Differences in Cancer Incidence and Mortality Among Socio-Economic Groups

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Objectives: In this article studies on the association between socioeconomic status (SES) and risk for cancer at different sites are reviewed. Methods: The review is restricted to studies conducted in affluent societies, after 1970. Only studies using income, education and/or occupation as SES indicators are included. Results: A more or less consistent positive association between SES and cancer risk was found for colon and breast cancer. More or less consistent inverse associations were found for lung, stomach, esophageal and esophagogastric cancer. Consistent associations were reported for cancer of the rectum and pancreas. Possible explanations for SES differences in cancer risk are discussed with special emphasis on lifestyle variables related to cancer risk. Conclusions: It is concluded that it is still unclear whether the reported associations can be (partially) attributed to lifestyle related risk factors for cancer such as smoking, nutritional habits, drinking habits and reproductive factors.

Key words: socio-economic status, education, occupation, income, cancer incidence, cancer mortality, review.

INTRODUCTION

Health differences between socioeconomic groups in industrialized countries have been reported frequently in the last decades (1, 2). Because of an increase in the general standard of living, it was expected that such health differences would have been diminished. Nevertheless, there are indications that the health gap between socioeconomic groups has not disappeared in affluent countries (3, 4). These health differences can become apparent through differences in life expectancy, perceived health status, anthropometric characteristics (birth weight, adult body height) and in differences in incidence and mortality of various chronic diseases, for example coronary heart disease and cancer (2, 5).

In this article studies conducted since 1970 on differences in cancer incidence and mortality between various socioeconomic groups are reviewed in which education, occupation and income are used as socioeconomic status (SES) indicators. The diversity of methods used in these studies makes a formal statistical overview impossible. Therefore, the results of the reviewed studies are compared in a qualitative manner. The year 1970 was chosen because literature on research on SES differences in cancer risk conducted before approximately 1970 has been reviewed before (6). This review is restricted to the three SES indicators mentioned because they are recommended as the most valid and reliable by various authorities and are the most widely used in epidemiologic research (7).

Although SES is associated with risk for various cancer sites, it is not supposed to be a direct risk factor. SES is commonly regarded as a proxy for differences in lifestyle variables that have been identified as possible risk factors for cancer, e.g. smoking, nutritional habits, reproductive factors, occupational exposure to carcinogens etc. (8). Therefore, the possibility of explaining differences in cancer incidence and mortality between SES groups through differences in lifestyle is discussed.

SOCIOECONOMIC STATUS

Socioeconomic status is usually operationalized through occupation, education and/or income (7). There are different scales to measure these three indicators of SES. The most complex indicator to measure is occupation. The earliest classification system widely used in epidemiologic research, which is based on occupation as SES indicator, is the British Regis-
Table 1. Relation between SES indicators and stomach cancer

