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Sociodemographic factors and incidence of melanoma in the Netherlands, 1994–2005

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ABSTRACT

Background: Time–space incidence maps of the Netherlands indicated differences in incidence of cutaneous melanoma (melanoma) over the country, which might be related to sociodemographic characteristics of living environment and socioeconomic status (SES) of the patients. The goal of this study was to refine the current approaches to prevention and early detection of melanoma by revealing relationships between sociodemographic factors and incidence of melanoma in the Netherlands.

Methods: Age-adjusted incidence rates were calculated from the Netherlands Cancer Registry. Data on sociodemographic factors were obtained from Statistics Netherlands. Logistic regression analysis was performed to investigate determinants of variation in incidence at the ecological level. At the individual level tumour characteristics were linked to SES based on postal code at the time of diagnosis.

Results: The lowest SES-group had a significantly lower incidence than the highest SES-group; 10.2 (95% confidence intervals (CI): 9.1–11.3) and 14.3 (95% CI: 12.9–15.8), respectively. Increased risk of melanoma was seen in municipalities with high population density, few people living on social security and many people with high income. Patients living in low SES neighbourhoods were diagnosed more often with higher stage disease (13% (95% CI: 12.3–13.8) diagnosed with pT4) than those living in high SES neighbourhoods (9% (95% CI: 8.5–9.8) diagnosed with pT4) ($p < 0.001$) and with higher Breslow thickness ($p < 0.001$).

Conclusions: Awareness of the risks of UV radiation (UVR) is important and in the higher SES-groups primary prevention should remain the focus. However, if the incidence rates for the higher SES-groups are illustrative for the lower SES-groups, then the focus should be on both primary and secondary prevention in the low SES-groups.

1. Introduction

Like in most countries of the Western world, the incidence of melanoma in the Netherlands is rising, being 11.3 in 100,000 in 1989 and 20.0 per 100,000 in 2007 (EAPC 4.0, $p < 0.001$).[1,2] This increase is partly attributable not only to better and earlier detection of melanoma but also to a change in sun-exposure behaviour, as more and more

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people expose themselves to natural and/or artificial ultraviolet radiation.[3,4]

The main risk factor for melanoma is intermittent exposure to ultraviolet radiation (UVR), especially at young age and interacting with fair skin type.[5] In 1989 a 'Freckle bus' campaign along the Midwestern seacoast of the Netherlands increased awareness of both the public and the general practitioners across the country.[6] However, several studies nowadays have shown an inverse relation between sunlight and incidence of several cancers, with sunlight exposure being protective for the development of several cancers.[7]

The incidence of melanoma has been positively associated with measures of socioeconomic status (SES),[8,9] possibly reflecting a lifestyle in which individuals receive more UVR through outdoor leisure activities that may involve travel to sunny destinations.[10] Time–space incidence maps of the Netherlands indicated the lowest incidence rates in the southeastern region and in the larger cities and the highest in the north-western (coastal) areas.[11,12] This geographical distribution was possibly related to the SES of the patients, e.g. in relation to ethnic background.

This study aims to improve the prevention and early detection of melanoma by identifying higher risk groups at ecological level. Sociodemographic factors might affect the incidence of melanoma in the Netherlands, pointing out risk groups on which prevention should be focussed. On the individual level the relationship between SES of the neighbourhood of residence and patient and tumour characteristics such as age at the time of diagnosis, stage and Breslow thickness contributes to this focus.

2. Patients and methods

2.1. Cancer registration

All cases of invasive cutaneous melanoma diagnosed between 1st January 1994 and 31st December 2005 were selected from the nationwide population-based Netherlands Cancer Registry (NCR) (n = 29,784). The NCR obtains notifications from the national Pathology Automated Archive (PALGA) and the Haematology Department in the region. Other sources are the Radiotherapy Department of the hospitals, as well as the National Registry of Hospital Discharge Diagnoses. Death certificates are not available in an identifiable form to the cancer registry due to privacy regulations. All data are obtained from patient files in the hospital and include identifying information (e.g. first letters of the name, date of birth, sex, postal code) and tumour characteristics (e.g. date of diagnosis, topography, morphology, stage, Breslow thickness). Topography and morphology are coded according to the International Classification of Diseases for Oncology (ICD-O).[13] The TNM classification is used for the staging of the tumours.[14]

