Socioeconomic status and head and neck cancer incidence in the Nordic countries

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Abstract (248 words)

Background: The impact of societal factors on the occurrence of head and neck cancers (HNCs) remains understudied, especially in the Nordic countries.

Methods: To quantify the association between socioeconomic status (SES) and the occurrence of HNC, this cohort study uses data from the Nordic Occupational Cancer (NOCCA) project that combines occupational and cancer registry data from 1961 to 2005 of 14.9 million individuals aged between 30 and 64 years. Occupational categories were combined into seven socioeconomic categories. Standardized incidence ratio (SIR) analyses were conducted with the cancer incidence rates for the entire national study populations used as reference rates.

Results: Altogether, 83 997 HNCs –72% in men and 28% in women – were recorded. Among men, a gradient of risk associated with SES was observed of cancers of the tongue, other oral cavity subsites, pharynx, oropharynx, and larynx in groups with lower SES. Managers showed decreased SIRs of 0.50 to -0.90 also for cancers of the lip, tongue, other oral cavity subsites, oropharynx, nasopharynx, nose, and larynx. In contrast, excess risks of tongue, other oral cavity subsites, pharyngeal, oropharyngeal, and laryngeal cancers were observed among clerical (SIRs 1.05-1.16), skilled workers (1.04-1.14), unskilled workers (1.16-1.26), and economically inactive men (1.38-1.87). Among women, no risk gradient similar to that in men was revealed.

Conclusion: The current study underscores the influence of SES on the incidence of HNCs and highlights the need for targeted interventions, including tobacco and alcohol control policies, and improved access to healthcare services, particularly for socioeconomically disadvantaged populations.

Keywords: head and neck cancer, social class, socioeconomic status, incidence, risk

Key messages

- The impact of societal factors on the occurrence of head and neck cancers (HNC) remains understudied, especially in the Nordic countries which are characterized by a strong commitment to social equality and a comprehensive welfare state.

- Among men, we observed an increasing risk gradient with decreasing SES emerged for cancers of the tongue, other oral cavity subsites, pharynx, oropharynx, and larynx.

- The current study has the potential to offer valuable insights for shaping policies aimed at easing the burden of HNC within socioeconomically disadvantaged communities, such as tobacco and alcohol policies, oral health programs, and facilitated access to healthcare services.

Introduction

The socioeconomically disadvantaged often find themselves in circumstances that predispose them to various health risks, including limited access to healthcare services, inadequate education, and reduced economic opportunities[1,2]. These factors, collectively, can profoundly impact an individual's risk of developing a range of diseases, including some cancers[3,4]. However, while studies suggest the burden of specific cancers continues to be disproportionately borne by the people with low socioeconomic status (SES), certain cancers have been conversely associated with higher SES[3,4].

The majority of head and neck cancers (HNCs) are attributable to known aetiologic factors, such as tobacco and alcohol consumption, and are typically characterized by a strong correlation with long-lasting exposure to carcinogens[5]. Additionally, human papillomavirus (HPV) is involved in the development of a subset of HNCs, mainly those affecting the oropharynx[6]. Still, other factors related to socioeconomic disparity may play a crucial, yet often underappreciated, role. Indeed, a 2014 pooled analysis consisting of 23 964 HNC cases and 31 954 controls from 27 countries uncovered over twice the odds of HNC among the lowest income and educational levels, not entirely explained by differences in behavioural risk factors[7].

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 cancer register data. In this register-based cohort study, we use data collected for the NOCCA project to explore the relationship between SES and the risk of HNC. The objective of these analyses was to assess and quantify the association between SES and the occurrence of HNC stratified by cancer site and sex, a subject remaining understudied[8].

Methods

Population. The current study employs a methodology consistent with that of prior studies based on the Nordic Occupational Cancer Study (NOCCA) database. Briefly, the NOCCA database comprises 45 years of cancer incidence data linked to occupational categories, covering the period from 1961 to 2005 and encompassing 14.9 million individuals, both men and women, from Denmark, Finland, Iceland, Norway, and Sweden, aged between 30 and 64 years, during the 1960, 1970, 1980/1981, or 1990 censuses. Individuals were recruited on January 1st following the earliest census in which they were registered, and they were connected to their occupational, vital status, and cancer-related data, facilitated by the unique personal identity codes assigned to all residents of the Nordic countries. A detailed description is available in a previous publication[9].