<table>
<thead>
<tr>
<th>Country</th>
<th>Period</th>
<th>Design</th>
<th>Cases</th>
<th>ContROLS/cohortsIze</th>
<th>SES</th>
<th>Association</th>
<th>Adjustment</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incidence</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Direction</td>
<td>Strength (high/low)</td>
<td></td>
</tr>
<tr>
<td>USA (17)</td>
<td>1978-82</td>
<td>correlation</td>
<td>np</td>
<td>np</td>
<td>education income</td>
<td>na</td>
<td>na</td>
<td>men and women in one analysis</td>
</tr>
<tr>
<td>USA (16)</td>
<td>1969-71</td>
<td>cross-sectional</td>
<td>202</td>
<td>4734</td>
<td>education income</td>
<td>(-)</td>
<td>OR = 0.48 males, OR = 0.31 females</td>
<td>stomach cancer versus all other cancer sites (excluding lung, larynx, oral, esophagus and bladder)</td>
</tr>
<tr>
<td>Italy (18)</td>
<td>1983-85</td>
<td>case-control</td>
<td>397</td>
<td>1944</td>
<td>education occupation</td>
<td>(-)</td>
<td>OR = 0.34, OR = 0.24</td>
<td>age, sex, marital status, smoking, coffee, alcohol consumption head of household's occupation</td>
</tr>
<tr>
<td>New Zealand (19)</td>
<td>1980-84</td>
<td>case-control</td>
<td>1016</td>
<td>19642</td>
<td>occupation</td>
<td>(-)</td>
<td>OR = 0.82</td>
<td>only men ≥20 years with registered occupation in study population</td>
</tr>
<tr>
<td>Spain (20)</td>
<td>1987-89</td>
<td>case-control</td>
<td>354</td>
<td>354</td>
<td>education occupation</td>
<td>(-)</td>
<td>OR = 0.59</td>
<td>men and women in one analysis</td>
</tr>
<tr>
<td>Sweden (21)</td>
<td>1961-79</td>
<td>cohort</td>
<td>12011</td>
<td>2809975</td>
<td>occupation</td>
<td>(-)</td>
<td>SMR = 0.92 males, SMR = 0.89 females</td>
<td>total population versus blue collar white collar versus total population</td>
</tr>
<tr>
<td>Finland (22)</td>
<td>1971-75</td>
<td>cohort</td>
<td>3338</td>
<td>np</td>
<td>education occupation</td>
<td>na</td>
<td></td>
<td>head of household's occupation</td>
</tr>
<tr>
<td>UK (23)</td>
<td>1971-75</td>
<td>cohort</td>
<td>513072</td>
<td>np</td>
<td>education occupation</td>
<td>na</td>
<td></td>
<td>only men in analysis</td>
</tr>
<tr>
<td>Mortality</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>only men in analysis</td>
</tr>
<tr>
<td>New Zealand (24)</td>
<td>1974-78</td>
<td>cross-sectional</td>
<td>np</td>
<td>np</td>
<td>occupation</td>
<td>(-)</td>
<td>RR = 0.24</td>
<td>study among high risk population of first and second generation US immigrants from Norway, Sweden and Germany</td>
</tr>
<tr>
<td>UK (25)</td>
<td>1979, 80, R2, R3</td>
<td>cross-sectional</td>
<td>np</td>
<td>np</td>
<td>occupation</td>
<td>(-)</td>
<td>SR = 0.55</td>
<td>only men in analysis</td>
</tr>
<tr>
<td>Switzerland (26)</td>
<td>1977-84</td>
<td>cross-sectional</td>
<td>195</td>
<td>np</td>
<td>occupation</td>
<td>(-)</td>
<td>OR = 0.86</td>
<td>study among high risk population of first and second generation US immigrants from Norway, Sweden and Germany</td>
</tr>
</tbody>
</table>

