ABSTRACT

Objectives. The Sami are the Indigenous people of the northernmost parts of Sweden, Finland and Norway, and of the Kola Peninsula of Russia. The present review summarizes the main results from studies on cancer morbidity and mortality among the Sami and discusses these results in relation to exposure of known risk factors.

Study Design. Literature review.

Methods. A systematic search over the time period 1966–2008 for relevant articles was conducted on MEDLINE. Updates and recalculations of some of the results from the original data were also done.

Results. Nine articles whose main focus is on cancer incidence or mortality among the Sami were identified. In all studies, the overall incidence of cancer or cancer mortality was lower among the Sami in comparison with the national populations. The differences were less striking in relation to regional reference populations, but the rates were still significantly lower for all populations of Sami, except for Swedish Sami women. Beyond the general trend of a lower cancer incidence among the Sami, there were some notable differences between the various Sami subpopulations.

Conclusions. The risk of developing and dying from cancer is low among the Sami. A life-style that includes cancer-protective factors, such as certain dietary components and physical activity, is the most likely explanation for the lower incidence of cancer among the Sami.

(Keywords: Sami, cancer, Nordic, Indigenous, Arctic, mortality)
INTRODUCTION

The Sami are the Indigenous people of the northernmost parts of Sweden, Finland, and Norway, and of the Kola Peninsula of Russia. Their homeland is referred to as Sápmi. The Sami are believed to have been living in the area since the latest ice age. For a long time they made a living out of hunting, fishing and gathering. A few centuries back, some Sami domesticated the reindeer and became reindeer herders.

Today, the Sami population is estimated to comprise around 100,000 individuals: 60,000 in Norway, 30,000 in Sweden, 8,000 in Finland and 2,000 in Russia (1). A small proportion (6,000–8,000) of the Sami is still economically dependent on reindeer herding while the vast majority of the Sami have common Western occupations. The life-style and culture of the reindeer-herding Sami are to a large extent characterized by traditional Sami values and a nomadic way of life, and reflects the migration of the reindeer herds between different grazing areas.

In Sweden, the Sami are most often divided into reindeer herders and non-herders, while in Norway the cultural variation among the Sami is greater in terms of life-style and living conditions in different parts of the country (2,3). Accordingly, reindeer herding is not as dominant as a carrier of the Sami culture in Norway where fishing and farming also are common Sami livelihoods. In Norway and Sweden there are mainly 3 Sami languages spoken today, Northern Sami, Lule Sami and Southern Sami, with Northern Sami being the most widely spoken.

In Finland, distinctions are often made between Skolt Sami, North Sami and the Inari Sami (4). The North Sami share the tradition and the history of the Sami populations in Norway and Sweden, while the Skolt Sami migrated from the municipality of Petsamo (in present Russia) after the Second World War. The Inari Sami live around the Lake Inari and their language is the only Sami language to be spoken exclusively in Finland.

Although knowledge of the health and living conditions among the Sami is poor compared to other Indigenous populations in the Arctic, the epidemiology of cancer in the Sami population has been investigated in several studies. The major reason for the interest in cancer is that large areas within Sápmi were contaminated by nuclear fallout as a result of atmospheric nuclear weapons testing on the island of Novaya Zemlya in the 1950s and 1960s and because of the Chernobyl nuclear reactor accident in 1986.

The aim of the present review is to summarize the main results from studies on cancer morbidity and mortality among Sami and to discuss these results in relation to exposure of known risk factors.
MATERIAL AND METHODS

A systematic search over the time period 1966 to 2008 was conducted on MEDLINE (www.pubmed.gov). The search terms were Sami; Saami; reindeer herder; reindeer breeder; Lapp; cancer; mortality; and causes of death. In addition, we had collaboration from the authors of the original articles who offered some updated data and recalculations from the original data to make some of the classifications used in summary statistics comparable between the countries.

