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ORIGINAL PAPER

Cancer incidence in a cohort with high fish consumption

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Abstract
Purpose Evidence suggests that fish-derived omega-3 polyunsaturated fatty acids inhibit cancer promotion and progression. On the other hand, fish may contain endocrine-disrupting and potentially carcinogenic environmental contaminants. Our objective was to describe cancer incidence among the Finnish professional fishermen and their wives who are presumed to eat a lot of fish, partly from the contaminated Baltic Sea. Additionally, we wanted to see whether occupational characteristics are reflected in the fishermen's cancer pattern.
Methods All Finnish fishermen during 1980–2002 were identified from the Professional Fishermen Register ($n = 6{,}410$) and their wives from the National Population Information System ($n = 4{,}260$). The cohort was linked with the Finnish Cancer Registry data until 2011, and the standardized incidence ratios (SIR) were calculated based on national incidence rates.
Results The total cancer incidence among the fishermen and their wives was the same as in the Finnish general population. Among the fishermen, the incidence was increased for lip (SIR 2.17, 95 % confidence interval 1.26–3.47) and testis (2.51, 1.15–4.75) and decreased for colon (0.72, 0.52–0.98) cancers.
Conclusions We cannot exclude the possibility that the observed excess in testis cancer among the fishermen could reflect life-long high exposure to environmental contaminants. An excess in lip cancer has been repeatedly observed among outdoor workers due to high exposure to ultraviolet radiation, whereas high physical activity during fishing is the most likely explanation for the deficit in colon cancer.

Keywords Cancers · Incidence · Fish · Fishermen · Contaminants · Fatty acids

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Introduction

Both in vitro and in vivo evidence suggest that fish-derived omega-3 polyunsaturated fatty acids (PUFAs) inhibit cancer promotion and progression [1]. There are several credible mechanisms that may be responsible for chemoprotective effects: (1) inhibition of arachidonic acid-derived eicosanoid biosynthesis (causing alterations in immune response, inflammation, cell proliferation, apoptosis, metastasis, and angiogenesis), (2) effects on transcription factor activity, gene expression, and signal transduction (causing changes in metabolism, cell growth, and cell differentiation), (3) alteration of estrogen metabolism (inhibiting estrogen-stimulated cell growth), (4) effects on the production of free radicals and reactive oxygen species, and (5) mechanisms involving insulin sensitivity and membrane fluidity [2–4]. However, a large body of epidemiological evidence is rather inconsistent [5]. According to the report commissioned by the Food and Agriculture Organisation (FAO) and the World Health Organization (WHO), high fish consumption might at least decrease the risk of colorectal cancer, but the totality of the evidence regarding the specific effects of omega-3 PUFA intake is weaker. In addition, there is suggestive epidemiological evidence that high fish-derived omega-3 PUFA intake might protect from hormone-dependent breast and prostate cancers [6, 7]. Vitamin D is abundant in fatty fish, and it is suspected to have chemoprotective properties against cancers of the breast, prostate, colorectum, and possibly lung [8, 9]. Thus, the combined protective effect of vitamin D and omega-3 PUFAs might be even stronger than their separate effects [10].

However, fish may contain persistent organochlorine pollutants that are endocrine-disrupting and potentially carcinogenic. In particular, the Baltic Sea in northern Europe is still heavily contaminated with polychlorinated dibenzo-*p*-dioxins and dibenzofurans (PCDD/Fs, generic term dioxins) and polychlorinated biphenyls (PCBs). For example, big Baltic herring and wild salmon often exceed the maximum level of WHO toxic equivalent quantity (6.5 pg $WHO_{PCDD/F\text{-}PCB}$TEq per gram fresh weight) given by the European Union (EU). The most toxic dioxin congener 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD) is classified as carcinogenic to humans (Group 1) by the International Agency for Research on Cancer (IARC) [11], and it has been shown to promote the growth and transformation of initiated cancer cells [12]. Previously, PCBs were classified as probably carcinogenic to humans (Group 2A), but the IARC has recently raised the classification into carcinogenic to humans (Group 1) [13]. There is some indication that dioxins could increase the risk of soft tissue sarcoma and non-Hodgkin lymphoma, whereas PCBs could increase the risk of liver and biliary cancer, breast cancer, non-Hodgkin lymphoma, and possibly multiple myeloma and prostate cancer [14]. However, some reviews have concluded that the human evidence is fairly weak [15–18].

