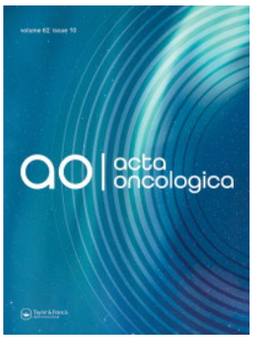

Acta Oncologica

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/ionc20

Cancer incidence among visual artists: 45 years of follow-up in four Nordic countries

Rayan Nikkilä, Miikka Peltomaa, Timo Carpén, Jan Ivar Martinsen, Sanna Heikkinen, Jenny Selander, Ingrid Sivesind Mehlum, Jóhanna Eyrún Torfadottir, Antti Mäkitie & Eero Pukkala

To cite this article: Rayan Nikkilä, Miikka Peltomaa, Timo Carpén, Jan Ivar Martinsen, Sanna Heikkinen, Jenny Selander, Ingrid Sivesind Mehlum, Jóhanna Eyrún Torfadottir, Antti Mäkitie & Eero Pukkala (2023) Cancer incidence among visual artists: 45 years of follow-up in four Nordic countries, Acta Oncologica, 62:10, 1265-1272, DOI: 10.1080/0284186X.2023.2263150

To link to this article: https://doi.org/10.1080/0284186X.2023.2263150

Published online: 05 Oct 2023.

ACTA ONCOLOGICA
2023, VOL. 62, NO. 10, 1265–1272
https://doi.org/10.1080/0284186X.2023.2263150

Taylor & Francis
Taylor & Francis Group

ORIGINAL ARTICLE

Cancer incidence among visual artists: 45 years of follow-up in four Nordic countries

Rayan Nikkilä[a,b,c], Miikka Peltomaa[a,d], Timo Carpén[a,b], Jan Ivar Martinsen[e], Sanna Heikkinen[c], Jenny Selander[f], Ingrid Sivesind Mehlum[g,h], Jóhanna Eyrún Torfadottir[i,j], Antti Mäkitie[a,b,k] and Eero Pukkala[c,l]

[a]Department of Otorhinolaryngology - Head and Neck Surgery, University of Helsinki and Helsinki University Hospital, Helsinki, Finland; [b]Research Program in Systems Oncology, University of Helsinki, Helsinki, Finland; [c]Finnish Cancer Registry, Institute for Statistical and Epidemiological Cancer Research, Helsinki, Finland; [d]Sibelius Academy, University of the Arts, Helsinki, Finland; [e]Cancer Registry of Norway, Oslo, Norway; [f]Institute of Environmental Medicine – IMM, Karolinska Institutet, Stockholm, Sweden; [g]National Institute of Occupational Health (STAMI), Oslo, Norway; [h]Institute of Health and Society, University of Oslo, Oslo, Norway; [i]Icelandic Cancer Registry, Reykjavik, Iceland; [j]Centre of Public Health Sciences, University of Iceland, Reykjavik, Iceland; [k]Division of Ear, Nose and Throat Diseases, Department of Clinical Sciences, Intervention and Technology, Karolinska Institutet and Karolinska Hospital, Stockholm, Sweden; [l]Health Sciences Unit, Faculty of Social Sciences, Tampere University, Tampere, Finland

ABSTRACT

Introduction: Professional visual artists constitute a heterogeneous vocational group, including, but not limited to painters, photographers, textile artists, and sculptors who may face exposure to workplace hazardous substances and lifestyle factors that may contribute to the development of selected cancers. The objective of this registry-based cohort study was to assess the cancer incidence among Nordic visual artists.

Materials and methods: This study is based on data from the Nordic Occupational Cancer (NOCCA) project that combines census data of 15 million people from all Nordic countries and cancer registries from 1961 to 2005. For the present study we selected a cohort of visual artists from Finland, Iceland, Norway, and Sweden. Standardized incidence ratio (SIR) analyses were conducted with the cancer incidence rates for the entire national study populations used as reference rates.

Results: In male visual artists, there were statistically significant excesses in cancers of the tongue (SIR 2.91, 95% confidence interval 1.74–4.55), oral cavity (2.09, 1.26–3.27), pharynx (2.18, 1.45-–3.15), testis (1.91, 1.11–3.05), renal pelvis (2.48, 1.42–4.03) and bladder (1.33, 1.14–1.55). The risk was significantly decreased for cancers of the lip (0.45, 0.18-0.93) and stomach (0.65, 0.50–0.84). In female visual artists, the only significantly increased risk was observed for breast cancer (1.29, 1.13–1.48) and the only significantly decreased risk for stomach cancer (0.43, 0.17–0.88). The incidence of lung cancer was close to the population average in both sexes.

Conclusions: The non-elevated incidence of lung cancer suggests a similar prevalence of smoking between visual artists and the general population, while the elevated risk of cancers of mouth and pharynx among male visual artists is suggestive of more widespread alcohol drinking. The excess risk of urogenital cancers might be associated with exposure to solvents.

NOVELTY & IMPACT

The exposure of visual artists to carcinogens remains unstudied and equivocal. The current study suggests that visual artists carry an overall cancer risk that is slightly above the risk among the general population of the four Nordic countries. We observed in men over two-fold excess risks of cancers of the tongue, oral cavity, pharynx, and renal pelvis, and also a significant risk of testis and bladder cancers.

ARTICLE HISTORY

Received 5 June 2023
Accepted 20 September 2023

KEYWORDS

Cancer; artistic work; incidence; occupation; risk

Introduction

Professional visual artists constitute a heterogeneous vocational group, including, but not limited to painters, photographers, ceramic makers, textile artists, and sculptors, who may face exposure to a convoluted chemical environment comprising several definite or plausible carcinogens. Indeed, arts and crafts materials, such as paints, pigments, and dyes, may contain chemicals hazardous to human health [1,2]. Known or suspected carcinogens to which visual artists may be exposed by inhalation or cutaneous contact comprise asbestos, silica, metal and wood dust, formaldehyde, benzene, and solvents [1,3]. Despite the wide variety of noxious materials, inadequate protection, poor ventilation and even the lack of knowledge on the hazardousness of the materials used were often commonplace in former times [2,4]. Additionally, when faced with deadlines, artists frequently work long hours and

CONTACT Antti Mäkitie antti.makitie@helsinki.fi Department of Otorhinolaryngology – Head and Neck Surgery, Helsinki University Hospital, HUS, Helsinki, Finland

sleep in their workplaces, which may further accentuate the potential for chemical toxicity by increasing the duration of exposure. Besides workplace hazards, precarity, irregular working hours, and ultimately stress could also result in persistent tobacco smoking and increased alcohol use, giving rise to elevated cancer rates [2,4–7].