Occupational Data. Occupational information was extracted from census questionnaires, which were subsequently coded and processed by the national statistical offices. These censuses were carried in Denmark in 1970, in Finland in 1970, 1980, and 1990, in Iceland in 1981, in Norway in 1960, 1970, and 1980, and in Sweden in 1960, 1970, 1980, and 1990. The first recorded census occupation was used in the analysis. For this study, occupational categories were stratified into six social class categories (Table 1). Individuals whose occupation was coded as "other economically active persons" (occupational titles not included in other occupational categories such as precision mechanic workers, athletes and sportsmen, photographers, bath attendants, and several subcategories of service workers) or "military personnel" (altogether n=746 284) were excluded due to the heterogeneity of the group and thus to facilitate the interpretation of results. Information regarding vital status and emigration was extracted from the national population information systems. Calculation of person-years (PYs) commenced on January 1st of the year following an

individual's first available census when aged between 30 and 64 years, and continued until the occurrence of emigration or death, or until December 31st of the following years: 2003 in Norway and Denmark, 2004 in Iceland, and 2005 in Finland and Sweden (whichever came first).

Cancer data. According to the International Classification of Diseases for Oncology 3rd Edition (ICD-O-3), HNCs were malignancies diagnosed in the lip (C00), tongue (C02), other oral cavity subsites (C03-C06), salivary glands (C07-C08), pharynx (C01, C09-C14), nasal cavity and paranasal sinuses (C30-C31), and larynx (C32). Incident cancer cases were sourced from the cancer registers of each of the five Nordic countries through record linkage using unique personal identity codes. Cancer registries obtained information on cancer cases from various healthcare sources – including medical professionals, healthcare facilities, and pathologic departments – and, except Sweden, also received information from death certificates[10].

Statistical analyses. We measured cancer risk in our study by standardized incidence ratios (SIRs), i.e., the observed number of cancer cases in a category divided by the expected number of cases. For each country and SES category, we stratified the observed number of cancer cases and PYs by sex, 5-year age groups (ranging from 30–34 to 85+ years) and 5-year calendar periods (from 1961–1965 to 2001–2005). The expected number of cancer cases was calculated based on the number of PYs within each stratum (defined by country, sex, age, and calendar period) and the incidence rate in the respective stratum of the entire national study population. Aggregate risk measures for all Nordic countries combined were computed as the ratio of the total observed cases to the total expected cases across the five nations. The exact 95% confidence interval (CI) was defined for each SIR, assuming a Poisson distribution of the observed number of cases. Additionally, we calculated estimates of the excess absolute risk. The excess absolute risk describes the difference

in absolute cancer incidence between the group under interest and the general population (observed cancers – expected cancers) and is given in this study per 100 000 PYs. Analyses were conducted using Stata 17 software (StataCorp. 2021. *Stata Statistical Software: Release 17*. College Station, TX: StataCorp LLC). Figures were created using R software (The R Project for Statistical Computing) version 4.3.1.

Results

The study cohort included 14.5 million persons contributing a total of 373.3 million PYs of follow-up (Table 2).

Among the 7.2 million men (49%) and 7.3 million women (51%), altogether 83 997 HNCs were recorded during the follow-up period – 60 299 (72%) in men and 23 698 (28%) in women (Table 3).

Site-specific risks, men

Among men, the SIR increased towards lower SES categories in cancers of the tongue, other oral cavity subsites, pharynx, oropharynx, and larynx (Figure 1). Managers showed a decreased incidence (SIRs 0.46 to 0.90) of all HNC subtypes except cancer of salivary glands (Table 4). In contrast, an increased risk of tongue, oral, pharyngeal, oropharyngeal, and laryngeal cancers was observed among clerical workers (SIRs 1.05 to 1.16), skilled workers (1.04 to 1.14), unskilled

workers (1.16 to 1.26), and economically inactive (1.38 to 1.84). Unskilled workers and economically inactive showed an elevated risk of lip cancer (SIRs 1.26 and 1.13, respectively).

