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Incidence of cutaneous squamous cell carcinoma in coastal and inland areas of Western Sweden

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ABSTRACT

Background: The incidence of squamous cell carcinoma (SCC) has increased in recent decades, both in Sweden and worldwide. The aim of this study was to investigate the development of SCC over time (1970–2007) in the western part of Sweden (WS), with emphasis on the incidence trends on the coast and in the inland areas.
Methods: Cancer data on SCC for different subareas in WS were obtained from the Swedish Cancer Registry. The incidence standardized for the Swedish population in 2000 was analyzed. The incidence trends were estimated and compared using regression analysis.
Results: The incidence was significantly higher in the coastal areas. The incidence rate in 2007 was higher for men than for women, whereas the average growth of the incidence was higher among women.
Conclusion: This study shows that another important aspect regarding sun exposure, apart from latitude, is whether an area lies in the inland or on the coast. The higher sun exposure on the coast is associated with higher incidence of SCC. Preventive actions are needed; and perhaps extra information should be given to people living on the coast, who have a higher sun exposure.

1. Introduction

Squamous cell carcinoma (SCC) and basal cell carcinoma (BCC), usually referred to as non-melanoma skin cancers (NMSC), are the most frequent types of cancers in humans [1]. Typically, SCC is found in sun-exposed skin such as the head, neck, and back of the hands of elderly individuals. At an early stage, it is easily cured, usually by surgical removal, but if untreated it may cause local destruction of underlying structures or spread to regional lymph nodes. A meta-analysis by Rowe et al. reported metastatic rates between 2.3% and 5.2% (higher in studies with longer follow-up [2]), and Weinberg et al. reported rates varying between 0.1% and 3.6% [3]. According to the Cause of Death Registry maintained by the National Board of Health and Welfare in Sweden, NMSC mortality in Sweden has varied between 0.38 and 0.75 per 100,000 inhabitants during the last decade; the corresponding figures for malignant melanoma are 3.92 and 5.39. The increasing incidence of SCC is a growing public health problem, which leads to an increasing burden on the health care system as well as direct and indirect costs.

Exposure to ultraviolet (UV) radiation, predominantly from the sun, is considered the major risk factor for developing skin cancer. Apart from sunlight, sunbeds are a source of exposure to UV radiation [4]. UV radiation causes mutations in cellular DNA, especially in the p53 suppressor gene, promoting the carcinogenic process by inducing a state of cutaneous immunosuppression [5]. The incidence of SCC increases with age and cumulative UV radiation exposure [6], and so people with outdoor occupations are at higher risk [7]. Daily use of sunscreen has been shown to reduce the risk of developing SCC and its precursors [8–10]. SCC is more common in males, but it is not clear whether this higher incidence rate is due solely to differences in sun exposure between the sexes, or to a true gender effect, as indicated by some animal studies [11]. A history of NMSC is associated with an increased risk of subsequent NMSCs [12].

The incidence of SCC varies greatly between different geographic areas. Australia has the highest reported incidence rates (1322 for men and 755 for women, age-standardized per 100,000 inhabitants), whereas the incidence rates in the US are lower (356/100,000 for men and 150/100,000 for women), as are those in Europe (18.2/100,000 for men and 8.5/100,000 for women) [13]. The incidence of SCC is increasing worldwide, particularly in the population over 55 years, though some reports show a stabilizing incidence [14]. Since 1958, the Swedish Cancer Registry includes

Abbreviations: SCC, squamous cell carcinoma; WS, Western Sweden; BCC, basal cell carcinoma; NMSC, non-melanoma skin cancer; UV, ultra violet; SCR, Swedish Cancer Registry; SMHI, Swedish Meteorological and Hydrological Institute.

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SCC and thus the incidence figures are more reliable than in countries where the incidence is estimated from surveys. Swedish data, comparing the standardized incidence rate in Sweden for 1970 and 2007, shows a 4-fold increase for both men and women (data from the website of the National Board of Health and Welfare in Sweden, www.socialstyrelsen.se). There are still no signs of a declining trend, which is a question of great concern.

A clear relationship between latitude, as an indicator of the intensity of UV radiation exposure, and the incidence of SCC has been demonstrated [15]. The incidence of SCC doubles with each 8–10 degrees of latitude closer to the equator [16]. However, individual behaviour (e.g. sun protection) and the climate (coast or inland) may have a large impact on personal UV radiation exposure in individuals living at the same latitude.

The aim of this project was to study the development of the incidence of SCC during the past 35 years within different geographic areas of Western Sweden (WS), considering the effect of varying sunshine duration in coastal and inland areas.