RESULTS

Altogether 9 articles were identified: 5 articles focused on cancer incidence or relative risks to develop cancer, and 4 articles focused on causes of death that included cancer mortality. Five articles were based on Swedish Sami populations (3,5–8), 2 on Norwegian Sami populations (2,9) and 2 on Finnish Sami populations (4,10). Descriptions of study populations, follow-up periods, cancer measures and reference populations of the included studies are given in Table I.

Sami cohorts, follow-up periods and reference populations

All studies used national registers on cancer diagnoses and/or on causes of death. The studies by Wiklund and co-workers (5,6) compiled all cancer diagnoses and causes of death between 1961 and 1984 in a population of reindeer-herding Sami identified in the national population and housing census of 1960 (Table I). The Sami cohort contained about 2,000 persons registered as reindeer herders or as members of reindeer-herding households. Comparisons were made with the Swedish general population and with the population in the northern two-thirds of the country.

Hassler et al. used the same reindeer-herding Sami cohort as Wiklund and others (7), but added the follow-up period of 1961 to 1997 and made comparisons with both the Swedish general population and a population of demographically matched (gender, age and area of residency) non-Sami population, four times as large as the Sami cohort (Table I). In addition, to enable analyses of changes over the follow-up period, a second Sami cohort was constructed by identifying those who were registered as reindeer herders, or as wife, husband or child of reindeer herders in the national population and housing census of 1980. This second cohort was followed from 1981 to 1997.

With the objective of enabling epidemiological studies on the non-reindeer-herding Sami in Sweden, an attempt was made to reconstruct the entire Swedish Sami population (8,11). This was achieved by identifying relatives of reindeer-herding Sami and voters in the elections to the Sami parliament. The relatives were traced through the kinship registers of the Swedish National Bureau of Statistics. Thus, over the time period 1961–1997, a total of about 42,000 Sami were identified. Different subcohorts were then followed with respect to cancer incidence and mortality over different time periods between 1961 and 2003 (3,8). Comparisons were made with a population of demographically matched (gender, age and area of residency) non-Sami population, four times as large as the Sami cohort (Table I).

In the Finnish studies, Sami and non-Sami from the two northernmost municipalities in Finland were identified through interviews...
| Study first author (ref.), year of publication | Country | Sami population | Cohort size | Follow-up period | Cancer measure | Reference population used for comparison |
|-----------------------------------------------|---------|-----------------|-------------|-----------------|---------------|------------------------------------------|
| Wiklund (5), 1990                            | Sweden  | Reindeer-herding Sami | 2,034       | 1961–1984      | Standardized incidence ratio (SIR) | 1. Population of northern Sweden 2. Swedish general population |
| Wiklund (6), 1991                            | Sweden  | Reindeer-herding Sami | 2,034       | 1961–1985      | Standardized mortality ratio (SMR) | 1. Population of northern Sweden 2. Swedish general population |
| Hassler (7), 2001                            | Sweden  | Reindeer-herding Sami | 2,031       | 1961–1997      | SIR           | 1. Demographically matched non-Sami population 2. Swedish general population |
| Hassler (8), 2005                            | Sweden  | Reindeer-herding Sami | 7,482       | 1961–2000      | SMR           | Demographically matched non-Sami population |
| Hassler (3), 2008                            | Sweden  | Reindeer-herding Sami | 7,482       | 1961–2003      | Incidence and SIR | Demographically matched non-Sami population |
| Soininen (4), 2002                          | Finland | Sami from two northern municipalities | 2,100       | 1979–1998      | SIR           | 1. Non-Sami from the same municipalities 2. The Hospital District of Lapland |
| Soininen (10), 2008                         | Finland | Sami from two northern municipalities | 2,091       | 1979–2005      | SMR           | 1. Non-Sami from the same municipalities 2. Finnish general population |
| Haldorsen (2), 2005                         | Norway  | Sami from the counties of Troms, Nordland and Finnmark | 19,801      | 1970–1997      | SIR           | 1. Rural population of the counties of Troms, Nordland and Finnmark 2. Norwegian general population |
| Tynes (9), 2007                             | Norway  | Sami from the counties of Troms, Nordland and Finnmark | 19,801      | 1979–1998      | SMR           | 1. Rural population of the counties of Troms, Nordland and Finnmark 2. Norwegian general population |

*The follow-up of the original study was 1979–1998. For the present review, the follow-up was extended to 2006.*
where language and genealogy served as ethnic markers (4,10). Based on these findings the Sami were classified into different subgroups, that is, North, Inari and Skolt Sami. The interviews were conducted in the 1960s and the risks for developing cancer, and cancer mortality, were analysed over different time periods between 1979 and 2005. Comparisons were made with non-Sami of the most northern municipalities of Finnish Lapland (Table I).