2.2. Socioeconomic status (SES)

Postal code at the time of diagnosis was used to determine SES. SES scores are available for each of the 411,303 six-digit and 3876 four-digit postal code areas in the Netherlands. SES scores for (the total) six-digit postal code areas are more precise because these areas are smaller (streets). SES scores for the six-digit and four-digit postal code areas were available for the year 2001. The mean number of inhabitants was 39 per six-digit postal code area and 4907 per four-digit postal code area in 2001. SES scores are provided by the 'Sociaal Cultureel Planbureau' (a governmental organisation) and based on the following items which were collected per six-digit postal code: (1) the mean annual income per household, (2) the percentage of households with a low income and (3) the percentage of households with a low education.[15] The six-digit postal code was only registered for 11,055 melanoma cases out of 29,784 (37%). Analyses were therefore performed with both six-digit and four-digit postal codes to reflect the effects of using larger areas.

The SES scores at the six-digit postal code level were used as follows: in three collective SES-codes which were based on deciles: 1 = 1st–3rd decile, 2 = 4th–7th decile and 3 = 8th–10th decile.

The variables at the four-digit level are computed by means of an aggregation of the raw SES scores of the six-digit level. After aggregation, the variables were merged into one score by means of factor analysis (principal components analysis).[15] A rank number (1–9) given to each postal code region was used as the SES. SES was divided into three groups based on the delivered rank numbers: 1 = rank number 1–5 'low SES' (SES score lower than mean SES score in the Netherlands; 26% of patients), 2 = rank number 6 'medium SES' (mean SES score of the Netherlands; 45% of patients) and 3 = 7–9 'high SES' (SES score higher than mean SES score in the Netherlands; 29% of patients).

2.3. Ecological analysis of sociodemographic factors and cancer incidence

2.3.1. SES level

World Standardised Incidence Rates (WSR) for melanoma were calculated for three SES-groups (low, medium, high) which were based on four-digit postal codes for the period 1998–2005. Number of inhabitants was available per four-digit postal code, for the period 1998–2005 at Statistics Netherlands, and therefore the number of inhabitants per SES-group could be calculated per four-digit scale.

2.3.2. Municipality level

WSR for melanoma were calculated for each of the 443 municipalities in the Netherlands. Multivariate logistic regression analysis was performed to investigate which factors were associated with high incidence rates in municipalities, using Statistical Package for Social Sciences (SPSS) version 12.0. In multivariate analyses, first all variables were entered into the model. Selection of the variables for the model was done by means of stepwise regression with backward elimination of non-significant candidate variables. The average incidence rates per municipality over the whole period were determined and divided into quartiles. To avoid looking at the closely related observations which are situated around the mean, municipalities with the lowest incidence (first quartile, n = 112) were compared to municipalities with the highest incidence (fourth quartile, n = 110), using the lowest incidence as reference category. Data on population density, use of social security and income at the municipality level in the period

1994–2005 were derived from Statistics Netherlands. The average data over the period 1994–2005 were divided into quintiles and entered into the model as dummy variables, using the lowest category as reference.[16] Odds ratios (OR) and 95% confidence intervals (95% CI) were calculated.

2.4. Analysis of the influence of ecological SES on individual tumour characteristics

Associations between SES of neighbourhood, age at diagnosis and Breslow thickness were assessed by performing a *t*-test, because age at diagnosis and Breslow thickness were used as continuous variables. Associations between SES of neighbourhood and stage of disease (pT) were analysed by Chi-square analysis. Stage of disease is described as the pT, which explains the extent of the primary tumour after surgery has been performed. Patients with unknown pT ($n = 1200$, 4%) or unknown Breslow thickness ($n = 4098$, 14%) were excluded from the analyses. In the analysis, the lowest SES scores were compared to the highest SES score, using the lowest SES score as reference category. First, analyses were done on the four-digit postal code level. Second, analyses were done on the six-digit level to reflect the effects of using larger or smaller areas.

3. Results

In the period 1994–2005, 29,784 people were diagnosed with melanoma in the Netherlands. Most patients were women (58%). The mean age at diagnosis was 54 years (range 0–105 years). Patients (32%) were diagnosed with pT1 and 46% had a Breslow thickness between 0.01 and 1.00 mm.

