factors; Heritable factors; Lung cancer; Cervical cancer; Testicular cancer

1. Introduction

Most migrant studies have shown that the incidence of cancer moves to the level of the new host population in one or two generations [1–11]. These studies have covered the major types of cancers and they leave little doubt about the overall importance of changing environmental factors and their effects on cancer. Most of the previous studies have examined migration between continents, cultures and politico-economic systems. The movement of people between approximately the same socio-economic backgrounds and between small geographical distances has rarely been covered and the questions about the possible differences in cancer incidence in ethnically uniform, culturally-mixed populations have not been answered. Migrant studies may also address questions about population differences in the genetic susceptibility to cancer because of the differential distribution of genotypes in the populations [12,13]. In this regard, the Nordic populations will be of particular interest. Scandinavians, Swedes, Norwegians, Danes and Islanders are of Germanic origin and share DNA haplotypes, which are considered evidence for genetic resemblance [14]. Finns, on the other hand, show distinct patterns that resemble haplotypes from other neighbouring Finno-Ugric populations, consistent with the demographic history of Finns [14–16].

The Nordic countries (Denmark, Finland, Iceland, Norway and Sweden; Iceland will not be discussed further because of its small population) have had an open labour market for decades and there have been no limitations on travel or settlement within their borders. Sweden has been the largest economy in the region and it has attracted a number of Nordic immigrants over the years. A large influx of Finns took place in the 1960s. Even though the Nordic countries have many cultural similarities, the incidence of cancer differs extensively between them (Table 1). The data are based on numbers

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Table 1
Age-adjusted incidence rates for common cancers in the Nordic countries in 1983–1987

Cancer sites	Men					Women				
	Sweden	Denmark	Finland	Norway	Largest/ Smallest	Sweden	Denmark	Finland	Norway	Largest/ Smallest
Upper aerodigestive tract[a]	6.1	9.3	6.9	6.7	1.5	1.3	1.7	1.2	1.4	1.4
Oesophagus	4.8	5.6	5.3	3.9	1.4	1.4	1.9	3.5	1.2	2.9
Stomach	19.9	19.2	31.2	24.5	1.6	10.1	8.9	17.0	12.4	1.9
Colon	27.1	33.6	20.0	31.8	1.7	23.9	31.0	17.4	28.2	1.8
Rectum	17.6	23.8	14.4	21.5	1.7	11.5	14.1	9.4	12.9	1.5
Pancreas	10.0	12.3	14.2	12.4	1.4	7.7	9.4	9.3	8.5	1.2
Lung	39.4	86.0	95.9	49.6	2.4	14.4	32.6	11.2	13.6	2.9
Breast						81.3	93.8	74.7	72.4	1.3
Cervix						10.9	19.8	5.6	15.9	3.5
Endometrium						18.5	21.3	16.8	17.1	1.3
Ovary						19.5	20.5	13.9	19.8	1.5
Prostate	81.6	48.9	61.8	71.8	1.7					
Testis	4.2	9.0	2.2	6.9	4.1					
Kidney	16.1	14.7	15.6	14.6	1.1	9.3	9.5	8.6	7.0	1.4
Urinary bladder	25.6	40.5	22.1	30.6	1.8	6.8	10.3	4.2	7.8	2.5
Melanoma	12.7	9.9	9.6	13.7	1.4	12.3	12.5	8.1	17.2	2.1
Thyroid gland	2.1	1.3	2.5	2.1	1.9	4.9	2.5	7.1	6.4	2.8
Non-Hodgkin's lymphoma	13.2	10.4	11.6	12.0	1.3	8.4	7.7	8.6	8.8	1.1
Hodgkin's diseases	2.5	2.8	2.9	2.4	1.2	1.8	1.7	1.9	1.4	1.4
Myeloma	4.2	3.9	4.0	5.4	1.4	2.6	2.9	3.1	3.4	1.3
Leukaemia	5.0	6.5	4.7	4.6	1.4	4.0	4.8	4.0	3.5	1.4
Other sites	57.2	58.7	51.4	47.2	1.2	52.7	49.4	46.4	39.6	1.3
Any sites	360.7	408.6	389.4	372.8	1.1	307.4	359.1	275.1	300.8	1.3