*not presented  
*no association  
+= inverse association; p < 0.05  
+= positive association; p < 0.05  
(-) = inverse association; p > 0.05  
(+)= positive association; p > 0.05  
?-? = no indication about significance
<table>
<thead>
<tr>
<th>Country</th>
<th>Period</th>
<th>Design</th>
<th>Cases</th>
<th>Control or cohort size</th>
<th>SES</th>
<th>Association</th>
<th>Adjustment</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Incidence</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>USA (17)</td>
<td>1978–82</td>
<td>correlation</td>
<td>np</td>
<td>np</td>
<td>education</td>
<td>na</td>
<td>population density</td>
<td>age, high SES versus total population</td>
</tr>
<tr>
<td>France (28)</td>
<td>1976–80</td>
<td>cross-sectional</td>
<td>np</td>
<td>np</td>
<td>education</td>
<td>(+)</td>
<td>SIR = 1.53</td>
<td>colon cancer versus all other cancer sites (excluding lung, larynx, oral, esophagus and bladder)</td>
</tr>
<tr>
<td>USA (16)</td>
<td>1969–71</td>
<td>cross-sectional</td>
<td>653</td>
<td>4323</td>
<td>income</td>
<td>(-)</td>
<td>OR = 1.12 males</td>
<td>age, race, smoking</td>
</tr>
<tr>
<td>Greece</td>
<td>1979–80</td>
<td>case-control</td>
<td>100</td>
<td>100</td>
<td>education</td>
<td>(+)</td>
<td>OR = 0.87 males</td>
<td>colon and rectum cases in one analysis</td>
</tr>
<tr>
<td>Italy (30)</td>
<td>1986</td>
<td>case-control</td>
<td>123</td>
<td>699</td>
<td>education</td>
<td>na</td>
<td>OR = 1.32</td>
<td>head of household's occupation</td>
</tr>
<tr>
<td>Italy (18)</td>
<td>1988</td>
<td>case-control</td>
<td>455</td>
<td>1944</td>
<td>education</td>
<td>(+)</td>
<td>OR = 1.40</td>
<td>head of household's occupation</td>
</tr>
<tr>
<td>Finland (22)</td>
<td>1971–75</td>
<td>cohort</td>
<td>1417</td>
<td>np</td>
<td>education</td>
<td>(+)</td>
<td>SRR = 0.87 males</td>
<td>head of household's occupation</td>
</tr>
<tr>
<td>UK (23)</td>
<td>1971–75</td>
<td>cohort</td>
<td>977</td>
<td>513072</td>
<td>education</td>
<td>(+)</td>
<td>SRR = 1.39 females</td>
<td>head of household's occupation</td>
</tr>
<tr>
<td>Sweden (21)</td>
<td>1961–79</td>
<td>cohort</td>
<td>12386</td>
<td>2809975</td>
<td>occupation</td>
<td>+</td>
<td>SRR = 2.16 males</td>
<td>head of household's occupation</td>
</tr>
<tr>
<td><strong>Mortality</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New Zealand (24)</td>
<td>1974–78</td>
<td>cross-sectional</td>
<td>np</td>
<td>np</td>
<td>occupation</td>
<td>+</td>
<td>RR = 1.09</td>
<td>age, only men in analysis</td>
</tr>
<tr>
<td>UK (25)</td>
<td>1979, 80, 82, 83</td>
<td>cross-sectional</td>
<td>np</td>
<td>np</td>
<td>occupation</td>
<td>na</td>
<td>SRR = 1.00</td>
<td>age, only men in analysis</td>
</tr>
<tr>
<td>Hong Kong (31)</td>
<td>1971</td>
<td>cross-sectional</td>
<td>157</td>
<td>np</td>
<td>income</td>
<td>+</td>
<td>RR = 1.92</td>
<td>age, only men in analysis</td>
</tr>
<tr>
<td>Switzerland (26)</td>
<td>1977–84</td>
<td>cross-sectional</td>
<td>442</td>
<td>np</td>
<td>occupation</td>
<td>+</td>
<td>OR = 1.30</td>
<td>age, sex, only men in analysis</td>
</tr>
<tr>
<td>UK (25)</td>
<td>1967–87</td>
<td>cohort</td>
<td>114</td>
<td>17530</td>
<td>occupation</td>
<td>(+)</td>
<td>SRR = 1.11</td>
<td>age, only men in analysis</td>
</tr>
</tbody>
</table>

Notes: see table 1
trar General’s scale, which includes five social classes, based on the occupation of the head of household (7). Nevertheless, each social class represents a very broad range of occupations (9) and the accuracy of classification is not always satisfactory (10).

Other problems when using occupational status as SES indicator have to do with differences in occupational classification between jobs usually carried out by women and jobs usually carried out by men (10, 11), how to classify persons without formal occupation, such as large groups of women with no formal employment, students and pensioners, and how to classify people who have changed jobs or have more than one job at the same time. Furthermore, occupation can be classified according to different categorizations: an exposure-based categorization, a prestige-based categorization or an economic-based categorization (12).

Highest level of education is a characteristic that is easily obtainable and recordable. It applies to every adult individual and in individuals it is stable over time (13). Measurement of educational level can be based on number of years at school, academic degrees or special certificates. Number of years at school is the most commonly used measure of education, but certification is found to be more influential in determining prestige (14). The fact that (level of) education is stable over time also has negative implications, since it can mask important changes in individual circumstances after education is finished (13). Inclusion of information on additional courses can probably correct this disadvantage. Another disadvantage of using education as a measure of SES is that people of higher age generally have a lower average level of education due to the gradually rising level of education in the last decades (cohort effect) (7, 15).

Measurement of the third indicator of SES, income, gives several problems. There is no uniform definition, it is unstable over time, age-dependent and questionnaire items on income are often not or incompletely answered (7, 12). Part of these objections also apply to occupation and education, but not as strong as for income. Another problem is that of comparability across households of different size. To overcome this problem, one can use the poverty index, which relates total family income to family size (7).

