

Is the co-occurrence of smoking and poor consumption of fruits and vegetables confounded by socioeconomic conditions?

Christine Muff · N. Dragano · K.-H. Jöckel ·
S. Moebus · S. Möhlenkamp · R. Erbel ·
K. Mann · J. Siegrist

Received: 29 November 2009 / Revised: 19 April 2010 / Accepted: 23 April 2010 / Published online: 4 June 2010
© Swiss School of Public Health 2010

Abstract

Objectives As smoking and unhealthy diet are more prevalent in lower socioeconomic groups, this study aims at exploring whether associations between smoking and fruit and vegetable consumption are confounded by socioeconomic conditions or if smoking is independently associated with consumption.

Methods Cross-sectional analyses of 4,814 middle-aged participants from the Heinz Nixdorf recall study, a population-based cohort study in Germany. Fruit and vegetable consumption was assessed by a food frequency questionnaire. Education and income were used as indicators for socioeconomic groups. Logistic regression models were run to estimate odds ratios for consumption by smoking status.

Results Smoking is associated with poor consumption of fruits and raw vegetables/salad in both genders, and with poor consumption of boiled vegetables and fruit/vegetable juice in men. Importantly, poor consumption is

related to smoking independently of people's socioeconomic conditions.

Conclusion The findings imply that smokers in all socioeconomic groups are at higher risk for unhealthy intake of fruits and vegetables. Public health interventions targeted to smokers should include dietary instructions.

Keywords Smoking · Fruit and vegetable consumption · Socioeconomic groups · Diet · Co-occurrence of health behavior

Introduction

Tobacco smoking and unhealthy diet are key aspects of a lifestyle that contributes to the risk of premature mortality (Kant 2000; Huijbregts et al. 1997; Murray and Lopez 1996). It is commonly accepted that poor socioeconomic conditions impair health-promoting dietary habits (Hulshof et al. 2003; James et al. 1997; Johansson and Andersen 1998), by restricting financial resources to buy healthy foods (Darmon et al. 2000; Drewnowski and Specter 2004), by reducing accessibility to fresh foods (Moore and Diez Roux 2006), and by inadequate knowledge of dietary guidelines (Wardle et al. 2000). Similarly, high prevalence of cigarette smoking among people in low socioeconomic groups is well established (Cavelaars et al. 2000; Giskes et al. 2005). Lack of knowledge about health-adverse effects, poor coping behaviors and environmental or psychosocial stressors due to socioeconomic adversity were identified as main factors (Jarvis and Wardle 2006; Schrijvers et al. 1999; Stronks et al. 1997). Given the fact that tobacco consumption and malnutrition are more prevalent in lower socioeconomic groups, social inequalities in those health-damaging behaviors are considered a key

C. Muff (✉) · N. Dragano · J. Siegrist
Department of Medical Sociology, University of Duesseldorf,
PO Box 101007, 40001 Duesseldorf, Germany
e-mail: christine.muff@uni-duesseldorf.de

K.-H. Jöckel · S. Moebus
Institute for Medical Informatics, Biometry and Epidemiology,
University Duisburg-Essen, Essen, Germany

S. Möhlenkamp · R. Erbel
Clinic of Cardiology, West-German Heart Center Essen,
University Duisburg-Essen, Essen, Germany

K. Mann
Division of Laboratory Research, Department of Endocrinology,
University Clinic Essen, Essen, Germany

factor explaining the social gradient of morbidity and mortality in advanced societies (Davey Smith and Brunner 1997; Schrijvers et al. 1999; Stronks et al. 1997).

It is generally assumed that unhealthy behaviors do not manifest themselves in isolation, but are interrelated in distinct patterned health-related lifestyles. For instance, higher alcohol consumption (Ma et al. 2000) and lower physical activity were observed among smokers compared to non-smokers (Mensink et al. 1997). In a large cohort of Finnish men, the co-occurrence of low physical activity, excessive alcohol consumption and malnutrition was highest in smokers, while non-smokers were thought to generally live more health-conscious (Prättälä et al. 1994). Studies supporting this assumption demonstrated that smokers were at increased risk of failing to meet the dietary guidelines, in particular of exhibiting reduced intake of fruits (Larson et al. 2007; Magretts and Jackson 1993; Marangon et al. 1998) and vegetables (Larson et al. 2007; Whichelow et al. 1988). However, some studies found no associations with vegetable consumption (Whichelow et al. 1988) and associations between smoking status and the intake of fat (Larson et al. 2007; Whichelow et al. 1988), carbohydrates, and protein (Marangon et al. 1998; Nuttens et al. 1992) are inconsistent.