Age-adjusted to the European standard population.
[a] Included lip, tongue, oral cavity, pharynx and larynx. In women only tongue, oral cavity and pharynx were included.

from 1983 to 1987 and were derived from information in the national cancer registries [17]. It is thus of interest to record the incidence of cancer after migration within the Nordic countries. We used the nationwide Swedish Family-Cancer Database, in which the birth country of each individual is recorded, to study cancer incidence in the Nordic immigrants and their Sweden-born offspring [18]. This is an extension of our previous study which covered all large immigrant populations to Sweden [19,20]. We included all the major cancer sites and paid special attention to marriages between compatriots and parents compared with offspring in order to discriminate between environmental and heritable factors.

2. Patients and methods

The Swedish Family-Cancer Database was initially created in the middle of the 1990s by linking an administrative family register on all Swedish families to the Swedish Cancer Registry [18,21]. For each child, there are data on both parents at the time of birth. Each person has been assigned a unique technical identification number (which is different from the national identification number, 'personal number'), allowing construction of families, for example through the mother. The Database includes all persons born in Sweden after 1931 with their biological parents, totalling over 10.2 million individuals. It has been updated in 2000 to include cancers from the nationwide Swedish Cancer Registry from 1958 to 1998. The Database includes 3.2 million families, with both parents and offspring.

The Swedish Cancer Registry is based on a compulsory notification of cases [22]. The completeness of cancer registration in the 1970s has been estimated to be over 95%, and is now considered to be close to 100%. A four-digit diagnostic code according to the 7th revision of the International Classification of Diseases (ICD-7) was used. The following ICD-7 codes were pooled: 'upper aerodigestive tract', codes 140–148, lip, mouth, tongue, pharynx and larynx except code 142 for salivary glands, and 'leukaemia', codes 204–207 (leukaemias), 208 (polycythemia vera) and 209 (myelofibrosis). The Finnish groups that represented the largest population of immigrants had to number over 50 cases for each site to be included. Exceptionally, testis was included because of the large differences in incidence between the Nordic countries.

Parental information was classified according to the country of birth, and the incidence of cancer was calculated for the immigrants and for their 0–66-year-old offspring. The immigrants had entered Sweden in their 20s and all had become parents in Sweden [19]. All tumour incidence rates were based on the data in the

Family-Cancer Database. Follow-up was started at birth or 1 January 1961, whichever came latest. Follow-up was terminated at the time of diagnosis of cancer, death, emigration, or the closing date of the study, 31 December 1998. Standardised incidence ratios (SIRs) were calculated as the ratio of observed (O) to expected (E) number of cases. The expected numbers were calculated from 5-year-age-, sex-, region- (large cities, south and north), period (10-year bands)- and tumour type-specific standard incidence rates. The incidence for Swedish parents or offspring was the standard rate. Confidence intervals (95% CI) were calculated assuming a Poisson distribution. However, because the main aim of this study was to follow the consistency in SIRs from parents to offspring, 90% CIs were used for offspring whose cancers were fewer than those of parents.

3. Results

The present study covered data from 1961 to 1998 from the Family-Cancer Database. The Swedish natives and their offspring constituted by far the largest group, which was used as a reference (Table 2). The Finns were the second largest group, 183 394 parents and 277 676 offspring. Norwegians parents numbered 42 112 and their offspring 77 774; Danish parents and their offspring were the smallest Nordic immigrant groups of 35 929 and 63 731 individuals, respectively. Compatriot marriages were common among the Finns, and 32% of the offspring were born to compatriot Finnish parents. This percentage was only 8.6 among the Norwegian immigrants.