The Norwegian studies were based on a cohort of about 20,000 Sami identified through a survey of Sami ancestry that was performed in the census of 1970 in the 3 northernmost counties of Norway: Nordland, Troms and Finnmark (2,9). In this census, questions on the use of the Sami languages and Sami self-identification were used to estimate the degree of Sami ancestry. Moreover, based on area of residency and the occupation the Sami cohort was divided into 4 subpopulations: living in areas with no reindeer breeding, some reindeer breeding, or the core area of reindeer breeding, and being a member of a reindeer breeding family. The cancer incidence was analysed for the period 1970–1997 and the mortality was analysed for the period 1970–1998 using two reference populations: the Norwegian general population and the rural population of the 3 northernmost counties (Table I).

### Table II. Observed and expected numbers of cancer cases in Swedish (n=41,721), Finnish (n=2,661) and Norwegian (n=19,801) Sami cohorts, together with standardized incidence ratios (SIR) and 95% confidence intervals (95% CI), based on regional reference populations. For details about the Sami cohorts and follow-up periods, see Table I.

| Study Site       | Men     | Women   |       |       |       |       |       |       |       |       |       |       |       |       |
|------------------|---------|---------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                  | Observed| Expected| SIR   | CI    | Observed| Expected| SIR   | CI    |
| Sweden, Hassler  | 994     | 1,103   | 0.90  | 0.85–0.96 | 970   | 932   | 1.04  | 0.97–1.10 |
|                  | 103     | 83      | 1.23  | 1.01–1.50 | 50    | 33    | 1.53  | 1.13–2.01 |
|                  | 52      | 70      | 0.74  | 0.55–0.97 | 70    | 59    | 1.19  | 0.93–1.50 |
|                  | 73      | 64      | 1.14  | 0.89–1.43 | 9     | 20    | 0.44  | 0.20–0.84 |
|                  | 235     | 308     | 0.76  | 0.67–0.87 | 43    | 55    | 0.94  | 0.63–1.34 |
|                  | 60      | 74      | 0.81  | 0.62–1.05 | 107   | 152   | 0.71  | 0.58–0.84 |
|                  | 9       | 10      | 0.91  | 0.42–1.73 | 7     | 6     | 1.06  | 0.39–2.31 |
|                  | 7       | 6       | 1.18  | 0.47–2.42 | 8     | 6     | 1.40  | 0.60–2.75 |
|                  | 2       | 8       | 0.24  | 0.03–0.85 | 3     | 2     | 1.36  | 0.28–3.96 |
|                  | 2       | 27      | 0.45  | 0.23–0.78 | 1     | 1     | 1.00  | 0.40–2.06 |
|                  | 25      | 34      | 0.74  | 0.48–1.08 | 18    | 35    | 0.52  | 0.31–0.82 |
|                  | 8       | 140     | 0.57  | 0.45–0.71 | 8      | 140   | 0.57  | 0.45–0.71 |
| Norway, Haldorsen | 821     | 948     | 0.78  | 0.73–0.84 | 559   | 711   | 0.84  | 0.78–0.91 |
|                  | 89      | 97      | 0.91  | 0.73–1.12 | 52    | 49    | 1.06  | 0.79–1.39 |
|                  | 31      | 62      | 0.50  | 0.34–0.71 | 36    | 58    | 0.62  | 0.43–0.85 |
|                  | 45      | 77      | 0.58  | 0.43–0.78 | 13    | 17    | 0.76  | 0.41–1.30 |
|                  | 86      | 150     | 0.57  | 0.45–0.71 | 80    | 140   | 0.57  | 0.45–0.71 |
|                  | 99      | 157     | 0.63  | 0.51–0.77 | 21    | 35    | 0.60  | 0.37–0.91 |