Since fish contain both beneficial and hazardous compounds, the overall effect of fish consumption is best assessed in a population with high fish consumption and can be seen as a natural experiment. The majority of Finnish professional fishermen live and work in the Baltic Sea area and are presumed to eat fish from their own catch. In our previous studies, in a sub-sample of the fishermen, they had almost twofold fish consumption and serum concentrations fish-derived omega-3 PUFAs and environmental contaminants (dioxins and PCBs) when compared with the men representing the general population of Finland [19, 20]. Furthermore, their serum WHO toxic equivalent quantity (TEq) for dioxins was comparable (~90 pg/g fat) to that measured among the residents of the highest exposure zone in Seveso, Italy, 20 years after the industrial accident [21]. Regardless, the fishermen and their wives had lower mortality from many diseases than the general population of Finland. Mortality from malignant neoplasms was decreased by 10 % among the fishermen and was similar to the population average among the wives [19]. However, mortality is not an ideal measure to assess cancer burden.

The aim of the present work was to describe cancer incidence among the Finnish professional fishermen and their wives to see whether high exposure to fish-derived nutrients and contaminants is reflected as either excesses or deficits in their cancer incidence. At the same time, we wanted to see whether the occupational characteristics are reflected in the fishermen's cancer pattern. For example, high exposure to ultraviolet (UV) radiation could be seen as an increase in the risk of skin cancers [22], whereas occupationally high physical activity could protect from, e.g., colon cancer [23].

Methods

In this longitudinal register-based study, the cohort consisted of Finnish professional fishermen ($n = 6{,}410$) and their wives ($n = 4{,}260$). All maritime and freshwater area fishermen who had entered the Professional Fishermen Register at least once between 1980 and 2002 were identified and included in the cohort. The Professional Fishermen Register was maintained by the Finnish Game and Fisheries Research Institute under the Ministry of Agriculture and Forestry from the early 1980s to 1995. The regional Employment and Economic Development Centres (TE-Centres) have kept the register since 1995, when Finland joined the EU. Since then, the Professional Fishermen Register has automatically included all fishermen, who own a fishing vessel. In addition, all fishermen are obligated to notify the agricultural industry district (regional TE-Centre) before taking up fishing activities. Women married to a fisherman at the time of the registration of the fisherman or later were identified from the national Population Information System of the Population Register Centre. Spouses cohabiting without marriage could not be identified. There were also some female fishermen ($n = 516$) and male spouses ($n = 75$), but due to low numbers their results were not reported.

The cohort was linked with the Finnish Cancer Registry data from 1980 to 2011 by unique personal identity codes. The nation-wide cancer database includes information on virtually all incident cancer cases diagnosed in Finland since 1953 [24].

The calculation of person-years started in the beginning of the year after the first registration (any year between 1981 and 2002) to the Professional Fishermen Register for the fishermen and the wives, or at marriage (if later) for the wives. The follow-up ended at emigration, at death, or on December 31, 2011, whichever occurred first. The observed numbers of cancers and person-years at risk were calculated separately by gender and 5-year age groups for eight calendar periods (1980–1983, 1984–1987, 1988–1991, 1992–1995, 1996–1999, 2000–2003, 2004–2007, and 2008–2011). The expected numbers of cancer cases were calculated by multiplying the number of person-years in each stratum by the corresponding national cancer incidence rate during the period of observation. The standardized incidence ratios (SIR) were calculated as the ratios of the observed to the expected cancer cases with 95 % confidence intervals (CIs) based on the Poisson distribution for observed cancer cases. The analyses were done separately for the fishermen and their wives.

Results

The study cohort provided 212,000 person-years, and the average follow-up time was 20 years (Table 1). The number of incident cancers was 1,623 at follow-up, and the total cancer incidence both among the fishermen and their wives was the same as in the general population of Finland (Table 2).

Among the fishermen, the incidence of lip (SIR 2.17, 95 % CI 1.26–3.47) and testis (2.51, 1.15–4.75) cancers was increased, whereas the incidence of colon cancer was decreased (0.72, 0.52–0.98). Other sites with more than five observed cases and the SIR estimate higher than 1.20 or lower than 0.80 were Hodgkin lymphoma (increased by 73 %), multiple myeloma (increased by 32 %), liver (decreased by 34 %), and melanoma of the skin (decreased by 24 %).