METHODS

In this article literature concerning studies on the association between SES and cancer risk conducted since 1970 is reviewed. In order to find relevant publications the MEDLINE computerized database from the Index Medicus was used. Initial keywords for the MEDLINE search were SOCIOECONOMIC AND CANCER. Also, strongly related or similar keywords like EDUCATION, OCCUPATION and INCOME, and TUMOR and NEOPLASMS were checked in various combinations. Furthermore, all references in the publications selected through MEDLINE were checked for relevant articles and reports not included in the MEDLINE selection. Finally, the Dutch literature database on socioeconomic health differences, located in Rotterdam, the Netherlands, was searched for literature on SES and cancer risk.

Publications had to meet the following criteria in order to be included in this review:

A) Studies must have been conducted after 1970;
B) The published studies must have been conducted in affluent societies;
C) The studies must have used education, occupation and/or income as indicators for SES. Furthermore, studies focusing primarily on occupation related exposure and not using occupation as SES indicator, were also excluded from this review.

SOCIOECONOMIC STATUS AND CANCER

Stomach cancer

The results of the thirteen reviewed studies (16–27) on stomach cancer risk and SES are summarized in Table I. An inverse association between SES and stomach cancer risk was found consistently. Relative risks (high versus low SES) between 0.24 and 1.09 were reported. Two of the eight reviewed studies on SES and stomach cancer incidence were adjusted for possible lifestyle related risk factors (18, 19). A case-control study conducted in Italy adjusted for smoking status, and for alcohol and coffee consumption (18), while a case-control study conducted in New Zealand adjusted only for smoking status (19). Both studies found inverse associations after adjustment comparable to the unadjusted results in the same studies. Five studies on SES and stomach cancer mortality were reviewed (24–27). Inverse associations with SES were found in all studies, one study reporting a significant association (24).

Colon cancer

The studies on SES and colon cancer risk are presented in Table II. A rather consistent positive association between SES and colon cancer risk was found (16–18, 21–23, 28–30) although more studies found a significant positive association with occupation (21–23, 28, 30) compared to education (22). Two studies used income as SES indicator; one reported a nonsignificant inverse association for both men and women (16) and in the second study no association was found (17). Relative risks between 0.87 and 2.16 were reported for high versus low SES. Two studies made adjustments for possibly lifestyle related risk factors, namely smoking, coffee and alcohol consumption (18) and smoking (16). Five studies on SES and colon cancer mortality were reviewed (24–26, 31). The results on the association between SES and colon cancer mortality are similar to the results for colon cancer incidence.
Other cancers of the digestive tract

A consistent inverse association was found between SES and oropharyngeal cancer. Five of the six case-control studies on the relation between SES and the incidence of oropharyngeal cancer showed a modest to strong inverse association (18, 32–35). The sixth study used a cross-sectional design (16) and took pharyngeal cancer separately into account. It showed inconsistent and nonsignificant results. Between the case-control studies there are great differences in strength of the association; odds ratios of high SES versus low SES vary from 0.16 to 0.61. In four studies (16, 18, 33–34) the researchers controlled for lifestyle variables like smoking and/or alcohol consumption. The results of these adjustments are not consistent. In one case-control study an unadjusted significant inverse relation between SES and oropharyngeal cancer changed after adjustment for smoking, alcohol consumption, age, race, marital status, geographic area, tooth loss and denture problems into a nonsignificant inverse association (33). In another case-control study a significant inverse association (OR = 0.16) did not really change after adjustment for smoking and alcohol consumption (OR = 0.19) (28), and in a cross-sectional study adjustment for smoking did not influence the results for pharyngeal cancer (16). Elwood et al. (34) reported only adjusted results for cancer of the mouth and pharynx separately. After adjustment for age, sex, alcohol and cigarette consumption, marital status, dental care and history of tuberculosis, they found a nonsignificant inverse association between occupational status and cancer of the mouth (OR = 0.66) and a significant inverse association between SES and cancer of the pharynx (OR = 0.46).

Although there was no clear relation between various SES indicators and the incidence or mortality of esophageal cancer in a cross-sectional study design (16, 24–25), one case-control study in Italy (18) and cohort studies in Finland (22) and Sweden (21) showed a significant, inverse association between SES (education and occupation) and incidence of esophageal cancer. It seems that there was no difference in the relation between esophageal cancer and the three SES-indicators. In all studies adjustment was made for age and sex. Ferrarotti et al. also adjusted for marital status, smoking, coffee and alcohol consumption. This adjustment did not make a real difference in the associations between esophageal cancer and education or social class, although there was a significant positive association between the risk of esophageal cancer and smoking habits and total alcohol consumption (18).