The exposure of visual artists to carcinogens remains unstudied and equivocal. Occupational exposure as a painter has been classified as a Group-1 carcinogen by the International Agency for Research on Cancer (IARC) based on increased risks for lung, mesothelioma, and bladder cancers [8]. However, exposure conditions among professional artists may differ from industrial settings. Thus far, research on cancer incidence among visual artists remains scarce. A case-control study reported an over two-fold excess of bladder cancer among artistic painters, adjusted for smoking habits, with a trend in risk with duration of employment [9].

The Nordic Occupational Cancer (NOCCA) project (http://astra.cancer.fi/NOCCA) linked the census data on occupations of approximately 15 million persons from the five Nordic countries and their respective cancer registries. In this paper, we use data collected for the NOCCA study and present the results for cancer incidence among Nordic visual artists. The objective of this registry-based cohort study was to demonstrate the patterns of cancer among Nordic visual artists as compared to the general population.

Materials and methods

Population

The details of the study materials, coding systems, and analysis methods have been described earlier [10]. Briefly, the study base consists of persons who participated in computerized population censuses in four Nordic countries: Finland (1970, 1980, and 1990 censuses), Iceland (1981 census), Norway (1960, 1970, and 1980 censuses), and Sweden (1960, 1970, 1980 and 1990 censuses). Data from Denmark were not included in this study due to a lack of access to individual-level data. For this study, we extracted from the NOCCA data a cohort consisting of individuals classified as visual artists in the earliest available census.

A person was categorized as a visual artist if working as such for over half the regular working hours during the census year. A person entered the cohort if he/she was 30–64 years old and still residing in the country on 1st January of the year following the census. Person-years (PY) were counted from January 1st of the year following the census until the date of emigration, death, or 31st December of the following years: in 2003 in Norway, 2004 in Iceland, and 2005 in Finland and Sweden – whichever came first. Data on the dates of death and emigration were retrieved from the national population registries.

Cancer data

Data on incident cancer cases were obtained *via* record linkage from each of the four Nordic countries' cancer registries, by utilizing the unique personal identity codes. National cancer registration was initiated in 1953 in Finland and Norway, in 1955 in Iceland, and in 1958 in Sweden. During the follow-up period of the NOCCA study, all cancer registries received information on cancer cases from general and specialist practitioners, hospitals, and from pathology departments. All countries, except Sweden, also received information from death certificates wherever cancer was mentioned. The completeness and accuracy of the Nordic cancer registries are considered very high by international comparison, and much work has been made to achieve comparability in cancer classifications across the Nordic countries over more than five decades of cancer registration [11]. All invasive incident cancers and benign brain tumors were included in the present study. However, the Swedish and Icelandic data comprise only the first incident cancer recorded within a given diagnostic group. Cancer cases were grouped into 54 main categories and 21 diagnostic subgroups based on national topography and morphology coding systems (Appendix tables 5–6 at http://astra.cancer.fi/NOCCA). Skin basal cell carcinomas were excluded.

Statistical analyses

Standardized incidence ratios (SIRs) were calculated as the ratio of the observed and the expected number of cancer cases, using the cancer incidence rates for the entire national study populations as reference rates. For each country, the observed number of cancer cases and PYs were stratified into sex-specific 5-year age groups (30–34; 35–39; …; 85+ years) and 5-year calendar periods (1961–1965; 1966–1970; …; 2001–2005). The expected number of cancer cases was based on the number of PYs in each stratum (country, sex, age, and calendar period) and the respective reference rate. Aggregate risk measures for all Nordic countries combined were calculated as the ratio of the total number of observed cases to the total number of expected cases in the four countries. We report SIRs stratified by sex, country, broad calendar period (1961–1975, 1976–1990, 1991–2005), and broad age category (30–49, 50–69, ≥70). For each SIR, the exact 95% confidence interval (CI) was defined assuming a Poisson distribution of the observed number of cases. Additionally, we calculated the excess absolute risk (EAR). EAR describes the difference in absolute cancer incidence between visual artists and the general population (observed cancers – expected cancers) and is given in this study per 10,000 PYs.

Results

The study cohort included 13,999 visual artists contributing to 342,213 PYs of follow-up (Table 1). Altogether, 2356 cancer cases, 1792 (76%) in men and 564 (24%) in women were recorded among the 9670 male (69%) and 4329 female (31%) visual artists during the time frame of the study. The SIR for all cancer sites combined was 1.06 (95% CI: 1.01–1.11) in men and 1.05 (0.97–1.14) in women (Table 2). No significant differences in the overall SIR were noted across the countries.

Table 1. Study population of visual artists and number of cancer cases stratified by country, age, and follow-up period.

	Men					Women				
	Finland	Iceland	Norway	Sweden	Total	Finland	Iceland	Norway	Sweden	Total
Number of persons	1128	59	1059	7423	9670	769	24	411	3125	4329
Average follow-up (years)	22.2	19.5	27.4	25.1	23.6	21.6	20.6	26.8	23.1	23.0
Person-years	25,073	1156	29,052	186,605	241,886	16,613	492	11,012	72,210	100,326
Observed number of cancers	171	15	247	1359	1792	88	3	90	383	564
Age group										
30–49	13	0	10	94	117	20	0	8	87	115
50–69	83	3	96	619	801	41	3	44	199	287
≥70	75	12	141	646	874	27	0	38	97	162
Follow-up period										
1961–1975	14		53	204	271	7		18	52	77
1976–1990	47	1	109	464	621	31	1	29	109	170
1991–2005	110	14	85	691	900	50	2	43	222	317

Site-specific risks, men

For male visual artists of all four countries combined (Table 2), there were statistically significant excesses in cancers of the tongue (SIR 2.91, 95% CI: 1.74–4.55), oral cavity (2.09, 1.26–3.27), pharynx (2.18, 1.45–3.15), testis (1.91, 1.11–3.05), renal pelvis (2.48, 1.42–4.03), and bladder (1.33, 1.14–1.55) corresponding to 0.52, 0.41, 0.63, 0.33, 0.40, and 1.73 excess cancers per 10,000 PYs. The excess in pharyngeal cancer was only significantly elevated for oropharyngeal cancer (SIR 2.72, 95% CI: 1.49–4.56). A reduced risk was observed for cancers of the lip (0.45, 95% CI: 0.18–0.93) and stomach (0.65, 0.50–0.84). The incidence for lung cancer was at the population level.