Farmers displayed a reduced risk of all HNC subtypes (SIRs 0.37 to 0.92), except for lip cancer (SIR 1.62. 95% CI 1.57-1.67).

The incidence of nasopharyngeal and sinonasal cancers was elevated only among skilled workers (SIRs 1.10 and 1.17, respectively).

No marked variation in the SIRs was observed across the countries.

Site-specific risks, women

Among women, no risk gradient similar to that in men was revealed (Figure 2 and Table 5). An elevated risk was observed in lip cancer among unskilled workers (SIR 1.14, 95 CI 1.01-1.29), in other oral cavity subsites among skilled workers (1.12, 1.04-1.21), in oropharyngeal cancer among clerical workers (1.14, 1.03-1.25), and in laryngeal cancer among skilled workers (1.29, 1.17-1.42), and unskilled workers (1.33, 1.18-1.48).

A decreased risk of pharyngeal (SIR 0.75, 95% CI 0.63-0.89), nasopharyngeal (0.65, 0.41-0.98), and laryngeal cancers (0.65, 0.50-0.82) was noted in managers. Lip cancer was not elevated in female farmers (SIR 1.06, 95% CI 0.92-1.21).

As in men, no marked variation in the SIRs was observed among women across the countries.

Time trends of SES variation, men and women

Individuals with lower SES (Skilled workers and unskilled workers) consistently showed over time higher SIRs compared to those with higher SES (Managers and clerical workers) for cancers of other oral cavity subsites, pharynx, oropharynx, nose and sinuses, and larynx (Supplementary Figures S1–S9). Farmers showed consistently an increased risk of lip cancer and a reduced risk of cancers of the tongue, other oral cavity subsites, pharynx, oropharynx, nose and sinuses, and larynx. For laryngeal cancer, a decrease in the SIR is observable in the higher SES group over time, whereas the SIR among farmers increased.

Discussion

Among men, a gradient of risk associated with SES was observed for cancers of the tongue, other oral cavity subsites, pharynx, oropharynx, and larynx: while managers showed a risk below the national average for these cancers, an excess risk was observed among clerical, skilled workers, unskilled workers, and economically inactive men. Additionally, an elevated risk of lip cancer was found among unskilled workers, farmers, and economically inactive men.

To the best of our knowledge, with 83 000 HNC cases, this study represents the most extensive study ever assembled to examine the association between SES and HNC. The research benefited from access to high-quality cancer register data spanning all the Nordic countries[10] and the substantial cohort size enables us to detect even small increases in the incidence of most HNCs, and reduces the influence of random variation, even when dealing with relatively uncommon types of cancer, such as salivary gland cancer. Furthermore, the data on cancer incidence allow for the

identification of non-fatal cancer cases, a feat not attainable through studies focusing solely on cancer mortality, and incurs no bias caused by occupational variation in cancer survival or in mortality from competing causes of death[11].

Our findings are consistent with patterns identified previously whereby lower SES strata – among else fewer years of education and/or low income – are affected by a higher incidence of HNC[7,12]. The association may manifest through pathways related to behavioural lifestyle factors. SES correlates with various social and environmental factors that contribute to the accumulation of chronic stress, which, in turn, can potentially lead to the adoption of lifestyle-related risk factors[13]. The differences in HNC incidence across SES groups may thus largely reflect a socio-economic gradient in smoking or alcohol consumption, well-established risk factors for HNC[14]. Corroborative of this theory is the evidence suggesting that individuals at lower levels of SES are more likely than those with higher SES levels to be current smokers[15,16]. Regarding alcohol consumption, the association is conflictive, as some observations suggest wider alcohol use among the higher SES strata [17]. Still and all, analyses report that even when controlling for smoking and alcohol consumption, the incidence of HNC remains higher in patients with lower SES. For instance, a meta-analysis assessing the risk of oral cancer concluded that in both high- and lower-income countries low SES was associated with an increased risk of oral cancer even after adjusting for smoking and alcohol behaviours[12].