Among the fishermen's wives, there were no statistically significant excesses or decreases. Sites with more than five observed cases and the SIR estimate higher than 1.20 or lower than 0.80 were rectum (increased by 29 %), gallbladder (increased by 42 %), pancreas (increased by 37 %), soft tissues (increased by 56 %), ovary (increased by 21 %), urinary organs (increased by 38 %), thyroid gland (increased by 41 %), stomach (decreased by 41 %), non-Hodgkin lymphoma (decreased by 20 %), and leukemia (decreased by 28 %).

The incidence of basal cell carcinoma of the skin was lower than expected both among the fishermen (SIR 0.80, 95 % CI 0.69–0.92) and their wives (0.83, 0.69–0.98). Basal cell carcinoma was not included in "all sites" to maintain comparability with results published from other countries where basal cell carcinoma is not registered at all.

Because a large proportion of the cohort members live at the south-western sea coast of Finland, we repeated the analyses for the fishermen with reference rates from the Turku University hospital district in south-western Finland. The SIR estimates were essentially the same. For example, the SIR for all cancers with national reference rates was 0.99 (0.93–1.04) versus 0.97 (0.91–1.02) with regional reference rates; for lip cancer 2.17 (1.26–3.47) versus 2.16 (1.26–3.46); for testis cancer 2.51 (1.15–4.75) versus 2.24 (1.02–4.25); and for colon cancer 0.72 (0.52–0.98) versus 0.68 (0.49–0.91).

Table 1 Numbers (*n*) and proportions (%) of the Finnish fishermen and their wives by age at the beginning of the follow-up and person-years at risk by age at follow-up during 1980–2011

Age (years)	Fishermen				Fishermen's wives			
	Persons		Person-years		Persons		Person-years	
	n	%	*n*	%	*n*	%	*n*	%
All ages	6,410	100	126,513	100	4,260	100	85,975	100
<30	974	15	5,308	4	517	12	2,000	2
30–44	2,434	38	28,868	23	1,792	42	19,412	23
45–59	2,089	33	48,209	38	1,386	33	33,540	39
60–74	835	13	34,660	27	515	12	23,853	28
75+	78	1	9,468	7	50	1	7,170	8

Discussion

In the present study, the total cancer incidence among the fishermen and their wives was the same as in the Finnish general population. Among the fishermen, an excess was observed for lip and testis cancers and a deficit for colon cancer.

In Finland, administrative registers have good coverage and validity. In addition, the computerized record linkage procedure is accurate and the follow-up of incident cancers is complete [25]. Presumably, diagnostic activity regarding cancers does not vary considerably between different areas or occupational groups in Finland. The file coverage of the Professional Fishermen Register is close to 100 % due to the automatic registration based on fishing vessel register and the notification obligation by law since 1995. In addition to high-quality registers, the Finnish professional fishermen are a unique population where the potential harmful effects of high exposure to environmental contaminants through the Baltic Sea fish are most likely seen.

A limitation is that we did not have data on true fish consumption or exposure to fish-derived nutrients and

Table 2 Observed (Obs) number of cancers and standardized SIR with 95 % CIs for the Finnish fishermen and their wives during 1980–2011 by cancer site