Table 3 shows the SIRs for cancer in the Danish immigrants and their offspring in Sweden. 95% CIs were used for the parents and 90% CIs for the offspring. Among the 26 sites covered, a Danish immigrant, married to an alien ('one Danish parent'), had an increased risk for cancer at the upper aerodigestive tract (SIR 1.33), rectum (1.37), lung (1.82), cervix (1.43) testis (2.09), bladder (1.49) and for Hodgkin's disease (1.74). When married to compatriots, increases at many sites remained, although some SIRs were not significant because of the small number of cases. Even skin cancer was in excess (1.57). However, only lung (1.44) and cervical (1.50) cancers were increased among the offspring of one Danish parent.

Offspring of two Danish parents showed increases for these sites and the SIR for cervical cancer, 2.68, was the highest SIR in the whole study. Ovarian (2.47) and testicular (1.92) cancers were also increased. On the other hand, Danish parents experienced a decreased risk of liver (0.65), pancreas (0.71) and prostate (0.71) cancers, and of melanoma (0.81) and non-Hodgkin's lymphomas (0.78). These remained in the compatriot marriages, and the protection against prostate cancer (0.53) and non-Hodgkin's lymphoma (0.62) was reinforced. Even leukaemia was decreased (0.55). No significant protection was observed among the offspring, except for melanoma (0.33) among the offspring of compatriot Danes.

Table 4 shows the SIRs for cancer in Finnish immigrants and their offspring in Sweden. Among 26 sites covered, a single Finnish immigrant parent had an increased risk for cancer of the stomach (SIR 1.44), lung (1.31) and thyroid gland (1.21). When married to compatriots, the SIRs were somewhat increased. Only the increase for thyroid cancer (1.20) remained in the second generation, and also pancreatic cancer was increased (1.68). The single Finnish immigrant parents experienced a decreased risk of cancer at 11 sites and in compatriot marriages at 13 sites, testicular cancer showing the lowest SIR of 0.36. In the second generation, the decreased risk remained for colon (0.79), ovarian (0.68), testicular (0.84) and bladder cancer (0.61) and for melanoma (0.87), but only melanoma was decreased (0.69) among the offspring of the compatriot Finns. Inconsistent with the parental experience, the SIR of kidney cancer was decreased in offspring.

Among single Norwegian immigrant parents (Table 5), an increased risk for cancer was noted at the colon (SIR 1.13), lung (1.28), cervix (1.37) and testis (1.55). When married to compatriots, only testicular cancer and cervix remained above unity, but the increases were non-significant. Cancer at the upper aerodigestive tract was increased among the offspring of one (1.54) or two (3.69) Norwegian parents, and that in the lung among the offspring of one Norwegian parent (1.32). Myeloma was also increased (1.83) in this group. Norwegian parents experienced a decreased risk of liver (0.75), breast (0.86), prostate (0.87) and nervous system

Table 2
Number of Swedes and Nordic immigrants in the study

Country	Parents			Offspring		
	Single	Compatriot	All	One parent	Both parents	All
Sweden	396 074	5 120 162	5 516 236	535 407	5 733 003	6 268 410
Denmark	24 951	10 978	35 929	54 032	9699	63 731
Finland	86 230	97 164	183 394	188 009	89 667	277 676
Norway	33 894	8218	42 112	71 048	6726	77 774