The differences in country-specific SIRs were the largest in colon cancer with the SIR varying from 2.25 in Finland (95% CI: 1.33–3.55) to 0.86 in Norway (95% CI: 0.53–1.31) (Table 3). We excluded Icelandic results from Table 3 because all site-specific expected numbers of cases were less than five.

No marked variations in the SIRs across the follow-up periods were noted (Table 4). The SIRs for most cancer types were quite similar or decreased during the 45-year follow-up period. The SIRs were also quite stable between the age categories (Table 5). A statistically significant excess in testicular cancer was observed in the youngest age category, while both observed and expected numbers of cases were small in the older age categories. Conversely, no excess risk in cancers of the tongue, oral cavity, or pharynx was observed in the youngest age category, while significantly increased SIRs were observed in the older age categories. The EARs were highest in the first follow-up period and oldest age category (6.42 and 18.15 excess cancers per 10,000 PYs, respectively).

Site-specific risks, women

In female visual artists (Table 2), the only significantly increased risk was observed in breast cancer (SIR 1.29, 95% CI: 1.13–1.48) and the only significantly decreased risk in stomach cancer (SIR 0.43, 95% CI 0.17-0.88) yielding 4.86 and −0.94 excess cancers per 10,000 PYs, respectively. The incidence of lung cancer was close to the population average.

While the risk of female breast cancer was significantly elevated in the age categories 30–49 (SIR 1.33, 95% CI: 1.03–1.69) and 50–69 years (SIR 1.39, 95% CI: 1.15–1.67), no excess was observed in the ≥70-years age category (33 cases observed *versus* 33.5 expected).

Discussion

The overall cancer incidence among visual artists in the Nordic countries closely mirrors the general population's incidence rates across all countries, both sexes, all age categories, and throughout the 45-year study period. Several statistically significantly elevated and decreased incidences were observed for various specific cancer types in men, while in female visual artists, the only significant findings were the elevated cancer risk of breast cancer (SIR 1.29) and the decreased risk of stomach cancer (SIR 0.43). We observed in men over two-fold excess risks of cancers of the tongue, oral cavity, pharynx, and renal pelvis, and also a significant risk of testis and bladder cancers.

Besides occupational exposure to carcinogens, numerous other environmental, and also genetical factors may play a role in cancer onset [12]. Furthermore, due to the heterogeneity of the artistic field and the multitude of substances used by artists – such as solvents, pigments, and dyes, to name a few – establishing a connection between specific materials or chemicals used by artists and cancer risk is challenging and would require thorough data collection. A survey study conducted in Finland revealed that 52% of Finnish visual artists engaged in painting and 33% in installation art (i.e., three-dimensional visual artworks) [13]. Visual artists can be exposed through inhalation, absorption *via* skin, and even ingestion of numerous hazardous materials with suspected or unknown carcinogenicity [2]. The increased incidence of bladder cancer in the current study corroborates previous observations by Miller et al. [14] whose case-control study reported an increased risk of bladder cancer mortality among artistic painters (RR adjusted for smoking 2.5, 95% CI: 1.1–5.7). Occupational exposure as a painter has been classified as a Group-1 carcinogen and is associated with an increased risk of bladder cancer. Indeed, epidemiological studies have demonstrated a consistent association between occupational exposure as a painter and bladder cancer [3]. Bachand et al. [15] conducted a meta-analysis based on 33 case-control studies and estimated a relative risk of bladder cancer adjusted for smoking of 1.30 (95% CI: 1.17–1.44) among painters. It would not be unreasonable to hypothesize that

Table 2. Observed (Obs) numbers of cancer cases, standardized incidence ratios (SIR) with 95% confidence intervals (CI), and excess absolute risk (EAR) per 10,000 person-years among visual artists in Finland, Iceland, Norway, and Sweden, follow-up 1961–2005. Statistically significant SIRs highlighted in bold and with red (increased) or green (decreased).