As the occurrence of smoking and unhealthy diet is more prevalent in lower socioeconomic groups (Cavelaars et al. 2000; Giskes et al. 2005; Hulshof et al. 2003; James et al. 1997; Johansson and Andersen 1998), it is important to establish whether this association is due to the confounding effect of socioeconomic conditions or whether it holds true independent of socioeconomic conditions. In the former case, public health policy implications should be directed primarily towards reducing the burden of socioeconomic inequalities. In the latter case, policy measures should target dietary habits of smoking people, with particular emphasis on people in lower socioeconomic groups.

This study sets out to assess the co-occurrence of smoking and poor fruit and vegetable consumption and to analyze their association with socioeconomic groups in a large population-based cohort study of middle-aged men and women living in an urban environment in Germany.

Methods

Sample

Data were collected during the baseline examination of the Heinz Nixdorf Recall (risk factors, evaluation of coronary calcium, and lifestyle) (HNR) Study, a population-based cohort study in Germany. The central aim of the HNR Study is to improve prediction of coronary heart disease by

combining established with new cardiovascular risk factors.

The study included men and women of the general population, aged 45–75 years, living in three adjacent cities of the densely populated Ruhr metropolitan area in Germany. Random samples of the general population of Essen, Bochum and Mülheim aged 45–75 were drawn from residents' registration offices. Briefly, 4,814 participants were recruited between 2000 and 2003. The baseline response was 56% (Stang et al. 2005). The rationale and design of the study have been described in detail elsewhere (Schmermund et al. 2002; Stang et al. 2005). The study was approved by the institutional local ethics committees and comprises extended quality management procedures, including a certification according to the DIN ISO 9001:2000. Informed consent was obtained from all participants.

Measures

Socioeconomic and behavioral data were assessed by trained personnel with standardized computer-assisted face-to-face interviews and paper-and-pencil questionnaires. Level of education and income were chosen as two alternative indicators of socioeconomic conditions. Education was classified according to the International Standard Classification of Education as total years of formal education, combining school and vocational training (UNESCO 1997). The continuous variable was grouped into four categories (highest ≥ 18 years, equivalent to a university degree; lowest ≤ 10 years, equivalent to a basic school education and no vocational training). Income was measured by equivalent household income, including information on disposable income, household size and number of adults and children according to OECD criteria. For the following analyses, income distribution was divided into gender specific quartiles.

To gather information concerning smoking status, respondents were asked questions about current and former smoking. 'Smokers' were defined as ever smokers who reported currently to smoke daily or regularly. 'Ex-smokers' are those who reported that they quit smoking, and 'never smokers' are defined as those who never smoked regularly. For all analyses, smoking status was categorized into 'current smokers' and 'non-smokers' (combining 'ex-smokers' and 'never smokers').

Given their frequent recommendation, fruits and vegetables are an important component of a healthy diet (Ding and Mozaffarian 2006; Donaldson 2004). Information on fruit and vegetable consumption and the intake of fruit or vegetable juice was obtained as part of a self-administered food frequency questionnaire (Schaeffler et al. 1996; Winkler and Döring 1998). Frequency of intake was

measured by a five-point scale including the categories 'daily', '4–6 times per week', '1–3 times per week', '1–3 times per month', and 'hardly ever or never'. With reference to fruit and vegetable consumption, the questionnaire contained the items 'fresh fruits', 'fresh raw vegetables/salad', 'fresh boiled vegetables' and 'fruit/vegetable juice'. Participants that reported consuming those items 'hardly ever or never' or '1–3 times per month' were categorized as poor consumers.

Body mass index (BMI) and leisure time physical activity were used as control variables in the multivariate models. Weight and height were measured in a standardized way in order to calculate BMI, leisure time physical activity was assessed in a standardized personal interview.