Table 3
SIR for cancers in immigrants from Denmark

Cancer site	Parents								Offspring							
	One Danish parent				Compatriots				One parent				Both parents			
	O	SIR	95%CI		O	SIR	95%CI		O	SIR	90%CI		O	SIR	90%CI	
Upper aerodigestive tract	113	**1.33**	**1.09**	**1.60**	24	1.02	0.65	1.52	11	0.81	0.46	1.35	0			
Oesophagus	30	1.14	0.77	1.63	7	0.97	0.38	2.01	2	1.03	0.18	3.37	0			
Stomach	93	0.82	0.66	1.01	19	0.65	0.39	1.02	9	1.18	0.62	2.08	1	1.59	0.05	7.95
Colon	239	1.09	0.96	1.24	59	1.01	0.77	1.30	23	0.76	0.52	1.08	1	0.36	0.01	1.80
Rectum	180	**1.37**	**1.18**	**1.59**	48	1.35	0.99	1.79	12	0.93	0.54	1.53	0			
Liver	55	**0.65**	**0.49**	**0.85**	17	0.76	0.44	1.22	4	0.60	0.21	1.41	0			
Pancreas	62	**0.71**	**0.54**	**0.91**	14	0.61	0.33	1.02	7	1.23	0.59	2.34	0			
Lung	487	**1.82**	**1.67**	**1.99**	141	**1.89**	**1.59**	**2.23**	32	**1.44**	**1.05**	**1.94**	3	1.94	0.54	5.14
Breast	451	0.97	0.88	1.06	112	0.84	0.69	1.01	131	0.96	0.83	1.11	11	0.95	0.54	1.58
Cervix	124	**1.43**	**1.19**	**1.70**	35	1.40	0.98	1.95	62	**1.50**	**1.20**	**1.85**	12	**2.68**	**1.56**	**4.38**
Endometrium	90	0.95	0.76	1.17	12	**0.44**	**0.23**	**0.77**	10	0.95	0.52	1.63	1	1.72	0.06	8.57
Ovary	102	1.11	0.90	1.34	17	0.65	0.38	1.04	32	1.24	0.90	1.66	6	**2.47**	**1.09**	**4.94**
Prostate	277	**0.71**	**0.63**	**0.80**	57	**0.53**	**0.40**	**0.69**	15	1.41	0.88	2.18	0			
Testis	44	**2.09**	**1.52**	**2.80**	9	1.80	0.82	3.44	47	1.11	0.86	1.42	10	**1.92**	**1.05**	**3.28**
Kidney	101	0.94	0.77	1.15	26	0.89	0.58	1.30	23	1.36	0.93	1.93	4	2.65	0.92	6.20
Urinary bladder	239	**1.49**	**1.30**	**1.69**	58	**1.32**	**1.00**	**1.70**	19	1.13	0.75	1.67	1	0.78	0.03	3.90
Melanoma	117	**0.81**	**0.67**	**0.98**	29	0.72	0.48	1.04	88	1.03	0.86	1.23	3	**0.33**	**0.09**	**0.87**
Skin	102	1.11	0.91	1.35	38	**1.57**	**1.11**	**2.16**	16	1.35	0.85	2.05	2	1.93	0.34	6.30
Nervous system	120	0.97	0.80	1.15	29	0.85	0.57	1.22	86	1.00	0.83	1.19	12	1.25	0.73	2.05
Thyroid gland	28	0.81	0.54	1.18	7	0.72	0.29	1.49	23	1.03	0.71	1.46	5	2.07	0.83	4.42
Endocrine glands	67	0.98	0.76	1.24	17	0.89	0.52	1.42	26	0.91	0.64	1.27	1	0.34	0.01	1.72
Connective tissue	25	1.01	0.66	1.50	6	0.90	0.32	1.97	8	0.59	0.30	1.08	0			
Non-Hodgkin's lymphoma	79	**0.78**	**0.62**	**0.98**	17	**0.62**	**0.36**	**0.99**	30	0.92	0.67	1.25	2	0.62	0.11	2.02
Hodgkin's disease	36	**1.74**	**1.22**	**2.41**	11	**2.07**	**1.03**	**3.71**	28	1.09	0.78	1.50	3	1.00	0.28	2.65
Myeloma	48	1.10	0.81	1.47	9	0.78	0.35	1.48	3	0.76	0.21	2.00	0			
Leukaemia	89	1.00	0.81	1.23	13	**0.55**	**0.29**	**0.94**	43	0.92	0.70	1.19	3	0.58	0.16	1.54
All	3398	**1.07**	**1.03**	**1.11**	831	0.95	0.89	1.02	790	1.04	0.98	1.10	81	1.10	0.91	1.32

CI, Confidence Interval; O, Observed; SIR, Standard incidence ratio. Bold type: CI does not include 1.00.

cancers (0.82). All these decreases were found among compatriots, but only that for the liver (0.37) was significant. Breast cancer (0.86) and Hodgkin's disease (0.65 for 'one parent') were the only offspring neoplasms that were decreased.