Cancer	Fishermen (n = 6,410)			Fishermen's wives (n = 4,260)		
	Obs	SIR	95 % CI	Obs	SIR	95 % CI
All sites	1,059	0.99	0.93–1.04	564	1.00	0.92–1.08
Lip	17	2.17	1.26–3.47	1	0.73	0.02–4.09
Digestive organs	192	0.86	0.74–0.98	121	1.15	0.96–1.36
Esophagus	11	0.82	0.41–1.47	5	1.45	0.47–3.37
Stomach	36	0.89	0.62–1.22	9	0.59	0.27–1.12
Colon	41	0.72	0.52–0.98	38	1.18	0.83–1.61
Rectum, rectosigmoid, anus	44	1.00	0.73–1.34	24	1.29	0.83–1.92
Liver	12	0.66	0.34–1.15	5	0.91	0.30–2.12
Gallbladder, bile ducts	9	1.19	0.54–2.25	10	1.42	0.68–2.60
Pancreas	35	0.94	0.65–1.30	27	1.37	0.91–1.99
Larynx, epiglottis	5	0.48	0.16–1.12	1	1.53	0.04–8.53
Lung, trachea	142	0.88	0.74–1.02	27	0.95	0.63–1.38
Melanoma of the skin	25	0.76	0.49–1.12	14	0.81	0.44–1.35
Skin, non-melanoma	47	1.19	0.88–1.58	18	1.06	0.63–1.68
Soft tissues	5	0.82	0.27–1.91	6	1.56	0.57–3.39
Breast	1	0.72	0.02–4.02	167	0.88	0.75–1.01
Female genital organs	–	–	–	77	1.03	0.82–1.29
Cervix uteri	–	–	–	7	1.05	0.42–2.16
Corpus uteri	–	–	–	37	0.98	0.69–1.35
Ovary	–	–	–	28	1.21	0.80–1.74
Male genital organs	352	1.08	0.97–1.20	–	–	–
Prostate	340	1.07	0.96–1.18	–	–	–
Testis	9	2.51	1.15–4.75	–	–	–
Kidney	42	1.05	0.76–1.41	21	1.29	0.80–1.97
Bladder, ureter, urethra	54	0.97	0.73–1.26	13	1.57	0.83–2.67
Brain, central nervous system	31	1.16	0.79–1.64	29	1.19	0.80–1.71
Thyroid gland	7	1.12	0.45–2.29	17	1.41	0.82–2.25
Lymphoid and hematopoietic tissue	91	1.11	0.90–1.36	30	0.75	0.51–1.07
Hodgkin lymphoma	7	1.73	0.69–3.56	2	1.30	0.16–4.71
Non-Hodgkin lymphoma	43	1.07	0.78–1.44	17	0.80	0.47–1.27
Multiple myeloma	18	1.32	0.78–2.07	4	0.56	0.15–1.44
Leukemia	23	0.99	0.63–1.49	7	0.72	0.29–1.47
Not included above						
Basal cell carcinoma of the skin	183	0.80	0.69–0.92	116	0.83	0.69–0.98

contaminant in this register-based study. Instead, we used the fishermen status as a proxy for high exposure. In our previous studies, a small sub-sample of professional fishermen had twofold fish consumption and serum concentrations of fish-derived omega-3 PUFAs and environmental contaminants when compared with a sub-sample of the general population [19, 20]. Further, we did not have data on confounding factors, such as diet, smoking, alcohol consumption, and physical activity, and thus, we were not able to control for their effects. In our previous study, fish consumption was associated with a healthier dietary pattern, especially higher consumption of vegetables, fruit, and berries and lower consumption of red meat also among the fishermen [20]. In addition, in our previous study, on a sub-sample of the Finnish fishermen, they had lower prevalence of smoking and higher physical activity at work when compared with a sub-sample of a general population [19].

There are only a couple of previous studies on cancer incidence among professional fishermen. The Nordic Occupational Cancer Risk Study (NOCCA) included 15 million people aged 30–64 years in Finland, Sweden, Norway, Denmark, and Iceland, including an occupational category of 66,926 fishermen, and the follow-up for cancer incidence was from 1961 to 2005 [26]. To enable comparison with the present study, the NOCCA results were re-calculated excluding the Finnish fishermen from the analyses (Table 3). A Swedish fishermen study included 2,904 fishermen and 2,042 wives from the east coast of Sweden (Baltic Sea) and 8,564 fishermen and 6,674 wives from the west coast (Skagerrak and Kattegat), and the follow-up was from 1968 to 2002 [27]. Similarly than in the present study, total cancer incidence has been observed to be close to unity both in the NOCCA study excluding Finland (Table 3) [26] and in the Swedish fishermen study [27].

In the present study, cancer incidence among the fishermen was statistically significantly increased only for cancers of the lip and testis and decreased only for colon cancer. Increased lip cancer incidence has also been observed among the other Nordic fishermen in the NOCCA study (Table 3) [26] and the Swedish study [27], and it is in line with the presumably high occupational exposure to UV radiation [28]. An excess in lip cancer has been observed also among Finnish [29] and other Nordic [26] farmers who have similar outdoor work and UV exposure. Smoking is another risk factor for lip cancer [28], but based on lung cancer incidence among the Finnish fishermen (SIR 0.88) the prevalence of smoking is probably lower among the fishermen in Finland when compared with the general population. Lower smoking prevalence among the fishermen compared with the general population has also been observed in our previous sub-study [19].