Statistical analyses

First, socio-demographic characteristics and smoking status of the study group were described (Table 1). As research findings illustrate that health-risk behaviors are particularly sensitive to gender differences (Johansson and Andersen 1998), all analyses were performed for men and women separately. Next, to investigate the association of socioeconomic groups and fruit and vegetable consumption, multivariate logistic regressions were run to test whether odds ratios (OR) and its 95% confidence intervals (CI) of poor fruit and vegetable consumption differ according to the two socioeconomic indicators (highest

education as reference vs. lower education; highest income as reference vs. lower income). As these results do not address the central question of this study, only OR and its 95% CI for the final model were presented (Table 2). The final model is controlled for variables that are usually taken into consideration when studying social inequalities in diet (age, BMI, leisure time physical activity, smoking, education respectively income).

As smoking and unhealthy diet are more prevalent in lower socioeconomic groups, the central aim of this study is to explore whether associations between smoking and fruit and vegetable consumption are confounded by socioeconomic factors or if smoking is independently associated with consumption. The following analyses were computed to study this question: Using cross-tabulations, the associations of poor fruit and vegetable consumption with socioeconomic groups, stratified by smoking status is shown in Tables 3 and 4. Then, multivariate logistic regression models were applied to examine the central question concerning smoking status and poor fruit and vegetable consumption (Table 5). For this purpose, four types of consecutive logistic regression models were performed. In a first model, unadjusted OR (95% CI) by smoking status were calculated for each one of the four items concerning fruit and vegetable consumption to test whether OR (95% CI) of infrequent consumption differ according to smoking status (non-smokers as reference vs. current smokers). In a second model, OR (95%) were adjusted for age. Previous studies have adjusted for additional health-related behaviors (BMI, leisure time physical activity) why those variables were included for the sake of completeness into the third model. Finally, a fourth model was adjusted for socioeconomic factors (education and income) in order to assess if the association of smoking and poor fruit and vegetable consumption is confounded by socioeconomic conditions or if the effect of smoking on consumption is independent of people's socioeconomic background.

Cases with missing data were excluded from multivariate analyses. For all analyses, STATA Version 10.0 for Windows was used (College Station, TX, USA).

Results

Table 1 presents a description of the study population. Males generally earn more and reach higher education than women. In women, the prevalence of never smokers is significantly higher than in men.

Bivariate analyses concerning the association of smoking and socioeconomic groups confirm a negative association of smoking with both indicators of socioeconomic conditions in men (highest educational group vs.

Table 1 Socio-demographic characteristics and smoking status of baseline participants in the German Heinz Nixdorf Recall Study (2000–2003), number and (%)

	Men (<i>n</i> = 2,395)	Women (<i>n</i> = 2,419)
Age (in years)		
45–54	746 (31.1)	748 (30.9)
55–64	940 (39.2)	957 (39.6)
65–75	709 (29.6)	714 (29.5)
Education (in years)		
≥18 (high)	325 (13.7)	182 (7.5)
14–17	799 (33.6)	269 (11.1)
11–13	1,136 (47.7)	1,536 (63.6)
≤10 (low)	120 (5.0)	427 (17.7)
Income		
Highest quartile	613 (26.7)	574 (26.0)
2nd quartile	528 (23.0)	530 (24.0)
3rd quartile	592 (25.8)	536 (24.3)
Lowest quartile	561 (24.5)	570 (25.8)
Smoking status		
Smokers	614 (25.7)	514 (21.3)
Ex-smokers	1,104 (46.3)	557 (23.1)
Never smokers	669 (28.0)	1,344 (55.7)

Table 2 Poor consumption (<3 times per month) of fruits, vegetables, and juice by education and income odds ratios and (95% confidence intervals)