3.1. Ecological analysis of sociodemographic factors and cancer incidence

3.1.1. SES level

Of all cases, 26% (95% CI: 25.3–26.3) had low SES and 29% (95% CI: 28.2–29.3) had high SES. Calculation of incidence rates within different SES-groups revealed that incidence of melanoma increased with increasing SES score, i.e. melanoma risk was higher among high SES-groups. In the lowest SES-group the average WSR over the whole period was 10.2 (95% CI: 9.1–11.3), in the medium SES-group 11.9 (95% CI: 10.7–13.2) and the group with the highest SES showed an average WSR of 14.3 (95% CI: 12.9–15.8).

3.1.2. Municipality level

Univariate and multivariate logistic regression analyses at the ecological level revealed that people living in municipalities with a high population density, a low proportion of the population living on social security and a high proportion having a high income exhibited an increased risk of melanoma (Table 1).

Table 1 – Sociodemographic determinants of low ($n = 112$) versus high incidence ($n = 110$) municipalities of melanoma in the Netherlands in the period 1994–2005.

Covariate	Univariate		Multivariate[a]	
	OR	95% CI	OR	95% CI
Population density (persons per km^2)				
<179	1	Reference	1	Reference
179–292	0.5	0.2–1.2	0.3	0.1–0.9
293–526	3.3*	1.4–7.5	3.0*	1.1–8.6
527–1214	4.2*	1.8–10.1	4.1*	1.3–13.0
>1214	2.0	0.8–4.7	3.1	0.9–11.1
Persons living on social security (%)				
<15	1	Reference	1	Reference
15–20	0.8	0.4–1.9	1.0	0.3–2.2
21–28	0.7	0.3–1.6	0.5	0.3–2.2
29–42	0.6	0.3–1.4	0.4	0.2–1.5
>42	0.2*	0.1–0.5	0.1*	0.1–0.7
Mean annual income (euros)				
<10,166	1	Reference	1	Reference
10,166–10,675	0.7	0.2–1.8	0.3	0.1–1.0
10,675–11,050	2.7*	1.1–6.9	1.8	0.6–5.3
11,051–11,675	3.1*	1.3–7.4	1.4	0.5–4.2
>11,675	16.8*	6.3–44.9	5.5*	1.7–17.7

[a] Adjusted for all other factors in the table.

* $p < 0.05$.

3.2. Analysis of the influence of ecological SES on individual tumour characteristics

Table 2 shows the distribution of gender, age, stage and Breslow thickness among the patients across SES strata. Analysis of SES at the level of the four-digit postal code revealed that patients living in neighbourhoods with lower SES levels were diagnosed on average at older age than those living in higher SES neighbourhoods ($p < 0.001$). Patients living in neighbourhoods with the lowest SES scores were diagnosed more often in higher stage: 13% (95% CI: 12.3–13.8) of patients with low SES were diagnosed with pT4 compared to 9% (95% CI: 8.5–9.8) of patients with high SES ($p < 0.001$). Similarly, patients living in neighbourhoods with the lowest SES scores had thicker melanomas compared to patients living in neighbourhoods with the highest SES scores ($p < 0.001$).

Similar trends were found for SES at the level of the six-digit postal code: 14% (95% CI: 12.3–15.4) of patients from neighbourhoods with the lowest SES scores had stage pT4 disease compared to 8% (95% CI: 6.9–8.5) of patients from neighbourhoods with high SES ($p < 0.001$). Patients from neighbourhoods with low SES scores had thicker melanomas ($p < 0.001$) and were older at the time of diagnosis ($p < 0.001$).

4. Discussion

In this study, incidence of melanoma was higher in municipalities with low percentage of people living on social security and high percentage of people with high income and also in densely populated municipalities. Furthermore, low neighbourhood SES was related to older age at diagnosis, more advanced stage at diagnosis and thicker melanomas.

Previous studies also reported an association between SES and melanoma[17,18] and recently, a study from the Netherlands revealed that the incidence of basal cell carcinoma is also higher in individuals with high socioeconomic status.[19] A potential explanation for this relationship might be a

Table 2 – Distribution of individual characteristics of patients with melanoma in the Netherlands across different SES strata (%).