*The follow-up of the original study was 1979–1998. For the present review, the follow-up was extended to 2006.*
Figure 2. Overall cancer incidence among the Sami in Sweden (1970–2003 [3]), Finland (1979–2006 [4]) and Norway (1970–1997 [2]), in comparison with that in the general population of each country. Rates adjusted for age to the World Standard Population.
Cancer incidence

In all studies, the overall incidence of cancer was lower among Sami in comparison with the general populations in Sweden, Norway and Finland, respectively (2–5,7) (Fig. 1). The relative differences in risk for cancer were smaller in relation to regional reference populations, but were still significantly lower for all subpopulations of Sami, except for Swedish Sami women (Table II). In all countries, the relative difference in cancer incidence between the Sami and the reference population was smaller among women than among men (Table II). The Finnish Sami men showed the lowest standardized incidence ratio (SIR) (0.71, 95% CI 0.58–0.84). The differences in SIRs across the various subpopulations of Sami are, at least to some extent, caused by different inclusion criteria applied in the compilation of the Sami cohorts and different reference populations, as well as by unequal follow-up periods.

Cancer of the stomach is one of the few specific sites where the Sami have had a higher incidence than the regional reference populations. Significantly higher risks were reported for Sami in Sweden, particularly among reindeer-herding Sami (3), and for the Skolt Sami of Finland (4), but not among other subgroups of Finnish Sami or among the Sami of northern Norway (Table II).

All Sami in Norway and Sami men in Sweden have had a significantly decreased colon cancer incidence. Significantly lower SIRs for bladder cancer were reported for Sami men in Finland and Norway and for Sami women in Sweden. Breast cancer was observed to be less common only among Sami women in Finland while the relative risk for prostate cancer appears to be significantly lower among the Sami men in all countries. Significantly low rates for lung cancer have been reported for both Sami men and women in Norway (Table II).

Cancer mortality

The SMRs for overall cancer mortality were significantly decreased among Sami men and among the Sami women in Norway and Sami men in Finland (Table III). The ratios were quite similar to the corresponding SIRs (Table II). Reindeer-herding and non-reindeer-herding Sami in Sweden showed similar low mortality ratios due to cancer (8). In the Finnish study the Skolt Sami, in contrast to the other Sami groups, showed an increased risk for cancer mortality, SMR 4.06 (1.63-6.36) (10).

Table III. Observed and expected numbers of deaths due to cancer among Swedish (n=41,721), Finnish (n=2,091) and Norwegian (n=19,801) Sami, together with standardised mortality ratios (SMR) and 95% confidence intervals (95% CI). For details about the Sami cohorts, reference populations and follow-up periods, see Table I.

| Study               | Men | Women |
|---------------------|-----|-------|
|                     | Observed | Expected | SMR  | 95% CI | Observed | Expected | SMR  | 95% CI |
| Sweden, Hassler (8) | 476 | 547    | 0.87 | 0.79–0.95 | 375 | 354 | 1.06 | 0.96–1.18 |
| Finland, Soininen (10) | 53 | 77 | 0.69 | 0.52–0.90 | 48 | 51 | 0.95 | 0.70–1.25 |
| Norway, Tynes (9)   | 535 | 621    | 0.86 | 0.79–0.94 | 364 | 408 | 0.89 | 0.80–0.99 |
DISCUSSION

The increased risk for stomach cancer reported among Sami in Sweden and Finland is likely to be associated with diet. A high intake of red meat, smoked food and foods rich in salt, nitrite and preformed nitrous compounds are associated with increased risk, whereas a high consumption of fresh fruits and raw vegetables and a high intake of antioxidants are related to reduced risk (12–15). As a high intake of smoked and salted foods and a low consumption of fresh fruits and vegetables characterize the traditional Sami diet in some Sami populations (16–20), it seems likely that these dietary habits elevate the risk of developing stomach cancer in these populations.