Socioeconomic groups	Fruits	Raw vegetables/salad	Boiled vegetables	Fruit/vegetable juice
Men	(n = 2,244)	(n = 2,226)	(n = 2,226)	(n = 2,170)
≥18 years of education (high)	1.00	1.00	1.00	1.00
14–17 years of education	1.26 (0.80–2.00)	1.21 (0.80–1.83)	1.23 (0.81–1.86)	1.37 (1.01–1.85)
11–13 years of education	1.53 (0.97–2.43)	1.81 (1.20–2.72)	1.50 (0.99–2.28)	1.68 (1.23–2.28)
≤10 years of education (low)	1.54 (0.78–3.07)	3.31 (1.87–5.88)	2.16 (1.16–4.04)	2.02 (1.23–3.32)
Highest income quartile	1.00	1.00	1.00	1.00
2nd income quartile	0.94 (0.65–1.36)	1.10 (0.80–1.52)	0.99 (0.71–1.39)	1.05 (0.81–1.35)
3rd income quartile	0.80 (0.54–1.19)	0.88 (0.62–1.24)	0.74 (0.51–1.07)	0.98 (0.75–1.28)
Lowest income quartile	0.96 (0.66–1.41)	0.88 (0.62–1.23)	0.86 (0.60–1.23)	1.22 (0.93–1.60)
Women	(n = 2,081)	(n = 2,082)	(n = 2,140)	(n = 2,068)
≥18 years of education (high)	1.00	1.00	1.00	1.00
14–17 years of education	1.39 (0.47–4.10)	1.15 (0.50–2.64)	1.47 (0.76–2.85)	1.15 (0.75–1.77)
11–13 years of education	2.19 (0.85–5.65)	1.44 (0.70–2.97)	1.02 (0.57–1.87)	1.16 (0.80–1.69)
≤10 years of education (low)	2.83 (1.00–7.96)	2.40 (1.10–5.25)	1.49 (0.74–3.00)	1.43 (0.92–2.21)
Highest income quartile	1.00	1.00	1.00	1.00
2nd income quartile	0.85 (0.50–1.43)	1.33 (0.85–2.07)	0.57 (0.36–0.89)	1.11 (0.85–1.45)
3rd income quartile	0.75 (0.44–1.28)	1.09 (0.69–1.72)	0.71 (0.46–1.10)	1.16 (0.88–1.52)
Lowest income quartile	0.90 (0.53–1.51)	1.47 (0.95–2.29)	0.87 (0.57–1.33)	1.16 (0.88–1.52)

Odds ratios (95% confidence intervals) adjusted for age, body mass index, physical activity, smoking status, income respectively education

Table 3 Poor consumption of fruits, vegetables, and juice by education and income, stratified by smoking status for men [number and (%) of participants with consumption less than 3 times per month]

Poor consumption	Education (in years)					Income				
	Total	≥18 (high)	14–17	11–13	≤10 (low)	Total	Highest quartile	2nd quartile	3rd quartile	Lowest quartile
Fruits										
Total	317 (13.6)	31 (9.7)	88 (11.2)	176 (15.9)	22 (19.0)	307 (13.6)	72 (13.0)	77 (13.4)	63 (12.2)	95 (15.8)
Smokers	141 (23.9)	11 (19.0)	30 (19.6)	85 (25.1)	15 (37.5)	134 (23.7)	32 (24.2)	31 (25.6)	25 (18.9)	46 (25.6)
Non-smokers	176 (10.1)	20 (7.6)	58 (9.2)	91 (11.8)	7 (9.2)	173 (10.3)	40 (9.5)	46 (10.1)	38 (9.8)	49 (11.6)
<i>p</i> from χ^2	0.000	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.000
Raw vegetables/salad										
Total	436 (18.9)	38 (11.8)	118 (15.2)	242 (22.1)	38 (32.8)	425 (19.0)	89 (16.2)	115 (20.0)	94 (18.4)	127 (21.4)
Smokers	151 (25.9)	9 (15.5)	33 (21.9)	95 (28.4)	14 (35.0)	147 (26.4)	28 (21.7)	35 (28.2)	34 (26.4)	50 (28.7)
Non-smokers	285 (16.5)	29 (11.0)	85 (13.6)	147 (19.3)	24 (31.6)	278 (16.6)	61 (14.5)	80 (17.7)	60 (15.7)	77 (18.3)
<i>p</i> from χ^2	0.000	0.333	0.011	0.001	0.709	0.000	0.050	0.009	0.007	0.005
Boiled vegetables										
Total	355 (15.4)	40 (12.5)	106 (13.6)	183 (16.7)	26 (22.4)	342 (15.3)	84 (15.3)	94 (16.3)	67 (13.1)	97 (16.3)
Smokers	125 (21.4)	12 (21.1)	28 (18.4)	73 (21.9)	12 (29.3)	119 (21.4)	31 (23.7)	27 (22.5)	25 (19.2)	36 (20.7)
Non-smokers	230 (13.3)	28 (10.7)	78 (12.4)	110 (14.4)	14 (18.7)	223 (13.3)	53 (12.7)	67 (14.7)	42 (11.0)	61 (14.5)
<i>p</i> from χ^2	0.000	0.032	0.051	0.002	0.191	0.000	0.002	0.039	0.016	0.064
Fruit/vegetable juice										
Total	915 (40.6)	94 (29.8)	283 (37.3)	481 (45.0)	57 (51.4)	886 (40.7)	193 (35.4)	221 (39.7)	197 (39.6)	275 (47.7)
Smokers	273 (48.0)	22 (40.0)	58 (39.5)	173 (52.7)	20 (51.3)	263 (48.4)	57 (44.5)	52 (43.3)	57 (45.2)	97 (57.4)
Non-smokers	642 (38.1)	72 (27.6)	225 (36.8)	308 (41.5)	37 (51.4)	623 (38.1)	136 (32.6)	169 (38.7)	140 (37.6)	178 (43.6)
<i>p</i> from χ^2	0.000	0.067	0.554	0.001	0.991	0.000	0.014	0.335	0.131	0.003