The very high risk of lip cancer among male farmers, gardeners, fishermen and forestry workers – more than 3-fold as compared to managers – has in earlier studies been attributed to the combined effect of UV radiation and smoking[18,19]. In this category, the risk is dominated by farmers but is highest among fishermen[20]. The absence of a marked excess risk of lip cancer in women in this

category could potentially be attributed to their lesser involvement in outdoor work and lower rates of smoking.

Welfare states such as the Nordic countries may provide a buffer against negative health impacts of lower SES through more accessible healthcare services and public health initiatives targeted to reduction of risk behaviours such as smoking and alcohol consumption. Comparing our findings with other high-income countries lacking robust welfare infrastructures is challenging. However, the meta-analysis by Conway et al.[7] reported that even after adjusting for smoking and alcohol use, lower education was still linked to higher HNC risk in North and South/Central America, but not in Europe.

Smoking prevalence has declined across the Nordic countries in the last decades[21], but the decrease has been most pronounced among the highly educated, in both men and women[22–24]. This is reflected in our study by the decrease in the SIR of laryngeal cancer in the higher SES group. However, no similar trends over time were observed for other HNCs, possibly because the impact of smoking and alcohol varies across different HNC subsites. In the Nordic countries, tobacco has carried a more pronounced fraction of the attributable risk for laryngeal cancer compared to other HNCs[25]. Lastly, socioeconomic disparities in smoking habits continue to exist in the Nordic countries, as evidenced by a clear gradient with individuals with lower educational attainment displaying higher smoking rates[26]. Consequently, the increased risk of HNCs noted among lower SES groups is likely to persist.

Women showed less SES variation in risk of HNCs than men. Only for laryngeal cancer, female skilled workers and unskilled workers had an increased risk, whereas managers had a lower risk,

mirroring the results in men. The absence of a comparable pattern in other HNC sites may be attributed to differing alcohol consumption habits between men and women, which are more strongly associated with other HNC subsites[27]. Historically, alcohol consumption between men and women across socioeconomic classes have shown notable differences. While men from lower SES have been more likely to exhibit harmful drinking patterns than men of higher SES, the differences among women have been much less pronounced, which may explain why SIRs in the low-SES categories for most HNCs were not elevated in women[28]. However, in the last three decades, there has been a gender convergence in drinking behaviours, which may result over time in an increased risk of HNCs among women in the lower SES groups, as in men[29,30].

Education and household income may play a direct role in determining the adequacy of one's diet[31], leading individuals with lower SES to adopt diets lacking in fruits and vegetables while being rich in processed and unhealthy foods[32,33]. This nutritional deficiency could also contribute to the development of HNC. A meta-analysis suggested that a diet emphasizing the consumption of fruits and vegetables is associated with a protective effect against oral cancer, with odds ratios of 0.51 (95% CI 0.40-0.65) and 0.50 (0.38-0.65) for each daily portion of fruit or vegetable, respectively[34]. In contrast, high intake of processed meat was associated with an increased risk of oral and oropharyngeal cancer, with a relative risk of 1.91 (95% CI 1.19-3.06)[35]. Furthermore, there is compelling evidence linking poor oral health to the development of oral cancer[36], and it is undeniable that a suboptimal diet contributes to poor oral health[37]. Notably, a social gradient exists in dental health, with individuals of lower SES experiencing worse dental health[38].

Certain occupational environments may involve higher rates of exposure to carcinogens, with individuals of lower SES more inclined to work in such settings[39]. For example, the increased risk

of nasopharyngeal and sinonasal cancers among skilled works could be predominantly due to inhalational hazards, such as exhausts or wood dust[40,41]. However, work-related social factors may also constitute more important determinants of some cancer risks than real occupational exposures[42]. Occupations can equally create protective environments against cancer, as it is not appropriate for individuals in certain roles, such as primary school teachers, or dentists, to smoke at work, which is reflected in a low prevalence of smoking[43].