The association between SES and pancreatic cancer risk is not clear. Four studies on pancreatic cancer incidence were reviewed (18, 21, 22, 36). One study found a nonsignificant positive association with income (36), and one study found a nonsignificant inverse association with education (18). Of the five studies on SES and pancreatic cancer mortality, two found nonsignificant inverse associations (24, 25), two found a significant inverse association with education and one study did not find significant results and did not present information on the direction of the associations found (25, 26).

A rather consistent inverse association between SES and liver cancer risk was found. Of the four studies on liver cancer incidence (18, 21–23), two found a significant inverse association with education and/or occupation (18, 22), Nevertheless, a cohort study conducted in Sweden found a higher liver cancer incidence among white collar workers in comparison with the general population, among men (21). Three studies evaluating the association between SES and liver cancer mortality all found inverse associations, significant results were found in three studies (24–26).

The association between SES and rectal cancer risk is not clear. Nine studies on SES and rectal cancer incidence were reviewed (26–28, 31–33, 38–40). Four studies found an inverse association (26, 28, 33, 40), three of these reported statistically significant results (28, 33, 40). In all studies reporting inverse associations occupation was used as SES indicator. One of these studies also found a significant inverse association between rectal cancer incidence and education (28). The studies reporting significant associations were two case-control studies conducted in Italy (28, 40), and a cohort study conducted in the U.K. (33).

A cross-sectional study conducted in the US reported nonsignificant positive associations between SES and rectal cancer incidence, with occupation and income as SES indicators, for income only among women (26). Five studies did not report associations between SES and rectal cancer incidence (27, 31, 32, 38, 39). Except for a case-control study conducted in Italy, where adjustment was made for alcohol and coffee consumption (28), no studies were found where the association between SES and rectal cancer incidence was adjusted for possible lifestyle related risk factors. Five studies on SES and rectal cancer mortality were reviewed (34–36, 41) with comparable results as were found for rectal cancer incidence.

Lung cancer

The reviewed studies on SES and lung cancer risk showed a consistent inverse association between lung cancer incidence or mortality and SES. Seven studies on SES and lung cancer incidence were reviewed. All studies on SES and lung cancer found an inverse (age-adjusted) association for men (26, 27, 31, 33, 47, 49) independent of study design, both for educational level and occupation, with relative risks of the highest versus the lowest categories varying from 0.4 to 0.9. In five studies results were presented for women separately (26, 31, 33, 48, 49). A cross-sectional study (26) showed a significant inverse association between lung cancer incidence and education among women (OR = 0.6) and a case-control study also showed significant associations with an OR of 0.5 for highest versus lowest occupational class and an OR of 0.7 for highest versus lowest education (49).

Another case-control study with lifetime non-smokers or former smokers showed no association (48). The two cohort studies with information on SES and lung cancer risk for men (31, 33) showed relative risks of lung cancer close to 0.9, comparing the highest versus lowest SES. Only one study design incorporated smoking, the most important risk factor for lung cancer, as control variable (26), which did not make any real difference in the inverse association between SES and lung cancer incidence. All studies on SES and lung cancer mortality showed a significant inverse association (34–36).