4. Discussion

Even though numerous migrant studies have been published in the literature, few studies have dealt with migration between similar socio-economic and cultural environments over short distances. The motives for such immigration may be other than purely economical, political or religious, and the selection forces in the immigrant populations may be weaker than those in transcontinental immigration. Another novel aspect of this study is that all the Nordic countries have excellent national cancer registries allowing a precise assessment of the cancer rates in the native country.

Two technical points need to be raised. Firstly, a number of comparisons were done and some associations were certainly due to chance. However, we compared for each neoplasm four SIRs, two among each of parents and offspring (and indirectly also the incidence rates in the countries of origin); for a biologically meaningful finding there has to be a coherence among these four or five comparisons. Secondly, because of the age structure of the populations, the number of cases was much fewer in the offspring generation compared with the parental one. Thus, in assessing the consistency of the results between the two generations, statistical significance should not be taken too literally, and for this reason 90% CIs were used for the offspring. The magnitude of the SIR and its consistency should be the main factors for consideration of an effect.

Finns have a different population history from the Scandinavians (Danes, Norwegians and Swedes), also reflected in their unrelated language [14–16]. Language was probably an important reason for the common compatriot marriages among Finns. Among offspring of the Finnish origin, 32% had both parents from Finland, whereas for Norwegian descendants the percentage was only 8.6. However, the cancer rates of Finns did not systematically differ from those of the Scandinavians (Table 1). The overall rates were quite similar between the countries, Denmark showing the highest male and female rates, Sweden the lowest male rates, and Finland