		Men				Women			
ICD-7	Site	Obs	SIR	95% CI	*EAR*	Obs	SIR	95% CI	*EAR*
140–204	All sites	1792	**1.06**	**1.01–1.11**	*4.22*	564	1.05	0.97–1.14	*2.83*
140	Lip	7	**0.45**	**0.18–0.93**	*−0.35*	0	0.00	0.00–3.33	*−0.11*
141	Tongue	19	**2.91**	**1.75–4.55**	*0.52*	2	1.42	0.17–5.12	*0.06*
143–144	Oral cavity	19	**2.09**	**1.26–3.27**	*0.41*	4	2.10	0.57–5.39	*0.21*
145–148	Pharynx	28	**2.18**	**1.45–3.15**	*0.63*	3	1.92	0.40–5.62	*0.14*
145	oropharynx	14	**2.72**	**1.49–4.56**	*0.36*	1	1.28	0.03–7.11	*0.02*
150	Oesophagus	23	1.02	0.65–1.54	*0.02*	1	0.37	0.01–2.08	*−0.17*
151	Stomach	61	**0.65**	**0.50-–0.84**	*−1.34*	7	**0.43**	**0.17–0.88**	*−0.94*
151.1	Cardia	12	0.88	0.46–1.54	*−0.07*	0	0.00	0.00–2.55	*−0.15*
152	Small intestine	5	0.57	0.19–1.34	*−0.15*	2	0.93	0.11–3.37	*−0.02*
153	Colon	141	1.10	0.93–1.30	*0.53*	32	0.80	0.55–1.13	*−0.79*
154	Rectum, rectosigma	99	1.13	0.92–1.37	*0.47*	20	0.97	0.59–1.50	*−0.07*
155.0	Primary liver	24	1.13	0.72–1.67	*0.11*	4	1.09	0.30–2.78	*0.03*
155.1	Gallbladder	12	1.34	0.69–2.35	*0.13*	2	0.33	0.04–1.20	*−0.40*
157	Pancreas	47	0.87	0.64–1.16	*−0.28*	13	0.89	0.48–1.53	*−0.16*
161	Larynx	19	1.02	0.61–1.59	*0.01*	0	0.00	0.00–4.89	*−0.07*
162,163	Lung	198	1.01	0.87–1.16	*0.07*	29	1.09	0.73–1.56	*0.23*
	adenocarcinoma	44	1.21	0.88–1.62	*0.31*	11	1.22	0.61–2.18	*0.20*
	small cell	26	1.10	0.72–1.61	*0.10*	2	0.50	0.06–1.79	*−0.20*
	squamous cell	62	0.92	0.71–1.18	*−0.22*	5	1.13	0.37–2.63	*0.06*
158,162	Mesothelioma	4	0.58	0.16–1.48	*−0.12*	0	0.00	0.00–7.39	*−0.05*
170	Breast					215	**1.29**	**1.13–1.48**	*4.86*
	ductal					96	**1.28**	**1.04–1.56**	*2.08*
	lobular					16	1.19	0.68–1.93	*0.26*
171	Cervix uteri					17	0.89	0.52–1.42	*−0.21*
172	Corpus uteri					41	1.27	0.91–1.72	*0.87*
175.0	Ovary					33	0.99	0.68–1.39	*−0.03*
177	Prostate	500	1.08	0.99–1.18	*1.57*				
178	Testis	17	**1.91**	**1.11-3.05**	*0.33*				
	seminoma	11	1.73	0.86–3.10	*0.19*				
179.0	Penis	5	0.87	0.28–2.02	*−0.03*				
180	Kidney	71	1.11	0.87–1.40	*0.29*	15	1.17	0.66–1.94	*0.22*
180.1	renal pelvis	16	**2.48**	**1.42–4.03**	*0.40*	4	3.46	0.94–8.87	*0.28*
181	Bladder	168	**1.33**	**1.14–1.55**	*1.73*	9	0.75	0.34–1.42	*−0.31*
190	Melanoma	53	0.98	0.73–1.28	*−0.05*	18	0.87	0.52–1.38	*−0.26*
191	Other skin	80	1.04	0.82–1.29	*0.12*	20	1.28	0.78–1.98	*0.44*
193	Brain	46	0.98	0.71–1.30	*−0.05*	24	1.23	0.79–1.83	*0.45*
194	Thyroid	9	1.09	0.50–2.06	*0.03*	12	1.52	0.79–2.66	*0.41*
200,202	Non-Hodgkin lymphoma	59	1.11	0.84–1.43	*0.24*	17	1.17	0.68–1.87	*0.25*
201	Hodgkin lymphoma	8	0.95	0.41–1.86	*−0.02*	1	0.54	0.01–3.00	*−0.09*
203	Multiple myeloma	18	0.66	0.39–1.05	*−0.38*	3	0.45	0.09–1.32	*−0.37*
204	Leukaemia	41	0.98	0.70–1.32	*−0.04*	9	0.92	0.42–1.75	*−0.08*
	chronic lymphatic	21	1.12	0.70–1.72	*0.10*	2	0.58	0.07–2.09	*−0.15*
	acute myeloid	9	0.86	0.39–1.63	*−0.06*	4	1.24	0.34–3.18	*0.08*

Table 3. Observed (Obs) numbers of selected cancers, standardized incidence ratios (SIR) with 95% confidence intervals (CI), and excess absolute risk (EAR) per 10,000 person-years among **male** visual artists in Finland, Iceland, Norway, and Sweden, stratified by country. Statistically significant SIRs highlighted in bold and with red (increased) or green (decreased).

		Finland				Norway				Sweden			
ICD-7	Site	Obs	SIR	95% CI	*EAR*	Obs	SIR	95% CI	*EAR*	Obs	SIR	95% CI	*EAR*
140-204	All sites	171	1.06	0.91–1.23	*4.03*	247	0.93	0.81–1.05	*−6.75*	1359	**1.08**	**1.03–1.14**	*5.70*
141	Tongue	2	2.95	0.36–10.7	*0.52*	3	2.91	0.60–8.50	*0.69*	14	**2.93**	**1.60–4.91**	*0.49*
143-144	Oral cavity	4	**5.89**	**1.60-15.1**	*1.32*	1	0.65	0.02–3.64	*−0.17*	14	**2.05**	**1.12–3.44**	*0.39*
145-148	Pharynx	1	1.14	0.03–6.35	*0.04*	4	2.34	0.64–5.99	*0.79*	23	**2.25**	**1.43–3.38**	*0.69*
145	oropharynx	1	2.90	0.07–16.1	*0.24*	1	1.64	0.04–9.14	*0.14*	12	**2.87**	**1.48–5.01**	*0.42*
151	Stomach	7	0.76	0.30–1.56	*−0.92*	7	**0.37**	**0.15–0.76**	*−4.10*	47	**0.73**	**0.53–0.96**	*−0.95*
153	Colon	18	**2.25**	**1.33–3.55**	*3.99*	21	0.86	0.53–1.31	*−1.20*	99	1.04	0.85–1.27	*0.22*
162,163	Lung	23	0.67	0.43–1.01	*−4.39*	26	0.74	0.49–1.09	*−3.10*	148	1.18	0.99–1.38	*1.18*
178	Testis	1	1.85	0.05–10.3	*0.20*	3	2.28	0.47–6.66	*0.59*	13	1.86	0.99–3.17	*0.32*
180	Kidney	5	0.76	0.25–1.78	*−0.64*	11	1.25	0.63–2.24	*0.76*	54	1.12	0.84–1.46	*0.32*
180.1	renal pelvis	1	2.45	0.06–13.7	*0.24*	2	1.95	0.24–7.03	*0.34*	13	**2.61**	**1.39–4.46**	*0.43*
181	Bladder	10	1.11	0.53–2.04	*0.40*	21	0.98	0.61–1.50	*−0.14*	136	**1.43**	**1.20–1.70**	*2.20*
193	Brain	6	1.35	0.50–2.95	*0.64*	7	1.19	0.48–2.45	*0.38*	32	0.87	0.60–1.24	*−0.25*
203	Multiple myeloma	0	0.00	0.00–1.79	*−0.84*	3	0.42	0.13–1.82	*−0.62*	15	0.74	0.42–1.23	*−0.28*

Table 4. Observed (Obs) numbers of selected cancers and standardized incidence ratios (SIR) with 95% confidence intervals (CI), and excess absolute risk (EAR) per 10,000 person-years among **male** visual artists in Finland, Iceland, Norway, and Sweden, stratified by follow-up period. Statistically significant SIRs highlighted in bold and with red (increased) or green (decreased).