Breast cancer

Table III summarizes the reviewed studies on breast cancer and SES. Although almost all of the twelve studies on SES
<table>
<thead>
<tr>
<th>Country</th>
<th>Period</th>
<th>Design</th>
<th>Cases</th>
<th>Controls/cohortsize</th>
<th>SES</th>
<th>Association</th>
<th>Adjustment</th>
<th>Comments</th>
</tr>
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<tbody>
<tr>
<td>USA (17)</td>
<td>1978–82</td>
<td>correlation</td>
<td>nq^1</td>
<td>nq</td>
<td>education income</td>
<td>+</td>
<td></td>
<td>population density for white women only</td>
</tr>
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<td>USA (16)</td>
<td>1969–71</td>
<td>cross-sectional</td>
<td>1167</td>
<td>2380</td>
<td>education income</td>
<td>+</td>
<td>OR = 1.4</td>
<td>age, race breast cancer versus non-smoking related cancer sites</td>
</tr>
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<td>USA (40)</td>
<td>1969–84</td>
<td>case-control</td>
<td>1467</td>
<td>10178</td>
<td>education occupation</td>
<td>?±2°</td>
<td>OR = 1.1</td>
<td>grammar school postgraduates versus career profession versus unskilled labor</td>
</tr>
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<td>Italy (41)</td>
<td>1980–83</td>
<td>case-control</td>
<td>368</td>
<td>373</td>
<td>occupation</td>
<td>+</td>
<td>OR = 2.0</td>
<td>education, marital status all other confounders occupation, marital status</td>
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<td>Italy (42)</td>
<td>1982–85</td>
<td>case-control</td>
<td>214</td>
<td>215</td>
<td>education</td>
<td>+</td>
<td>OR = 2.5</td>
<td>age</td>
</tr>
<tr>
<td>Denmark (43)</td>
<td>1983–84</td>
<td>case-control</td>
<td>1486</td>
<td>1336</td>
<td>social class education</td>
<td>(+)</td>
<td>OR = 1.4</td>
<td>age, parity, breast feeding, family history, age at menarche, age at first pregnancy</td>
</tr>
<tr>
<td>USA (44)</td>
<td>1979–81</td>
<td>case-control</td>
<td>401</td>
<td>519</td>
<td>education</td>
<td>nst</td>
<td>OR = 1.0</td>
<td>age only association between family history or breast feeding and breast cancer risk</td>
</tr>
<tr>
<td>The Netherlands (45)</td>
<td>1985–87</td>
<td>case-control</td>
<td>133</td>
<td>289</td>
<td>education</td>
<td>(+)</td>
<td>OR = 1.46</td>
<td>strength of association varied with difference in cutpoints highest employees versus total highest education versus total after ten years of follow-up</td>
</tr>
<tr>
<td>Finland (46)</td>
<td>1971–75</td>
<td>cohort</td>
<td>3419</td>
<td>4.6 million</td>
<td>occupation</td>
<td>+</td>
<td>SIR = 150</td>
<td>age</td>
</tr>
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<td>USA (47)</td>
<td>1971–84</td>
<td>cohort</td>
<td>122</td>
<td>7304</td>
<td>education poverty index</td>
<td>+</td>
<td>RR = 2.5</td>
<td>age</td>
</tr>
<tr>
<td>UK (23)</td>
<td>1971–75</td>
<td>cohort</td>
<td>381</td>
<td>692</td>
<td>occupation</td>
<td>(+)</td>
<td>SRR = 1.5</td>
<td>age, residence according to own occupation total pop., versus blue collar white collar versus total population</td>
</tr>
<tr>
<td>Sweden (21)</td>
<td>1961–79</td>
<td>cohort</td>
<td>6706</td>
<td>80600</td>
<td>occupation</td>
<td>+</td>
<td>SRR = 1.2</td>
<td>age, nationality, marital status</td>
</tr>
<tr>
<td>Switzerland (26)</td>
<td>1977–84</td>
<td>cross-sectional</td>
<td>275</td>
<td>ap</td>
<td>occupation</td>
<td>(+)</td>
<td>OR = 1.3</td>
<td>age, nationality, marital status</td>
</tr>
</tbody>
</table>

Notes: see table 1
and breast cancer incidence reported a positive association (16, 17, 21, 23, 40–47), there are differences in significance and magnitude: relative risks of the highest versus the lowest category varied from 1.0 to 2.5. These differences in results are probably due to differences in the use of control variables, because in almost all studies that included age as the only confounding variable, significant positive associations were found, with relative risks varying from 1.2 to 2.5. Only one study examined the relation between SES and breast cancer mortality. It showed a nonsignificant positive association (26).

**DISCUSSION AND CONCLUSIONS**

In this review consistent positive associations between the three SES indicators and breast cancer risk were reported, and more or less consistent positive associations with SES were reported for colon cancer. Consistent inverse associations between SES and cancer risk were found for lung, stomach and oropharyngeal cancer, while more or less consistent inverse associations were found for liver and esophageal cancer. Inconsistent associations with SES were found for rectum and pancreatic cancer. The associations seem to be largely independent of which SES indicator is used and the country where the study was conducted. Only for cancer of the colon most significant associations were found with occupation as SES indicator.