Table 4
SIR for cancers in immigrants from Finland

Cancer site	Parents								Offspring							
	One Finnish parent				Compatriots				One parent				Both parents			
	O	SIR	95%CI		O	SIR	95%CI		O	SIR	90%CI		O	SIR	90%CI	
Upper aerodigestive tract	200	0.94	0.81	1.08	110	0.98	0.80	1.18	32	0.90	0.66	1.21	5	0.91	0.37	1.95
Oesophagus	68	1.16	0.90	1.47	28	0.92	0.61	1.34	4	0.99	0.34	2.30	0			
Stomach	408	**1.44**	**1.30**	**1.58**	194	**1.50**	**1.30**	**1.73**	20	1.00	0.66	1.45	3	1.16	0.32	3.07
Colon	473	**0.75**	**0.68**	**0.82**	205	**0.75**	**0.65**	**0.86**	71	**0.79**	**0.64**	**0.96**	14	0.89	0.54	1.39
Rectum	274	**0.77**	**0.68**	**0.87**	129	**0.79**	**0.66**	**0.94**	29	0.94	0.68	1.29	3	0.81	0.22	2.14
Liver	228	0.93	0.81	1.06	79	**0.78**	**0.62**	**0.98**	23	1.08	0.74	1.54	4	1.17	0.41	2.74
Pancreas	232	0.98	0.85	1.11	106	1.02	0.84	1.24	23	**1.68**	**1.16**	**2.39**	2	1.35	0.24	4.20
Lung	863	**1.31**	**1.22**	**1.40**	511	**1.54**	**1.41**	**1.68**	45	0.93	0.71	1.19	3	0.57	0.16	1.52
Breast	2029	**0.90**	**0.86**	**0.94**	702	**0.84**	**0.78**	**0.90**	300	0.91	0.83	1.00	35	0.84	0.62	1.12
Cervix	375	**0.84**	**0.76**	**0.93**	138	**0.81**	**0.68**	**0.96**	114	0.92	0.79	1.08	19	0.86	0.57	1.26
Endometrium	335	**0.83**	**0.74**	**0.92**	100	**0.72**	**0.59**	**0.88**	22	0.19	0.62	1.31	2	1.20	0.21	3.89
Ovary	345	**0.80**	**0.72**	**0.89**	113	**0.73**	**0.60**	**0.88**	52	**0.68**	**0.54**	**0.86**	12	0.93	0.56	1.57
Prostate	433	**0.71**	**0.64**	**0.77**	267	**0.69**	**0.61**	**0.77**	16	0.82	0.52	1.25	0			
Testis	41	**0.44**	**0.31**	**0.60**	19	**0.36**	**0.22**	**0.57**	132	**0.84**	**0.73**	**0.97**	31	0.89	0.64	1.20
Kidney	301	0.98	0.87	1.10	139	0.96	0.81	1.13	49	**0.76**	**0.59**	**0.96**	8	0.65	0.33	1.18
Urinary bladder	255	**0.70**	**0.62**	**0.79**	123	**0.64**	**0.53**	**0.76**	25	**0.61**	**0.42**	**0.85**	5	0.92	0.37	1.98
Melanoma	377	**0.66**	**0.59**	**0.73**	160	**0.58**	**0.50**	**0.68**	214	**0.87**	**0.77**	**0.97**	33	**0.69**	**0.51**	**0.92**
Skin	149	**0.70**	**0.59**	**0.82**	63	**0.64**	**0.49**	**0.82**	25	0.83	0.58	1.17	4	0.82	0.29	1.92
Nervous system	494	1.03	0.94	1.12	220	0.99	0.86	1.13	355	0.96	0.88	1.05	81	1.00	0.82	1.20
Thyroid gland	197	**1.21**	**1.05**	**1.40**	89	**1.26**	**1.02**	**1.56**	89	**1.20**	**1.00**	**1.43**	18	1.22	0.79	1.82
Endocrine glands	288	1.03	0.92	1.16	121	1.02	0.84	1.21	83	0.92	0.76	1.11	15	0.89	0.55	1.38
Connective tissue	94	1.08	0.88	1.33	36	0.89	0.62	1.23	58	1.04	0.83	1.30	14	1.15	0.70	1.81
Non-Hodgkin's lymphoma	340	1.06	0.95	1.17	153	1.01	0.85	1.18	127	1.08	0.93	1.26	25	1.09	0.76	1.53
Hodgkin's disease	89	0.98	0.79	1.21	45	1.02	0.74	1.36	97	0.89	0.75	1.06	19	0.78	0.51	1.15
Myeloma	108	0.91	0.74	1.10	51	0.95	0.71	1.25	8	0.85	0.43	1.55	2	1.90	0.33	6.17
Leukaemia	241	0.91	0.79	1.03	89	**0.72**	**0.58**	**0.88**	227	0.97	0.86	1.08	53	0.98	0.77	1.23
All	9237	**0.91**	**0.89**	**0.93**	3990	**0.88**	**0.85**	**0.91**	2240	**0.92**	**0.89**	**0.95**	410	**0.91**	**0.84**	**0.99**

Bold type: CI does not include 1.00.

the lowest female rates. Indeed, Finland would have shown the lowest male rates for all cancers if lung cancer had not been considered in the calculation. However, the similar overall rates hide a number of differences between the individual sites; there are also differences in rates within each country, and immigrants are unlikely to represent exactly the mean national rates [23]. The differences in incidence between the Nordic countries were surprisingly consistent between men and women, i.e. in 16 of 21 sites for which the rates were given for both men and women in Table 1, the country of the highest male rate also had the highest female rate. This implies that there could be some carcinogenic or protective factors that influenced both genders. Genetic susceptibility and gene–environment interactions could be such factors, and, presumably, the largest contrast would then be between the Finns and the Scandinavians.