A similar excess in testis cancer as in the present study has not been observed among the other Nordic fishermen in the NOCCA study (Table 3) [26], whereas in the Swedish fishermen study, testis cancer was not reported [27]. The incidence of testis cancer has been increasing in the western countries, but its etiology is not well understood [30–32]. It has been suggested that exposure to environmental endocrine-disrupting organochlorine compounds such as dioxins and PCBs, especially during fetal development, might increase the risk of testicular cancer [31, 33–35]. In addition, organochlorine exposure has been hypothesized to be a risk factor for testicular dysgenesis syndrome (TDS) and cryptorchidism (i.e., undescended testis) which is one of the few established risk factors for testis cancer [30, 36], but some studies do not support this hypothesis [37, 38].

Since Finnish fishermen typically eat a lot of fish [19] and many of them are offspring of fishermen families, they might have been exposed to environmental contaminants even during the fetal development, and the exposure may extend over past generations. This is in line with the observation that 45 years or older fishermen had somewhat higher SIR estimate (3.14, based on five cases) than those younger than 45 years (2.00, based on four cases) although testis cancer typically occurs around the age of 30 years. The absence of excess in testis cancer among other Nordic fishermen [26] could be explained by the fact the northern coast of the Gulf of Finland still is the most dioxin-contaminated area of the Baltic Sea [39, 40]. Accidental exposure to dioxins has not resulted in an excess in testis cancer in Seveso, Italy, 20 years after the industrial accident [21] which might reflect the importance of exposure during fetal development and long latency. However, it should be noted that the number of observed testis cancer cases was low (9) in the present study. In addition, multiple comparisons always increase the probability of false-positive findings, and thus, the excess in testis cancer may also be due to chance. The low number of cases and possibility of chance findings should be kept in mind when interpreting the results related to any other cancer site, too.

Table 3 Re-calculated results from the Nordic Occupational Cancer Risk Study (NOCCA): Observed (Obs) number of cancers and SIR with 95 % CIs for the fishermen from Sweden, Norway, Denmark, and Iceland during 1961–2005 by cancer site

Cancer	Nordic fishermen ($n = 63{,}956$)		
	Obs	SIR	95 % CI
All sites	15,391	1.02	1.00–1.04
Lip	370	2.28	2.05–2.52
Esophagus	198	1.01	0.87–1.16
Stomach	1,393	1.37	1.30–1.45
Colon	1,249	0.94	0.89–0.99
Rectum, rectosigmoid	777	0.94	0.87–1.01
Liver	107	0.79	0.65–0.96
Gallbladder	88	1.06	0.85–1.31
Pancreas	570	1.09	1.00–1.18
Larynx	236	1.21	1.06–1.38
Lung	2,419	1.17	1.12–1.22
Melanoma of the skin	207	0.50	0.44–0.58
Soft tissues	49	0.71	0.53–0.94
Prostate	3,102	0.89	0.85–0.92
Testis	71	0.90	0.70–1.13
Kidney	553	1.09	1.00–1.18
Bladder	1,427	1.15	1.09–1.21
Brain	315	0.89	0.79–0.99
Thyroid gland	93	1.38	1.11–1.69
Non-Hodgkin lymphoma	330	0.96	0.86–1.07
Hodgkin lymphoma	57	0.87	0.66–1.13
Multiple myeloma	251	0.95	0.84–1.08
Leukemia	297	0.77	0.68–0.86

Decreased colon cancer incidence observed in the present study has also been observed among the Nordic fishermen in the NOCCA study (Table 3) [26] and among the east coast fishermen in the Swedish study [27]. This finding is in line with high fish consumption and high intake of fish-derived omega-3 PUFAs among the fishermen. Some meta-analyses, reviews [41–43], and follow-up studies [44, 45] have concluded that fish consumption or omega-3 fatty PUFA intake may protect from colorectal cancer although some reviews find the evidence less convincing [46, 47]. However, decreased colon cancer incidence has also been observed among Finnish [29] and other Nordic [26] farmers, which indicates that high physical activity at work or some other beneficial lifestyle factor might at least partially explain the decrease. In addition, the SIR estimate for colon cancer was increased among the fishermen's wives in the present study which implies that either their fish consumption was not high enough to reach the potentially protective effect or the decreased SIR estimate among the fishermen was caused by something else in their lifestyle than fish consumption, such as high physical activity.

With regard to the fishermen's wives, their cancer pattern was similar to that of the general female population of Finland. Although their fish consumption was approximately 40 % higher than in a population representing the general Finnish female population, it was lower than that among the fishermen and may not be high enough to protect from cancers. Similarly, the wives' exposure to fish-derived dioxins and PCBs was only half of the fishermen's exposure and thus probably not high enough to increase the risk of cancers [48].