We restricted this review to studies conducted in industrialized countries. The differences in SES in developing countries are of a different magnitude. Furthermore, the problems of malnutrition, contaminated drinking water, poor living conditions, etc. related to extreme poverty in some of these countries and vast differences in lifestyle compared to affluent societies, makes the comparison of associations between SES and cancer risk in these countries to the associations found in industrialized countries difficult. This restriction to industrialized countries reduces the possibility of interaction according to study region. Another restriction was made for studies conducted before 1970. A review on SES and cancer risk by Logan summarizes the literature on studies conducted before approximately 1970, reporting comparable results (6).

In this review different search strategies were used to select relevant publications. The initial literature search was done through MEDLINE. Some information is available on the effectiveness of MEDLINE searches. In a review study on food supplements and their efficacy, conducted in 1991, MEDLINE search provided a little less than 50% of all relevant publications included in the review (48). Comparable results were published by Dickersin and by Hofmans (49, 50). In our study a smaller part of the publications reviewed were selected through MEDLINE, because of the small number of studies focussing primarily on differences in cancer risk according to SES. Studies included in this review, where the association between SES and cancer risk was a secondary subject of study, were mainly selected through checking of references of the articles found through the first search.

Publication bias is a possible problem in every review article. Studies with negative results might have less chance to be submitted or published. In this review, publications where the association between SES and cancer risk was a secondary object of investigation were also included. It seems reasonable to assume that publication bias in relation to the association between SES and cancer risk will be less important in these studies. The associations found in these studies are in accordance with those found in studies focussing primarily on SES and cancer risk. Therefore, we conclude that the general directions of the associations presented in this review are not likely to be severely influenced by publication bias.

Although occupational status, education and income show differences in strength with other health indicators (51, 52), the patterns of associations are broadly the same. Therefore, the choice of indicators can be determined by the availability of information.

In the second paragraph of this article different problems when using occupation, education and income as indicators of SES have been mentioned. Most of the studies reviewed did not pay attention to these issues.

The association between cancer risk and SES is not the same when the different individual cancer sites are compared. This finding does not support the hypothesis that lower SES groups have a generally higher susceptibility for cancer. Explanations for the relation between SES and cancer point at measurement artefacts, natural or social selection, a materialist explanation and lifestyle risk factor differences between SES groups (23, 33, 54).

The artefact explanation emphasizes the (in)correctness of measurement of social class. The occupation-based classification of SES can give misleading results. The proportion of semi- and unskilled work is diminishing, because part of it has been taken over by machines, and as a result people that enter the workforce move into skilled or white collar jobs. Therefore, a higher incidence or mortality of cancer in the lowest SES groups may be a result of the higher
average age (53). The same problems can arise when SES is conceptualized by education or income. Standardization or stratification for age can overcome this problem. Most of the studies in this review were adjusted for age, hence the associations between SES and the incidence or mortality of the different cancer sites cannot be considered as an artefact.

The natural or social selection theory assumes that those in better health are more likely to be upwardly mobile and those in worse health downwardly (12, 53). The influence of cancer incidence or mortality on social mobility will probably not play an important role, because most types of cancer are diagnosed at a later age (55). Therefore this explanation is probably more important in research on general health and SES.

The materialist explanation points at social class differences in health linked to aspects of living (the distribution of income and wealth, poverty, access to education, poor housing) and aspects of working (heavy work, noise, exposure to carcinogenic agents) (53). Various authors suggest that occupational exposure to carcinogenic agents might be an important risk factor for the cancer sites inversely associated with SES (56, 57). Positive associations between SES and cancer can not be explained by exposure to carcinogenic agents but differences in physical activity during work might lead to positive associations with some types of cancer.

Another possible explanation for the differences in cancer risk between SES groups might be differences in lifestyle variables that are related to cancer risk between these groups. Differences between SES groups in variables like smoking habits, diet, alcohol intake, and parity between SES groups have been reported frequently in affluent societies. However, only very few studies on differences in cancer risk between SES groups have attempted to study whether the differences found could be attributed to differences in lifestyle related risk factors. Furthermore, it has to be kept in mind that differences might exist in the relation between SES indicators and lifestyle aspects between age-groups and between countries (58, 59).