The ambiguity of the traditional Sami food regarding the risk for gastrointestinal cancer is due to the fact that the diet contains some items that are supposed to increase the risk of cancer (i.e., smoked and salted meat and fish, and a low intake of fresh fruits and vegetables), and others that are known to decrease the risk (i.e., reindeer meat and wild fish that are rich in selenium, omega-3 acids and vitamin A, and a low intake of dairy products) (16–20).

Low consumption of vegetables and fresh fruits also constitutes a risk factor for colon cancer. The relatively low intake of these food items, in combination with a traditional diet that is not necessarily favourable for decreasing the risk of colon cancer, indicate that the decreased risk of colon cancer reported among Sami men in Norway and Sweden as well as Sami women in Norway is caused by other risk factors, for example, a high level of physical activity or heredity factors.

Except for 1 study indicating high smoking rates among reindeer herders in Finland (21), and 1 Norwegian study demonstrating that the number of daily smokers was somewhat lower among the Sami than among the non-Sami in the same region (22), the smoking habits of the Sami seem to be similar to that of the general population (23–26). Still the incidence of lung cancer among Sami in Norway is below the reference rates, and low SIRs for bladder cancer that is also smoking-related were reported for Sami men in Finland and Norway and for Sami women in Sweden (Table II). Thus, since it appears that the smoking habits of the Sami are similar to that of the non-Sami population, and since the Sami are unlikely to be more exposed to known environmental risk factors, these factors are probably not responsible for the lower relative incidences of cancer at these sites among the Sami. It is suggested that factors that can potentially prevent bladder cancer be investigated in future case-control studies using Sami and non-Sami study populations.

The lower risk for breast cancer observed in Sami women in Norway and Finland is in concordance with findings in other Arctic populations, such as the Inuit (27). It is known that the risk of breast cancer is reduced in women who have a large number of children. This might be a contributing factor to the low incidence of breast cancer among the Sami since they have a slightly higher birth rate in comparison with the non-Sami population (28,29). It is also known that risk-increasing factors for breast cancer, such as a diet rich in fat, early menarche, obesity, null parity and late childbearing are rare in the Sami and other Arctic populations as compared with the national averages (28–31).
It is well established that there are substantial differences in incidence and mortality of prostate cancer within various ethnic groups. For instance, the incidence rate among black American men is about 13 times as high as that of Japanese men (32). The observations made among the Sami add to the impression that the low risk of developing prostate cancer is a common trait among the Native people of the circumpolar region (32,33). Although genetic factors have been suggested as contributing to ethnic differences in prostate cancer (32), life-style factors, such as diet and physical activity, dominate the discussion on why the Sami are less likely to develop cancer of the prostate (2–5,7). In a recent study among the Swedish Sami, an analysis of prostate cancer in relation to life-style and genetic heritage indicated that the main reason for the lower risk of developing prostate cancer points to life-style rather than to genetic factors (3). Thus, the relative risk, relative to non-Sami of the same geographic setting, was significantly lower among Sami living more traditionally as compared with Sami with a more Westernized life-style.

A potential explanation for the low rates of non-symptomatic cancers among the Sami, such as prostate, breast cancer, thyroid and some skin cancers, could be that the Sami are less prone to participate in the screening of such cancers (34). In one of the Finnish studies (2) the analysis was stratified according to the stage of cancer at diagnosis, and it was concluded that the risk decrease was not attributable to diagnostic bias. The finding also reported in this paper that the SMRs are similar to SIRs points in the same direction. Thus, the risk for developing cancer appears to be truly lower among the Sami, at least for men, rather than being an effect of underdiagnosis.