In the parental generation, the increased cancer risks reflected the incidence rates in the country of origin. Finns showed an increased risk of stomach, lung and thyroid cancers, all of which were higher in Finland compared with Sweden (Table 1). Among Danish immigrants, tobacco-related sites were increased as were cervical and testicular cancer, all of which show a high incidence in Denmark. High lung cancer rates were also found among the first generations of Finns and Norwegians, but only the second generation of Finnish immigrants show rates comparable to the Swedes. Thus, the persistent parental smoking habits was maintained by the offspring of Danes and Norwegians. Denmark is a high-risk country for cervical cancer, for which sexual habits and incomplete screening programmes are likely to contribute [24–27]. The risk was maintained among offspring of one Danish parent (SIR 1.50) and, particularly, two Danish parents (SIR 2.68). Cervical cancer was also increased among Norwegian immigrants, but not among their daughters; cervical cancer screening has been very limited in Norway [24]. The Danish incidence of testicular cancer is among the highest in the world for unknown reasons [28,29], and it exceeds the Swedish rates more than two times (Table 1). The risk had disappeared among the offspring of one Danish parent (SIR 1.11), but it was elevated in offspring of two Danish parents (1.92, 90% CI 1.05–3.28). Among Norwegian men, testicular cancer was also increased in the first generation (1.55), but no longer in the second generation (0.99 from one parent). Among Finnish immigrant parents, testicular cancer was decreased to 0.44 (0.36

Table 5
SIR for cancers in immigrants from Norway

Cancer site	Parents								Offspring							
	One Norwegian parent				Compatriots				One parent				Both parents			
	O	SIR	95%CI		O	SIR	95%CI		O	SIR	90%CI		O	SIR	90%CI	
Upper aerodigestive tract	96	1.06	0.86	1.29	14	1.10	0.60	1.86	35	**1.54**	**1.14**	**2.04**	3	**3.69**	**1.02**	**9.77**
Oesophagus	33	1.11	0.76	1.55	4	1.00	0.26	2.57	4	1.00	0.35	2.33	1			
Stomach	184	1.14	1.98	1.32	14	0.75	0.41	1.26	14	0.98	0.60	1.54	0			
Colon	341	**1.13**	**1.01**	**1.25**	33	0.97	0.66	1.36	58	1.19	0.95	1.49	2	1.05	0.19	3.42
Rectum	183	1.07	0.92	1.24	12	0.58	0.30	1.02	25	1.04	0.73	1.46	0			
Liver	95	**0.75**	**0.61**	**0.92**	5	**0.37**	**0.12**	**0.86**	14	1.15	0.70	1.81	0			
Pancreas	128	1.04	0.87	1.24	14	1.00	0.55	1.69	10	0.89	0.49	1.52	0			
Lung	384	**1.28**	**1.16**	**1.42**	41	1.02	0.73	1.38	55	**1.32**	**1.04**	**1.65**	0			
Breast	638	**0.86**	**0.80**	**0.93**	60	0.80	0.61	1.03	214	**0.86**	**0.77**	**0.97**	5	0.58	0.23	1.23
Cervix	188	**1.37**	**1.18**	**1.58**	21	1.45	0.90	2.22	73	1.20	0.98	1.46	3	1.12	0.31	2.98
Endometrium	149	0.90	0.76	1.05	18	1.14	0.67	1.80	21	0.87	0.59	1.26	0			
Ovary	168	1.07	0.91	1.24	12	0.78	0.40	1.37	33	0.76	0.56	1.01	0			
Prostate	349	**0.87**	**0.78**	**0.97**	52	0.86	0.65	1.13	20	0.88	0.58	1.28	0			
Testis	26	**1.55**	**1.01**	**2.28**	5	1.63	0.51	3.84	49	0.99	0.77	1.26	1	0.37	0.01	1.86
Kidney	123	0.88	0.73	1.05	18	1.05	0.62	1.67	26	0.94	0.66	1.30	1	0.84	0.03	4.21
Urinary bladder	201	1.13	0.98	1.29	25	1.03	0.67	1.52	23	0.75	0.51	1.06	0			
Melanoma	165	1.07	0.92	1.25	15	0.72	0.40	1.19	98	0.86	0.72	1.02	5	0.99	0.40	2.11
Skin	108	0.94	0.77	1.14	7	0.52	0.20	1.07	17	0.91	0.59	1.38	0			
Nervous system	126	**0.82**	**0.69**	**0.98**	15	0.78	0.43	1.29	105	0.95	0.80	1.12	4	0.70	0.24	1.63
Thyroid gland	45	0.97	0.71	1.30	3	0.55	0.10	1.61	30	0.96	0.69	1.30	0			
Endocrine glands	98	1.03	0.84	1.26	10	0.92	0.44	1.70	51	1.20	0.94	1.51	3	1.65	0.46	4.38
Connective tissue	30	0.99	0.67	1.42	7	1.84	0.73	3.81	15	0.86	0.53	1.33	0			
Non-Hodgkin's lymphoma	109	0.87	0.71	1.05	12	0.77	0.39	1.34	42	0.87	0.67	1.13	1	0.48	0.02	2.38
Hodgkin's disease	24	0.97	0.62	1.44	2	0.60	0.06	2.21	20	**0.65**	**0.43**	**0.95**	0			
Myeloma	65	1.09	0.84	1.39	4	0.57	0.15	1.48	14	**1.83**	**1.11**	**2.87**	0			
Leukaemia	111	0.98	0.81	1.18	7	0.51	0.20	1.05	50	0.88	0.69	1.12	2	0.62	0.11	2.00
All	4167	1.00	0.97	1.03	430	**0.87**	**0.79**	**0.95**	1116	0.96	0.91	1.01	31	**0.64**	**0.47**	**0.87**