		1961–1975				1976–1990				1991–2005			
ICD-7	Site	Obs	SIR	95% CI	*EAR*	Obs	SIR	95% CI	*EAR*	Obs	SIR	95% CI	*EAR*
140–204	All sites	271	**1.18**	**1.04–1.33**	*6.42*	621	1.05	0.97–1.13	*3.21*	900	1.04	0.97–1.11	*3.66*
141	Tongue	3	3.22	0.66–9.42	*0.33*	5	2.14	0.69–4.99	*0.32*	11	**3.38**	**1.69-6.04**	*0.84*
143–144	Oral cavity	1	0.71	0.02–3.97	*−0.06*	9	**2.59**	**1.19–4.93**	*0.64*	9	2.14	0.98–4.06	*0.53*
145–148	Pharynx	8	**3.51**	**1.52–6.93**	*0.89*	10	**2.19**	**1.05–4.03**	*0.63*	10	1.67	0.80–3.07	*0.44*
145	oropharynx	4	**7.62**	**2.08–19.5**	*0.54*	4	2.54	0.69–6.52	*0.28*	6	1.96	0.72–4.28	*0.32*
151	Stomach	17	0.72	0.42–1.15	*−1.04*	25	**0.65**	**0.42–0.96**	*−1.59*	19	**0.61**	**0.37–0.95**	*−1.35*
153	Colon	29	**1.74**	**1.16–2.50**	*1.91*	41	0.92	0.66–1.24	*−0.43*	71	1.06	0.83–1.34	*0.46*
162,163	Lung	34	1.09	0.75–1.52	*0.44*	82	1.04	0.83–1.29	*0.35*	82	0.95	0.76–1.18	*−0.46*
178	Testis	3	1.32	0.27–3.85	*0.11*	8	**2.54**	**1.10–5.00**	*0.57*	6	1.72	0.63–3.74	*0.27*
180	Kidney	22	**1.91**	**1.20–2.90**	*1.63*	22	0.87	0.54–1.31	*−0.40*	27	1.00	0.66–1.45	*0.00*
180.1	renal pelvis	5	**4.95**	**1.61–11.6**	*0.62*	4	1.57	0.43–4.02	*0.16*	7	2.42	0.97–4.99	*0.45*
181	Bladder	27	**1.79**	**1.18–2.60**	*1.85*	62	**1.37**	**1.05–1.75**	*1.95*	79	1.20	0.95–1.50	*1.46*
193	Brain	9	0.94	0.43–1.78	*−0.09*	18	1.03	0.61–1.63	*0.07*	19	0.94	0.57–1.47	*−0.13*
203	Multiple myeloma	2	0.48	0.06–1.73	*−0.34*	7	0.68	0.27–1.40	*−0.39*	9	0.71	0.32-1.34	*−0.40*

Table 5. Observed (Obs) numbers of selected cancers and standardized incidence ratios (SIR) with 95% confidence intervals (CI), and excess absolute risk (EAR) per 10,000 person-years among **male** visual artists in Finland, Iceland, Norway, and Sweden, stratified by age at follow-up. Statistically significant SIRs highlighted in bold and with red (increased) or green (decreased).

		30–49				50–69				70+			
ICD-7	Site	Obs	SIR	95% CI	*EAR*	Obs	SIR	95% CI	*EAR*	Obs	SIR	95% CI	*EAR*
140–204	All sites	117	1.14	0.94–1.36	*1.44*	801	1.03	0.96–1.11	*2.34*	874	**1.08**	**1.01-1.15**	*18.15*
141	Tongue	4	**4.91**	**1.34-12.6**	*0.33*	11	**2.91**	**1.45-5.21**	*0.65*	4	2.07	0.56–5.30	*0.61*
143–144	Oral cavity	1	1.18	0.03–6.59	*0.02*	13	**2.51**	**1.34-4.29**	*0.71*	5	1.64	0.53–3.82	*0.55*
145–148	Pharynx	3	2.03	0.42–5.93	*0.16*	13	1.63	0.87–2.78	*0.45*	12	**3.57**	**1.84-6.23**	*2.51*
145	oropharynx	1	1.44	0.04–8.00	*0.03*	7	2.13	0.86–4.39	*0.33*	6	**5.14**	**1.88-11.2**	*1.40*
151	Stomach	3	0.53	0.11–1.56	*−0.27*	32	0.71	0.49–1.01	*−1.17*	26	**0.61**	**0.40-0.89**	*−4.96*
153	Colon	11	1.64	0.82–2.93	*0.45*	53	1.00	0.75–1.31	*−0.01*	77	1.13	0.89–1.41	*2.54*
162,163	Lung	13	1.47	0.78–2.51	*0.44*	103	0.96	0.79–1.17	*−0.35*	82	1.02	0.81–1.26	*0.41*
178	Testis	13	**2.23**	**1.19-3.82**	*0.75*	4	1.56	0.43–4.00	*0.13*	0	0.00	0.00–6.94	*−0.15*
180	Kidney	8	1.39	0.60–2.74	*0.23*	40	1.15	0.82–1.57	*0.48*	23	0.98	0.62–1.47	*−0.15*
180.1	renal pelvis	1	2.30	0.06–12.8	*0.06*	10	**3.13**	**1.50-5.76**	*0.62*	5	1.77	0.58–4.14	*0.64*
181	Bladder	8	1.39	0.60–2.73	*0.23*	70	1.26	0.98–1.59	*1.29*	90	**1.39**	**1.12-1.71**	*7.41*
193	Brain	8	0.77	0.33–1.52	*−0.25*	20	0.77	0.47–1.18	*−0.55*	18	**1.69**	**1.00-2.67**	*2.13*
203	Multiple myeloma	1	0.65	0.02–3.63	*−0.05*	12	0.93	0.48–1.62	*−0.08*	5	**0.39**	**0.13-0.92**	*−2.28*

visual artists, particularly artistic painters, would be exposed, at least to some degree, to the same chemical compounds and thus the same carcinogens as professional painters.