	SES; four-digit postal code level			SES; six-digit postal code level		
	Low	Middle	High	Low	Middle	High
Gender						
Male	40	42	43	40	42	44
Female	60	58	57	60	58	56
Age						
0–14	0.3	0.3	0.3	0.2	0.2	0.2
15–29	8	7	7	10	8	5
30–44	22	24	27	18	28	26
45–59	28	33	32	22	32	38
60–74	25	24	22	28	23	24
75+	17	12	11	22	9	7
Stage						
1	31	33	35	37	41	44
2	27	28	29	25	26	26
3	29	28	26	25	23	23
4	13	10	9	14	9	8
Breslow						
0–1	51	53	56	51	55	57
1–2	23	24	24	22	23	23
2–3	16	16	14	16	14	14
>3	10	8	7	11	7	6

difference in sun-exposure behaviour. More and more people expose themselves to natural and/or artificial UVR. However, individuals living in poverty are less likely to be exposed to UVR compared to the people with higher SES, except for outdoor workers, such as bricklayers and farmers. However, such professions infer a chronic sun exposure, which is associated with a decreased melanoma risk.[20] UVR exposure in childhood is important in the development of melanoma. People with higher SES and their children are more often involved in outdoor recreational activities, have a stronger desire to tan and spend more holidays in (sub)tropical climates or at high altitudes.[21,22] Our findings fit within a hypothesis that early onset melanomas may represent gene–sun exposure interactions that occur early in life and result in thinner melanomas (high SES), in contrast to late onset melanomas which may reflect accumulated sun exposure resulting in thicker melanomas (low SES).[23,24]

Because SES is a concept which is composed of many factors, we also linked incidence rates to sociodemographic indicators such as average income and proportion of people living on social security in a neighbourhood. We observed higher incidence rates in municipalities with high population density, fewer people living on social security and more people with high income. The fact that incidence of skin melanoma was rather low in areas with low population density, thus with the highest proportion of farmers, is in line with the research finding that outdoor workers have a low risk of skin melanoma.[25]

In the analysis of individual tumour characteristics and SES we found lower stage of disease at the time of diagnosis in the patients in the higher SES-groups. This is an interesting relationship because in contrast to their higher risk of melanoma, people in higher SES communities have lower stage disease. This might indicate differences in the awareness of melanomas or in health care consumption between people in low and high SES neighbourhoods. Other studies already reported that people with low SES might have poorer health consciousness which may contribute to later stage at diagnosis,[26–28] which is in line with our findings.

Although this investigation cannot link behavioural aspects of the individual directly to the outcome (melanoma), it reveals factors that contribute to melanoma incidence. It is likely that both the ecological and individual relationships are important. In general, analyses at the ecological and individual levels do not necessarily yield similar results, e.g. the risk of melanoma may be lowest in *areas* with the lowest average income or SES, but at the same time also among *individuals* with the highest SES. In the Netherlands the proportions of the lowest social strata tend to be largest in areas where the average SES is lowest – well-to-do people generally prefer living outside of the cities – and therefore the conclusions of the present paper based on ecological analyses would also have been obtained if an analysis at the level of individuals had been possible. One disadvantage of ecological analyses is that the joint distribution of exposure and health remains unknown (ecological fallacy), which leads to possible distortion of association between exposure and outcome.[29] Furthermore, migration might have produced misclassification bias, but the magnitude of this bias cannot be readily assessed. Also, SES scores were not available for every year but it might be expected that SES scores did not change much over the time period of this study.

By dividing the data into quantiles we discarded some information. On the other hand, it allows for simpler presentation. In regression analyses continuous explanatory variables are categorised into two or more groups. Although this

slightly complicates the analysis, it avoids a direct assumption that there is a linear relation between the variable and the outcome of interest. In addition to the logistic regression we analysed the data by using the incidence groups as a continuous variable. This analysis pointed out that the same variables (living on social security, income and population density) showed trends in relation to incidence (data not shown, $p < 0.001$).

Awareness of the risks of UV radiation is still a big issue and primary prevention should remain the focus in the higher SES-groups. Despite their lower risk of melanoma, focus for residents of neighbourhoods with low SES should be on melanoma education and early detections programmes because of their potentially greater risk of thicker melanomas. If the results of the higher SES-groups are illustrative for future incidence in lower SES-groups, then the focus should be on both primary and secondary prevention in the lower SES-groups.

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Conflict of interest statement

None declared.

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