Table 4 Poor consumption of fruits, vegetables, and juice by education and income, stratified by smoking status for women [number and (%) of participants with consumption <3 times per month]

Poor consumption	Education (in years)					Income				
	Total	≥18 (high)	14–17	11–13	≤10 (low)	Total	Highest quartile	2nd quartile	3rd quartile	Lowest quartile
Fruits										
Total	150 (6.4)	5 (2.8)	12 (4.5)	102 (6.8)	31 (7.7)	137 (6.3)	35 (6.2)	31 (5.9)	31 (5.9)	40 (7.2)
Smokers	64 (13.0)	1 (3.3)	6 (8.5)	49 (14.9)	8 (12.3)	57 (12.6)	14 (11.3)	13 (13.0)	11 (10.3)	19 (15.6)
Non-smokers	86 (4.6)	4 (2.7)	6 (3.1)	53 (4.5)	23 (6.8)	80 (4.7)	21 (4.8)	18 (4.3)	20 (4.8)	21 (4.9)
<i>p</i> from χ^2	0.000	0.835	0.063	0.000	0.125	0.000	0.008	0.001	0.033	0.000
Raw vegetables/salad										
Total	244 (10.5)	10 (5.5)	20 (7.6)	146 (9.8)	68 (17.3)	225 (10.5)	40 (7.2)	56 (10.8)	52 (10.1)	77 (14.1)
Smokers	78 (15.8)	3 (10.0)	8 (11.3)	45 (13.8)	22 (32.8)	72 (15.9)	14 (11.4)	18 (18.0)	13 (12.0)	27 (22.1)
Non-smokers	166 (9.0)	7 (4.6)	12 (6.2)	101 (8.7)	46 (14.1)	153 (9.1)	26 (6.0)	38 (9.0)	39 (9.6)	50 (11.8)
<i>p</i> from χ^2	0.000	0.240	0.169	0.006	0.000	0.000	0.039	0.009	0.456	0.004
Boiled vegetables										
Total	216 (9.2)	17 (9.4)	33 (12.5)	125 (8.3)	41 (10.1)	200 (9.3)	64 (11.4)	35 (6.7)	45 (8.6)	56 (10.2)
Smokers	64 (13.0)	3 (10.0)	14 (19.7)	36 (11.0)	11 (17.2)	59 (13.1)	22 (17.7)	9 (8.7)	13 (12.4)	15 (12.6)
Non-smokers	152 (8.2)	14 (9.3)	19 (9.8)	89 (7.6)	30 (8.8)	141 (8.3)	42 (9.6)	26 (6.2)	32 (7.7)	41 (9.6)
<i>p</i> from χ^2	0.001	0.909	0.030	0.049	0.040	0.002	0.012	0.344	0.123	0.311
Fruit/vegetable juice										
Total	860 (37.8)	56 (31.5)	92 (36.4)	544 (37.3)	168 (43.3)	779 (37.3)	187 (34.4)	195 (38.4)	179 (35.5)	216 (41.1)
Smokers	191 (39.7)	10 (33.3)	27 (40.9)	127 (39.7)	27 (41.5)	176 (40.0)	42 (35.6)	40 (40.8)	43 (40.6)	51 (43.2)
Non-smokers	669 (37.2)	46 (31.1)	65 (34.8)	417 (36.6)	141 (43.7)	603 (36.6)	147 (34.1)	155 (37.8)	136 (34.1)	165 (40.5)
<i>p</i> from χ^2	0.319	0.809	0.372	0.315	0.754	0.192	0.763	0.582	0.215	0.602

lowest educational group: 18.2 vs. 34.2% smokers; highest income quartile vs. lowest income quartile: 23.9 vs. 30.2% smokers). In women, no consistent social patterns of smoking habits were observed.