The excess risk of urogenital cancers observed among men in our study might be associated with exposure to solvents. Indeed, solvents are widely used in the visual arts such as spray paints, lacquers, thinners, inks, varnishes, leather and textile dyes, adhesives, and plastic cements, and have been associated with increased risk of testicular [16–18], kidney [18], and bladder cancers [19]. Data from the NOCCA cohort previously revealed that occupational exposure to trichloroethylene, aromatic hydrocarbon solvents, benzene, and toluene has been associated with an increased risk of bladder cancer [19]. Exposure, both by inhalation and *via* skin contact, can occur through manual handling during preparation of the paint. High airborne concentrations of solvents can result from open solvent containers, solvent-soaked brushes, and accidental spills. Even when with low solvent concentrations, long hours of exposure in an art studio, especially if poorly ventilated, can contribute to chronic solvent toxicities [2]. Besides inhalation and skin absorption, ingestion of chemicals in art studios could also occur unintentionally through contamination while eating, drinking, smoking, or touching the lips.

A noteworthy observation to emerge from the current study is that the risk of kidney cancer was not elevated after 1975 and SIR of bladder cancers decreased towards the latest periods. A conceivable explanation would be the improvement in workplace safety: use of protective equipment, better ventilation systems, and greater awareness of hazards [1]. In addition, the gradual decline of certain solvents and materials previously widely employed could be conducive to a steady decline of carcinogenic exposure throughout the NOCCA study period. For instance, the overall use of trichloroethylene as a solvent – linked to bladder and kidney cancer [19,20] – has declined by 85% between 1984 and 2006 in Europe [21]. Benzidine – an aromatic amine used in the production of dyes, associated with bladder cancer – has been withdrawn from most industries, including the arts [22]. Since 1966, the use of styrene – a derivative of benzidine used to model architecture and interior spaces and other displays and linked to kidney cancer [23] – has progressively declined in Europe [24].

We uncovered elevated incidence rates of cancers of the tongue, oral cavity, and pharynx among male visual artists. Supportive of our findings, the literature describes an association between solvents employed by visual artists and the occurrence of oral and pharyngeal cancers, though the

evidence is limited and conflicting. A pooled analysis [25] comprising 8839 head and neck cancer (HNC) cases and 13,730 controls conveyed an increased risk of HNC [odds ratio (OR) adjusted for confounders 1.36, 95% CI: 1.00–1.85] among painters not employed in construction (no details on the proportion of artists were available). Carton et al. [26] observed elevated ORs for HNC among women ever exposed to trichloroethylene (adjusted OR 2.15, 95% CI 1.21–3.81), increasing along exposure duration (OR 4.44, 95% CI 1.56–12.6 for 10 years or more). However, the same observation did not emerge in men [27]. In a subsequent study [28], the authors uncovered that individuals affected by high levels of cumulative exposure to diethyl ether – an oxygenated solvent – had a significant excess risk of oropharyngeal cancer (OR 7.78, 95% CI: 1.42–42.59). Ever-exposure to another oxygenated solvent, tetrahydrofuran, was associated with an OR of 1.87 for oral cancer (95% CI: 0.97–3.61), albeit with no exposure-response trend. A literature review published in 2012 [29] reported a modest association between polycyclic aromatic hydrocarbons – emitted from drying paints [30] – and oral and pharyngeal cancer risk (pooled RR 1.14, 95% CI: 1.02–1.28). However, the authors failed to uncover an association between cancer risk and exposure to any solvent in general (pooled RR 0.98, 95% CI: 0.77–1.23)

Few data are available on visual artists' lifestyle factors that would help in the interpretation of their cancer risk pattern. The non-elevated incidence of lung cancer suggests a similar smoking prevalence between visual artists and the general population, while the elevated risk of cancers of the tongue, oral cavity, and pharynx is supportive of more widespread alcohol drinking among visual artists. Still, the increased SIRs of these alcohol-related cancers are at odds with results from the survey study conducted in 2012 by Houni et al. [31] on the well-being of Finnish artists. The study comprised 266 visual artists of whom 2% reported heavy alcohol use ($\geq$25 units a week). Correspondingly, in the Finnish population aged 30–64, the prevalence of hazardous drinking – 24 alcohol units for men and 16 for women – was estimated at 5.8% (8.5% in men and 3.1% in women) in 2000 [32].

Regarding the cancer risk among female visual artists, our results did not show statistically significant deviations from the reference estimates, suggestive of a similar, or even healthier, lifestyle as compared to the general population. Indeed, the female visual artists had a significantly lower incidence of gastric cancer (SIR 0.43) whose known risk factors are among else increased *Helicobacter pylori* infections, excessive salt intake, as well as low fruit and vegetable consumption [33]. Incidence of smoking- and alcohol-related lung cancer and HNCs among female visual artists did not differ markedly from the rates in the general population, supportive of similar smoking and drinking habits as the general population. In line with our rationale are the Finnish survey studies which conveyed that visual artists are mindful of their well-being, pursue healthier lifestyles today than in the past, and sleep and exercise as much as other Finns [13,31]. However, a moderate risk excess was recorded for breast cancer (SIR 1.29) which may stem from exposure to solvents. As in men for urogenital cancers, the risk of breast cancer among women was not significantly elevated during the 1991–2005 period. Several studies hint at an increased vulnerability for breast cancer among women exposed to solvents [34–38]. Particularly, exposure before the first birth was according to Ekenga et al. [34] associated with an increased risk for estrogen receptor-positive invasive breast cancer among parous women. It is also acknowledged that high age at first pregnancy and low parity increase the breast cancer risk [39]. Female visual artists may have fewer children or their first birth at a later age than the reference population, increasing their risk of breast cancer.

The foremost strength of the present study is the relatively large size and long follow-up of the cohort, which allows us to identify modest to high excesses for at least most common cancers. To the best of our knowledge, no similar-sized cohort study on cancer risk among visual artists has been published before. The study had access to high-quality cancer registry data from across the Nordic countries [11]. Due to the high coverage, precision, and validity of the linked files, the cancer risk estimates can be deemed reliable. Moreover, the cancer incidence data permit the identification of non-fatal cancers, which would not be achievable in cancer mortality studies. We also had access to histology information, allowing risk evaluation by histological cancer subtype. As the present study was based on incident cancer cases and exact PYs, there is no bias caused by occupational variation in cancer survival and mortality from competing causes of death.