Infection with the HPV is a recognized risk factor for oropharyngeal cancer (OPC)[6]. HPV prevalence in OPC has shown a noteworthy increase globally over time. For example, in Europe, the proportion of HPV-positive OPC cases has risen from 39.7% (95% CI 32.8-47.0) before 2000 to 59.0% (95% CI 30.2-82.7) between 2000 and 2004[44]. While HPV-negative OPC appears to be more prevalent in lower socioeconomic groups, HPV-positive OPC has been associated with higher socioeconomic status[45]. However, it is important to consider that the average latency period from HPV infection to the development of HPV-positive OPC is estimated to be 10 to 30 years. Consequently, it implies that not all HPV-induced OPC cases may have become apparent in the subjects included in the last census, and the possible changes in SES patterns of HPV infections in the 1990s and later would not yet be reflected in the cancer risks reported in this study.

While this study provides findings that can be readily interpreted for future research, it is important to highlight some inherent limitations. To begin, we relied on an occupation-based indicator of SES, which may fail to capture a person's wealth. Indeed, some individuals in high SES occupations may have lower incomes due to various factors like part-time employment or fluctuations in the job market and occupations can span a wide range of income levels. Fortunately, occupational stability is deemed high in the early decades of follow-up, with greater stability

among men than women, and the highest stability observed in occupational categories requiring lengthy education, such as physicians or nurses[46]. To minimize the potential for occupational misclassification at the start of individuals' careers, follow-up was initiated from the occupation held at age 30 or older. When compared to the results of specialized occupational cancer studies, it becomes evident that the risk-diluting impact of misclassification is minimal[47].

Most of the data collected for this study date back several decades. Changes in the economy and the job market, such as the emergence of technology-related occupations or artificial intelligence, can alter occupation-based socioeconomic classes over time[48]. Nevertheless, there are several compelling reasons to consider our findings relevant to contemporary times. The possible mechanisms linking lower SES to higher cancer risk in the Nordic countries – such as higher prevalence of risk-increasing behaviours and greater exposure to occupational hazards – most probably remain prevalent today. This is evidenced by the persistent socioeconomic gradient in smoking behaviours, despite the declining smoking prevalence in the Nordic countries[26]. Moreover, the Gini index, which measures income distribution disparities within an economy, has remained stable over time, suggesting that economic inequalities are still enduring nowadays[26]. Consequently, the associations we observed between SES groups and HNC are likely to also remain relevant in the future.

In conclusion, we have shown the often-overlooked socioeconomic perspective to play an important role in the development of HNC. The current study can offer valuable insights to policies designed to alleviate the burden of HNC within socioeconomically disadvantaged populations, such as tobacco and alcohol policies, oral health programs, and facilitated access to healthcare services.

Declarations

Ethics approval: The current study was based on data from existing registries and did not include any human intervention. The NOCCA study had ethics approvals and permissions as required in each of the participating countries at the time of data collection. The data were anonymized before using them in the analyses. Study participants were not contacted during the execution of the study. All methods were carried out in accordance with relevant guidelines and regulations.

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

Supplementary data: Supplementary data are available at IJE online.

Author contributions: The study was designed by Rayan Nikkilä, Timo Carpén, Antti Mäkitie, and Eero Pukkala. Elsebeth Lynge, Jenny Selander, Ingrid Sivesind Mehlum, Jóhanna Eyrún Torfadóttir, and Eero Pukkala are responsible for the accuracy of the NOCCA data from Denmark, Sweden, Norway, Iceland, and Finland, respectively. Jan Ivar Martinsen performed all statistical analyses. The first draft of the manuscript was devised by Rayan Nikkilä. All authors contributed to the revision of the manuscript and had final approval of the submitted and published versions.

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Figure captions

Figure 1. Standardized incidence ratios (SIRs) of head and neck cancer cases among men in the Nordic countries during 1961–2005, by cancer site and socioeconomic status.

Figure 2. Standardized incidence ratios (SIRs) of head and neck cancer cases among women in the Nordic countries during 1961–2005, by cancer site and socioeconomic status.