Differences in smoking prevalence are thought to be largely responsible for the difference in lung, mouth, pharynx and esophageal cancer risk between SES groups (24, 26). Smoking has been found to be more prevalent among lower SES groups in most affluent countries (16, 60, 61) and this difference might even be growing in some countries (60–62). Strange enough, there is only one study that included smoking habits in the analysis of the relation between SES and lung cancer (16) and surprisingly, this did not change the association between SES and lung cancer.

There is evidence that a higher alcohol consumption might be a risk factor for cancer sites of the upper digestive tract (34, 35, 63). Furthermore, it has been suggested that there is also a relation between alcohol consumption and rectum, liver and/or breast cancer (58, 64–68). The relation between SES and alcohol consumption is not clear (58). Studies in the Netherlands reported a higher percentage of total abstainers among the lowest SES-groups (59, 69). But data on the relation between SES and excessive alcohol consumption do not show unequivocal results (69–71). So, there is no clear evidence that differences in alcohol consumption between SES groups can be responsible for part of the associations found between SES and cancer risk. In some studies, differences in nutritional habits between the SES groups have been suggested to be a possible explanation for the differences in cancer risk (22, 29, 31). Surprisingly, no studies were found in which the associations between SES and cancer risk were adjusted for possible dietary risk factors, with an exception for alcohol and coffee consumption (18). In general, diets high in fat, and obesity, caused by a positive energy balance over an extended period of time, are considered to increase cancer risk at various sites (72, 73). In contrast, diets high in (fresh) fruit and vegetables and dietary fiber are considered protective for various cancer sites (72, 74). Especially the preventive effect of fruit and vegetables for cancers of the digestive tract, and cancers of the respiratory system is supported by strong and extensive epidemiological evidence (74). Dietary fiber may be protective, particularly for colorectal cancer (75). Food consumption research in different countries suggest that diets of higher SES groups are in better concurrence with dietary guidelines for cancer prevention. Subjects of upper SES categories generally eat more fruit and vegetables and dietary fiber, and less fat and energy (59, 69, 76, 77) and might have a lower intake of nitrates and nitrosamines (77).

The positive association between SES and colon cancer risk found in this review is not in agreement with the more protective diet generally found among higher SES groups. Because physical activity has consistently been shown to be inversely related to colon cancer risk (78, 79), the positive association may be attributable to higher levels of physical activity, which is more prevalent in lower occupations. For stomach cancer and cancer of the esophagus the inverse asso-
cation found between cancer risk and SES is in agreement with the more protective diet generally found among subjects of higher SES. The more protective diet found among higher SES groups is not in accordance with the higher breast cancer risk among women of higher SES. Nulliparity, late age at first birth, and late age at menopause are thought to be more important risk factors (80, 81) and these risk factors are more prevalent among women of higher SES (82).

It can be concluded that differences in lifestyle factors between SES groups could be partly responsible for the differences in cancer risk between these groups. It is therefore surprising that in most studies there was not much attention given to the adjustment for lifestyle variables, when the relation between SES and cancer was studied. Only very few studies were found on SES and cancer risk where adjustment for lifestyle variables was made and even fewer used techniques to compare the relation between SES and cancer incidence (or mortality) with and without adjustment for lifestyle variables. Furthermore, in most of the studies there is hardly any information on how lifestyle variables were measured. So no information was available on possible misclassifications of lifestyle variables. Misclassification of, for example, can potentially give invalid results. In conclusion, additional research is necessary to study whether differences in cancer risk between SES groups could be attributable to lifestyle differences.

In the Netherlands a prospective cohort study was started in 1986, on diet, other lifestyle variables, sociodemographic indicators and cancer risk. The cohort included 58,279 men and 62,573 women aged 55–69 years at the start of the study. The data were gathered by means of a self-administered questionnaire on lifestyle factors (smoking habits, alcohol consumption, dietary habits), sociodemographic indicators (age, marital status, place of residence, education, work history) and other possible risk factors for cancer (family history of cancer, precancerous lesions) (83). By means of record linkage to cancer registries and a pathology register, the incidence of cancer cases in the cohort are identified (84). This information will be used to study the association between SES and the incidence of lung, breast, colon and rectal cancer, with and without adjustment for possible relevant lifestyle variables, to gain more insight into the association between SES and cancer.

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