However, this study on visual artists has inherent shortcomings worth further discussing. Firstly, data on occupational duration and exposure characteristics were not available. The occupational affiliation at a certain juncture in life may not always reflect lifelong occupational history. However, a comparison of results based on a single cross-sectional occupational information with results from studies with complete occupational histories indicates that the diluting effect due to misclassification is minor, especially in specialized occupations [10]. Occupational stability in the visual arts is high, and hence we can assume that the risk estimates genuinely depict the cancer pattern of visual artists [13]. Secondly, stratification of the results according to the exact visual artistic profession, albeit unfeasible with the data available to us, would have also refined the interpretation of the results. Finally, most of the data of this study were collected decades ago and the results may not be generalized to modern-day occupational conditions of visual artists.

Conclusion

In summary, this study suggests that visual artists carry an overall cancer risk that is slightly above the risk among the general population of the four Nordic countries. The excess risk of urinogenital cancer might be associated with exposure to solvents. The non-elevated incidence of lung cancer suggests a similar prevalence of smoking between visual artists and the general population, while the elevated risk of cancers of mouth and pharynx is suggestive of more widespread alcohol drinking among visual artists.

Authors' contributions

This article was designed by Eero Pukkala, Miikka Peltomaa, and Antti Mäkitie. Eero Pukkala, Jenny Selander, Ingrid Sivesind Mehlum, and Jóhanna Eyrún Torfadottir, and are responsible for the accuracy of the data from their countries. Statistical analyses were performed by Jan Ivar Martinsen. The manuscript was devised by Rayan Nikkilä, Miikka Peltomaa, Timo Carpén, Jan Ivar Martinsen, Sanna Heikkinen, Jenny Selander, Ingrid Sivesind Mehlum, Jóhanna Eyrún Torfadottir, Antti Mäkitie, Eero Pukkala. All authors contributed to the revision of the manuscript and had final approval of the submitted and published versions.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported by the Finska Läkaresällskapet, the Helsinki University Hospital Research Funding, and the Nordic Cancer Union (NCU). The funders had no role in the study design; in the collection, analysis, and interpretation of the data; in the writing of the report; and in the decision to submit the paper for publication.

ORCID

Rayan Nikkilä http://orcid.org/0000-0002-0999-2734
Antti Mäkitie http://orcid.org/0000-0002-0451-2404

Data availability statement

Data available on https://astra.cancer.fi/NOCCA/

References

[1] McCann MF. Occupational and environmental hazards in art. Environ Res. 1992;59(1):139–144. doi: 10.1016/s0013-9351(05)80233-6.
[2] Hinkamp D, McCann M, Babin AR. Occupational health and the visual arts: an introduction. J Occup Environ Med. 2017;59(9):859–866. doi: 10.1097/JOM.0000000000001079.
[3] Agents Classified by the IARC Monographs. Volumes 1–133 [Internet]. Lyon (FR): International Agency for Research on Cancer. Available from: http://monographs.iarc.fr/ENG/Classification/ index.php.
[4] McCann M. The impact of hazards in art on female workers. Prev Med. 1978;7(3):338–348. doi: 10.1016/0091-7435(78)90279-7.
[5] Tuisku K, Houni P, Seppänen J, et al. Association between unstable work and occupational wellbeing among artists in Finland: results of a psychosocial survey. Med Probl Perform Art. 2016;31:96–103.
[6] Becker HC. Influence of stress associated with chronic alcohol exposure on drinking. Neuropharmacology. 2017;122:115–126. doi: 10.1016/j.neuropharm.2017.04.028.
[7] Slopen N, Kontos EZ, Ryff CD, et al. Psychosocial stress and cigarette smoking persistence, cessation, and relapse over 9-10 years: a prospective study of middle-aged adults in the United States. Cancer Causes Control. 2013;24(10):1849–1863. doi: 10.1007/s10552-013-0262-5.
[8] IARC Working Group on the Evaluation of Carcinogenic Risks to Humans. Painting, firefighting, and shiftwork. Lyon (FR): International Agency for Research on Cancer; 2010. (IARC Monographs on the Evaluation of Carcinogenic Risks to Humans; 98)
[9] Miller BA, Silverman DT, Hoover RN, et al. Cancer risk among artistic painters. Am J Ind Med. 1986;9(3):281–287. doi: 10.1002/ajim.4700090311.
[10] Pukkala E, Martinsen JI, Lynge E, et al. Occupation and cancer – follow-up of 15 million people in five Nordic countries. Acta Oncol. 2009;48(5):646–790. doi: 10.1080/02841860902913546.
[11] Pukkala E, Engholm G, Højsgaard Schmidt LK, et al. Nordic cancer registries – an overview of their procedures and data comparability. Acta Oncol. 2018;57(4):440–455. doi: 10.1080/0284186X.2017.1407039.
[12] Arem H, Loftfield E. Cancer epidemiology: a survey of modifiable risk factors for prevention and survivorship. Am J Lifestyle Med. 2018;12(3):200–210. doi: 10.1177/1559827617700600.
[13] Herranen K, Houni P, Karttunen S. Kuvataiteilijan ammattirooli ja osaamistarpeet tulevaisuuden työelämässä. [The visual artist's professional role and competence needs in the future working life]. Cupore 2013. Available from: https://www.cupore.fi/fi/julkaisut/cuporen-julkaisut/kaisa-herranen-pia-houni-ja-sari-karttunen-pitaisi-laajentaa-tyoalaansa. Finnish.
[14] Miller B, Blair A, McCann M. Mortality patterns among professional artists: a preliminary report. semantic scholar. J Environ Pathol Toxicol Oncol. 1985;6(2):303–313.
[15] Bachand A, Mundt KA, Mundt DJ, et al. Meta-analyses of occupational exposure as a painter and lung and bladder cancer morbidity and mortality 1950-2008. Crit Rev Toxicol. 2010;40(2):101–125. doi: 10.3109/10408440903352826.
[16] Guo J, Pukkala E, Kyyrönen P, et al. Testicular cancer, occupation and exposure to chemical agents among Finnish men in 1971-1995. Cancer Causes Control. 2005;16(2):97–103. doi: 10.1007/s10552-004-2236-0.
[17] Nori F, Carbone P, Giordano F, et al. Endocrine-disrupting chemicals and testicular cancer: a case-control study. Arch Environ Occup Health. 2006;61(2):87–95. doi: 10.3200/AEOH.61.2.87-95.
[18] Purdue MP, Stewart PA, Friesen MC, et al. Occupational exposure to chlorinated solvents and kidney cancer: a case-control study. Occup Environ Med. 2017;74(4):268–274. doi: 10.1136/oemed-2016-103849.
[19] Hadkhale K, Martinsen JI, Weiderpass E, et al. Occupational exposure to solvents and bladder cancer: a population-based case control study in Nordic countries. Int J Cancer. 2017;140(8):1736–1746. doi: 10.1002/ijc.30593.
[20] Chiu WA, Jinot J, Scott CS, et al. Human health effects of trichloroethylene: key findings and scientific issues. Environ Health Perspect. 2013;121(3):303–311. doi: 10.1289/ehp.1205879.
[21] IARC Working Group on the Evaluation of Carcinogenic Risks to Humans. Trichloroethylene, tetrachloroethylene, and some other chlorinated agents. Lyon (FR): International Agency for Research on Cancer; 2014. (IARC Monographs on the Evaluation of Carcinogenic Risks to Humans; 106).
[22] IARC Working Group on the Evaluation of Carcinogenic Risks to Humans. Chemical agents and related occupations. Lyon (FR): International Agency for Research on Cancer; 2012. (IARC Monographs on the Evaluation of Carcinogenic Risks to Humans; 100F)
[23] Karami S, Boffetta P, Brennan P, et al. Renal cancer risk and occupational exposure to polycyclic aromatic hydrocarbons and plastics. J Occup Environ Med. 2011;53(2):218–223. doi: 10.1097/JOM.0b013e31820a40a3.
[24] Van Rooij JGM, Kasper A, Triebig G, et al. Trends in occupational exposure to styrene in the European glass fibre-reinforced plastics industry. Ann Occup Hyg. 2008;52(5):337–349. doi: 10.1093/annhyg/men020.
[25] Khetan P, Boffetta P, Luce D, et al. Occupations and the risk of head and neck cancer: a pooled analysis of the international head and neck cancer epidemiology (INHANCE) consortium. J Occup Environ Med. 2019;61(5):397–404. doi: 10.1097/JOM.0000000000001563.
[26] Carton M, Barul C, Menvielle G, et al. Occupational exposure to solvents and risk of head and neck cancer in women: a