In the Swedish study (8), a subdivision of reindeer-herding and non-reindeer-herding Sami indicated similar mortality ratios due to cancer. It was suggested that these results support the hypothesis that the Sami possess genetic factors reducing their risk to develop cancer since there are still considerable differences in life-style between reindeer-herding and non-reindeer-herding Sami in Sweden (e.g., the reindeer-herding Sami have maintained a more traditional life-style). Interestingly, the SMR among the non-herding Sami women in Sweden increased significantly during the period 1961–2000, perhaps indicating a reduction of cancer protective factors as their life-style becomes more similar to that of the general population. A similar finding was reported from Finland as well (10).

Beyond the similarities between different Sami populations regarding cancer mortality there seem to be some notable differences. In the Finnish study, it was found that the Skolt Sami, in contrast to the other Sami groups, showed an increased risk for cancer mortality, especially from stomach cancer (10). According to the authors, this might be a reflection of the particularly low standard of living among the Skolt Sami.

Impact of exposure to radioactive fallout

There are two major sources of radioactive contamination of the Sami living areas: the nuclear weapons tests in Novaya Zemlya in the 1950s and 1960s and the Chernobyl nuclear reactor accident in 1986. As the Sami represent the end of the food chain
(lichen-reindeer-human), particular attention has been given to studying their risk of exposure to radiation and radioactive-sensitive cancers such as leukaemia and cancer of the thyroid, bone and breast. However, no enhanced risks for radiation-related cancers have been observed among the Sami (2–5,7). These findings are in concordance with the estimates made from whole body measurements in the northern region. Although estimates based on whole body measurements on reindeer herders in Finland indicate higher doses of radiation among reindeer herders, it was concluded that the statistical effect of radioactivity increasing the risk of cancer is negligible (35).

Genetic factors
The Sami are recognized as genetically distinct from other European populations, but their origin is still somewhat mysterious (36). It has been suggested that the Sami originate from the area around Lake Ladoga and Lake Onega (in present Russia, close to the Finnish border) and subsequently spread throughout Fennoscandia. Studies of genetic markers, such as blood groups, enzyme polymorphisms and serum proteins, demonstrate interesting differences between the Sami and the general populations in Sweden and Norway, whereas the similarities between the Sami and the Finns appear to be larger (36).

Since the Sami are thought to originate from a small population and have a history of infrequent marriages with non-Sami, they are considered to be well suited for studies of genetic risk factors (36,37). It has been suggested that ethnic differences in cancer risk can be due to ethnic variations in polymorphic alleles of genes that are related to modest alterations in risk (38). It has been shown that the human serum protein orosomucoid (ORM) may act as a blocking factor that protects the tumour cells against an immunological attack (39). The frequency of the alleles controlling the production of ORM is ten times lower among the Sami as compared with non-Sami in Scandinavia (40,41). This difference might contribute to the lower cancer incidence among the Sami (3,7).

Conclusions
The risk of developing and dying from cancer is low among the Sami, both in comparison with general populations in the Nordic countries and with regionally matched reference populations of non-Sami. Genetic factors might partly explain the low susceptibility for cancer among the Sami. Yet the most likely reasons are that they have maintained a life-style that includes cancer-protective factors (e.g., dietary components and physical activity).

Although there are notable differences between various Sami groups, the relative decrease in cancer risk seems to be, by and large, lower among men than among women. It has been argued that the Westernization of the Sami has not only changed their food habits but has also reduced their level of physical activity and, as a result of fertility control through contraceptives, reduced the length of time a woman breastfeeds (28–31). This suggests that the Sami women have lost more cancer protective factors in the acculturation process in comparison with the men. For instance, the motorization and the reduced economic profitability of the
reindeer-herding husbandry have forced the women to take employment outside the Sami communities, where they have been more exposed to the Western lifestyle (42,43).

In general, the Westernization of Indigenous cultures has had an unfavourable effect on their risk of developing cancer (27,36). The acculturation process among the Sami is somewhat different from other Indigenous populations in the circumpolar area since the Sami entered the epidemiological transition several centuries ago. The Westernization of the Sami culture is still an ongoing process, but it is not any longer as linear in its transition as it was in the early phases, that is, it is moving towards reduced levels of health in more complicated ways. This emphasizes the importance of closely following the development of the cancer incidence within different Sami populations in future studies.

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