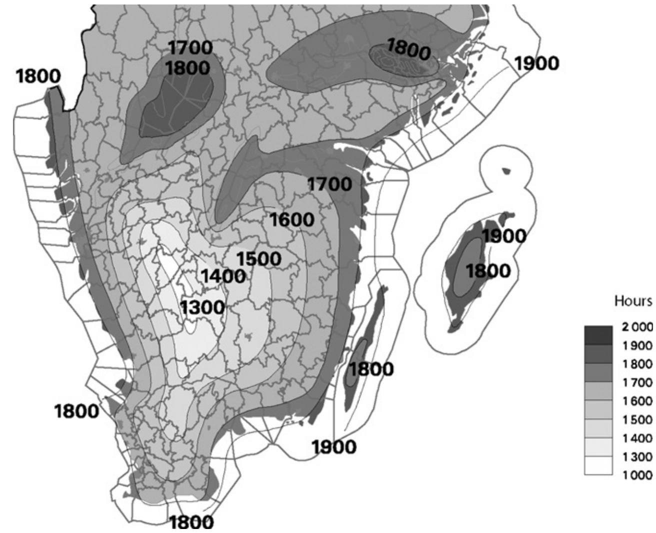

Fig. 1. Average number of sun hours per year during the period 1961–1990. SMHI.

2. Materials and methods

2.1. Cancer data

Data were obtained from the Swedish Cancer Registry (SCR) of the National Board of Health and Welfare in Sweden (Socialstyrelsen, www. socialstyrelsen.se). Data included the number of cases, the incidence of cutaneous SCC, and the median and average age at diagnosis for the years 1970–2007. The series were reported separately for different geographic areas of WS, further described in the section on sunshine duration. The diagnosis used was cutaneous SCC (ICD-7 191.0-9, morphologic type 146). In situ carcinomas were excluded.

To characterize the number of new cases, two yearly series were available, namely the **total number of reported cases** (i.e. All cases) and the **total number of reported persons with at least one tumor** (i.e. First-time cases). All cases include all tumors, also when the same patient has more than one tumor during the same year. Regarding First-time cases, only the first time that the patient was diagnosed with SCC is counted. The reason for analyzing First-time cases was to investigate whether there had been an increase in the number of patients, or whether the increased incidence could be explained by more tumors per patient. The data set consisted of the following variables: number of cases, standardized incidence (standardized for the Swedish population in 2000), number of first-time cases, and standardized incidence for first-time cases (standardized for the population in 2000). For all these variables, data were delivered separately for men and women.

2.2. Sunshine duration and geographic areas

We wanted to investigate possible differences in skin cancer incidence between coastal and inland areas. Data from the Swedish Meteorological and Hydrological Institute (SMHI), showing the average number of sun hours (Fig. 1) indicated more sun exposure on the coast and a cut-off of 1700 sun hours per year seemed a natural border between coastal and inland municipalities. Each municipality in WS was classified as having either "many sun hours" (on average 1701–1900 h of sun per year during the period 1961–1990) or "few sun hours" (up to 1700 h per year). Some municipalities covered areas with different sun exposure; when classifying these, we took the population density into consideration, and classified each municipality according to the sun exposure class that applied to the majority of its population. Almost all the municipalities on the coast were classified into the group with high sun exposure. In addition to the comparison between coast versus inland, we also wanted to compare the northern and southern areas of WS. Gothenburg belongs to the category "many sun hours" but was analyzed separately, both because it is a much larger city with a very mobile population and because it is situated on the border between the northern and southern coastal areas. The five geographic areas are shown in Fig. 2.

2.3. Data analysis

To compare the development of the incidence of SCC in the different geographic areas, the trends were estimated using ordinary least squares regression. The standardized incidence was used (new cases in relation to population size, standardized for the population in 2000). The standardized incidence allows a comparison over time that is unaffected by any changes in the age distribution over the study period. If the number of new cases follows a Poisson distribution, and there is a trend in the data, then the variance is assumed to increase with the trend (i.e. not assumed to be constant). When analyzing the standardized incidence, we used a log-transformation to stabilize the variance:

$$\ln(Y_t) = \beta_0 + \beta_t t + e_t,$$

where Y_t = incidence at time t, t = time in years (t = 1 represents 1970), and the error terms e_t were assumed to be independent and identically distributed, following a normal distribution with expected value 0 and variance σ^2; that is, e_t was assumed to be iid $N(0; \sigma^2)$. When anti-logging, we obtained an exponential trend where $(\exp(\beta_1) - 1)$ is an estimate of the growth of the exponential trend (the average relative increase per year). The presence of a trend was tested by the hypothesis H_0: $\beta_t = 0$.

When comparing the incidence series in different geographic areas, we used regression models that allowed for **differences in the incidence level** between the coastal and inland areas: $\ln(Y_t) = \beta_0 + \beta_c c + \beta_t t + e_t$. The indicator variable c took the value 1 for the coastal area and 0 for the inland area, and a possible level difference was tested by H_0: $\beta_c = 0$. We also analyzed whether there were **different trends** for the development of the incidence on the coast compared to the inland, using the model $\ln(Y_t) = \beta_0 + \beta_c c + \beta_{ct} c t + \beta_t t + e_t$. The variable $t \times c$ was the product of the time variable and the coastal/inland indicator variable, and trend differences were tested by H_0: $\beta_{ct} = 0$. Data