population-based case-control study in France. BMJ Open. 2017; 7(1):e012833. doi: 10.1136/bmjopen-2016-012833.

[27] Barul C, Fayossé A, Carton M, et al. Occupational exposure to chlorinated solvents and risk of head and neck cancer in men: a population-based case-control study in France. Environ Health. 2017;16(1):77. doi: 10.1186/s12940-017-0286-5.

[28] Barul C, Carton M, Radoï L, et al. Occupational exposure to petroleum-based and oxygenated solvents and oral and oropharyngeal cancer risk in men: a population-based case-control study in France. Cancer Epidemiol. 2019;59:22–28. doi: 10.1016/j.canep.2019.01.005.

[29] Paget-Bailly S, Cyr D, Luce D. Occupational exposures to asbestos, polycyclic aromatic hydrocarbons and solvents, and cancers of the oral cavity and pharynx: a quantitative literature review. Int Arch Occup Environ Health. 2012;85(4):341–351. doi: 10.1007/s00420-011-0683-y.

[30] Brown VM, Crump DR, Gardiner D. Determination of aromatic hydrocarbon emissions from paint and related products by an impinger method. Environ Int. 1990;16(3):283–289. doi: 10.1016/0160-4120(90)90122-M.

[31] Houni P, Ansio H. Taiteilijan työ: taiteilijan hyvinvointi taidetyön muutoksessa. [artist's work: artist's well-being amid the evolution of artistic work]. Finnish Institute of Occupational Health. 2013. Available from: https://www.julkari.fi/handle/10024/132110. Finnish

[32] Halme JT, Seppä K, Alho H, et al. Hazardous drinking: prevalence and associations in the Finnish general population. Alcohol Clin Exp Res. 2008;32(9):1615–1622. doi: 10.1111/j.1530-0277.2008.00740.x.

[33] Smyth EC, Nilsson M, Grabsch HI, et al. Gastric cancer. Lancet. 2020;396(10251):635–648. doi: 10.1016/S0140-6736(20)31288-5.

[34] Ekenga CC, Parks CG, D'Aloisio AA, et al. Breast cancer risk after occupational solvent exposure: the influence of timing and setting. Cancer Res. 2014;74(11):3076–3083. doi: 10.1158/0008-5472.CAN-13-2430.

[35] Glass DC, Heyworth J, Thomson AK, et al. Occupational exposure to solvents and risk of breast cancer. Am J Ind Med. 2015;58(9):915–922. doi: 10.1002/ajim.22478.

[36] Pedersen JE, Strandberg-Larsen K, Andersson M, et al. Risk of breast cancer in danish women occupationally exposed to organic solvents, including ethanol. Am J Ind Med. 2022;65(8):660–668. doi: 10.1002/ajim.23397.

[37] Lee DG, Burstyn I, Lai AS, et al. Women's occupational exposure to polycyclic aromatic hydrocarbons and risk of breast cancer. Occup Environ Med. 2019;76(1):22–29. doi: 10.1136/oemed-2018-105261.

[38] Peplonska B, Stewart P, Szeszenia-Dabrowska N, et al. Occupational exposure to organic solvents and breast cancer in women. Occup Environ Med. 2010;67(11):722–729. doi: 10.1136/oem.2009.046557.

[39] Katuwal S, Tapanainen J, Pukkala E. Multivariate analysis of independent roles of socioeconomic status, occupational physical activity, reproductive factors, and postmenopausal hormonal therapy in risk of breast cancer. Breast Cancer Res Treat. 2022;193(2):495–505. doi: 10.1007/s10549-022-06571-x.