Bold type: CI does not include 1.00.

when married to a compatriot), but the protection was less in the offspring generation (0.89, 90% CI 0.64–1.20 when both parents were Finnish). These data argue for the environmental aetiology of testicular cancer and agree with the analysis of time trends [28,29]. The fact that for cervical and testicular cancers the strongest effects were observed in families where both parents were Danish may indicate a particular adherence to Denmark or Danish habits. The high risk of Hodgkin's disease in the first generation Danes disappeared in the second generation, in line with an environmental aetiology.

Protective effects were observed at many sites, particularly among the Finnish immigrants, and many of these were strongest among compatriot Finns suggesting an environmental aetiology. Among the offspring population, protective effects were found only at five concordant sites shared with parents. Melanoma was decreased among the offspring of both Finnish and Danish immigrants, but among the Danes only when both parents were Danish. As neither the melanoma incidence nor skin type differ appreciably between these countries, the likely explanation is cultural. When both parents were compatriots, a great part of holidays were spent in the country of origin, i.e. Finland or Denmark. Thus, the likelihood of excessive exposure to the sun was less than that among Swedes that spent their holidays in southern counties. Among the remaining sites at which protection was observed, breast cancer was decreased among offspring of both one and two Norwegian parents, and ovarian and bladder cancers were decreased among the offspring of Finnish immigrants. Breast and ovarian cancers have reproductive risk factors and, as these have not been controlled for, they may explain the small differences noted. On the other hand, the protective effects for bladder and ovarian cancer from Finnish parents may be a consequence of the low rates of these cancers in Finland. The rate of female bladder cancer is low in Finland even when compared with the rates in other European countries (GLOBOCAN 2000 [29]). The protective effects for bladder and ovarian cancer were not present in the few families where both parents were of the Finnish origin, making the contribution of genetic factors less likely.

In summary, cervical and testicular cancers, that were in excess among Danish immigrants to Sweden and in their offspring, appeared to have a predominately environmental cause. Among the three sites, breast, ovary and urinary bladder, where plausible evidence for

protection was found even among offspring, this was not reinforced among offspring of compatriot parents, which is inconsistent with heritable effects. Protection against melanoma was strongest among the offspring of compatriots (for the Finns and Danes), but the contribution of cultural factors cannot be excluded. As the parents immigrated to Sweden in their 20s, their cancer pattern appears to have been set before that age because the differences to the Swedes persisted in the cancers associated with old age [19,20,30]. The reason for this pattern may be imported socio-cultural habits that are maintained for life. Immigrant populations would appear to be attractive subjects to study etiological factors of cancer, particularly at sites where the causes remain poorly understood, such as testicular cancers.

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