The SIR estimate for multiple myeloma was statistically non-significantly increased among the Finnish fishermen, and the same has also been seen among the Swedish east coast (Baltic Sea) fishermen [27] and among those accidentally exposed to dioxins 20 years ago in Seveso, Italy [21], but not among other Nordic fishermen in the NOCCA study (Table 3) [26]. The etiology of multiple myeloma is not well understood, but the association between dioxin exposure and multiple myeloma has been suspected since multiple myeloma is a malignancy of B cells and dioxins can cause B cell dysregulation [49].

A statistically non-significant 73 % increase in the incidence of Hodgkin lymphoma was observed in the present study, but there was no excess among the other Nordic fishermen in the NOCCA study (Table 3) [26]. The etiology of Hodgkin lymphoma is not well known beyond infections with Epstein–Barr and human immunodeficiency viruses. However, both Hodgkin and non-Hodgkin lymphomas are malignancies of the immune system, and organochlorine compounds are thought to be immunotoxic [50, 51]. In particular, the association between PCBs and non-Hodgkin lymphoma has been established [52, 53], but in the present study, the SIR estimate for non-Hodgkin lymphoma was only slightly elevated. Thus, it could be hypothesized that high exposure to fish-derived organochlorine compounds might have a role in the causation of multiple myeloma and Hodgkin lymphoma.

The SIR estimate for liver cancer was statistically non-significantly decreased among the Finnish fishermen in the present study, and a statistically significant deficit in liver cancer incidence has also been observed among the other Nordic fishermen in the NOCCA study (Table 3) and the Swedish west coast fishermen [27]. One explanation could be high intake of omega-3 PUFAs that is thought to protect from cancer [1]. In a recent Japanese study, fish consumption and fish-derived omega-3 PUFA intake were observed to protect from hepatocellular carcinoma regardless of hepatitis infection [54]. Another explanation could be lower alcohol consumption presumed based on low mortality from alcohol-related diseases and accidental poisonings by alcohol among the Finnish fishermen [19].

Regardless of occupationally high exposure to UV radiation and observed increase in lip cancer incidence among the fishermen, the SIR estimate for melanoma of the skin was decreased, although statistically non-significantly. Similarly, a statistically significant decrease in skin melanoma has also been observed among the Nordic fishermen in the NOCCA study [26]. There is some evidence that fish-derived omega-3 PUFAs, especially eicosapentaenoic acid (EPA), may reduce UV-induced inflammation in the skin and thus protect from photocarcinogenesis [55]. However, a statistically significant decrease in melanoma, although smaller than among the fishermen, has been observed among the Nordic farmers in the NOCCA study [26] which indicates that omega-3 PUFAs may not be an explanation for the decrease. A more likely explanation is that outdoor workers are resistant to sunburns due to constant sun exposure.

In the present study, the incidence of basal cell carcinoma of the skin among the fishermen and their wives was statistically significantly lower than in the general population. A similar decrease has been observed in a Finnish farmer study [29]. This might be due to lower than average diagnostic activity among the fishermen and farmer families.

There is convincing in vivo [56–58] and also some epidemiological evidence [43, 59, 60] that high fish consumption and high fish-derived omega-3 PUFA intake might protect from cancers of the prostate and breast. Still, several reviews have concluded that the epidemiological evidence is weak [46, 61–63]. In the NOCCA study, prostate cancer incidence among the fishermen was statistically significantly decreased (Table 3) [26], whereas in the present study and in the Swedish fishermen study [27] the SIR estimates for prostate cancer among the fishermen and for breast cancer among the fishermen's wives were close to unity. In general, the SIR estimates among the fishermen's wives were not well in line with the previous literature and the observed cancer pattern among the fishermen.

To conclude, we cannot exclude the possibility that the increased incidence of testis cancer among the fishermen, especially in the oldest age groups, could reflect a life-long high exposure to environmental contaminants, whereas the increased lip cancer incidence is explained by high occupational exposure to UV radiation. Decreased colon cancer incidence is in line with presumably high omega-3 PUFA intake but is most likely explained by high occupational physical activity. Except for testis cancer, the presumed high exposure to environmental contaminants was not seen as an elevated cancer risk in the present study. It appears that exposure to environmental contaminants was not high enough to cause excess cancer cases, or the beneficial health effects of fish consumption or some other occupational or lifestyle factor compensated the potential hazardous health effects.

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