Table 2 presents adjusted multivariate results regarding the association of socioeconomic groups and poor fruit and vegetable consumption. Results reveal consistent associations of low education and infrequent consumption of fruits and vegetables. In lower educated men OR for poor consumption of raw vegetables/salad, boiled vegetables and fruit/vegetable juice are significantly elevated. In women, strong educational gradients are observed for low intake frequency of fruits and raw vegetables/salad. Interestingly, no consistent associations between poor fruit and vegetable consumption and income could be detected.

The distribution of participants with poor consumption of fruits and vegetables by education and income stratified by smoking status is given in Table 3 for men and in Table 4 for women. In men, smoking is strongly associated with poor fruit and vegetable consumption in a majority of educational and income groups. Weaker associations are found for infrequent intake of fruit/vegetable juice, although results indicate that smokers are at higher risk for poor consumption across most socioeconomic groups (Table 3).

In women, smokers are at higher risk for poor consumption of fruits and raw vegetables/salad than non-smokers in most socioeconomic groups. Less marked differences between smokers and non-smokers are observed for boiled vegetables, although results show that smoking is related to infrequent consumption in all educational and income groups. However, the intake of fruit/vegetable juice is not consistently associated with smoking status (Table 4).

Multivariate results for the central question concerning the co-occurrence of poor fruit and vegetable consumption and smoking are reported in Table 5. In men, smoking is strongly associated to all studied items concerning infrequent fruit and vegetable consumption. In women, odds ratios for poor consumption of fruits and raw vegetables/salad are significantly elevated in smokers. Importantly, odds ratios of smoking on poor consumption are not reduced in any systematic way after final adjustment for socioeconomic conditions. This consistent finding supports the notion that low consumption frequency of fruits, raw vegetables/salad (both genders), boiled vegetables, and juice (only in men) is related to smoking independent of people's socioeconomic condition.

Whereas their co-occurrence is higher among people in lower socioeconomic groups (especially among men in this

Table 5 Poor consumption (<3 times per month) of fruits, vegetables, and juice by smoking status, odds ratios and (95% confidence intervals)

Smoking status	Fruits	Raw vegetables/salad	Boiled vegetables	Fruit/vegetable juice
Men	(n = 2,244)	(n = 2,226)	(n = 2,226)	(n = 2,170)
Non-smokers	1.00	1.00	1.00	1.00
Smokers				
Model 1 ^a	2.72 (2.12–3.50)	1.79 (1.43–2.26)	1.80 (1.41–2.31)	1.50 (1.24–1.83)
Model 2 ^b	2.45 (1.90–3.16)	1.80 (1.43–2.28)	1.62 (1.26–2.09)	1.54 (1.26–1.88)
Model 3 ^c	2.10 (1.61–2.73)	1.59 (1.25–2.02)	1.51 (1.17–1.96)	1.38 (1.13–1.70)
Model 4 ^d	2.03 (1.55–2.64)	1.50 (1.18–1.92)	1.46 (1.13–1.91)	1.31 (1.06–2.61)
Women	(n = 2,081)	(n = 2,082)	(n = 2,140)	(n = 2,068)
Non-smokers	1.00	1.00	1.00	1.00
Smokers				
Model 1 ^a	2.82 (1.97–4.04)	1.86 (1.38–2.53)	1.67 (1.20–2.31)	1.16 (0.94–1.44)
Model 2 ^b	2.68 (1.84–3.91)	2.09 (1.52–2.88)	1.42 (1.01–1.99)	1.19 (0.94–1.47)
Model 3 ^c	2.58 (1.75–3.81)	2.10 (1.52–2.91)	1.32 (0.93–1.86)	1.16 (0.93–1.47)
Model 4 ^d	2.54 (1.72–3.76)	2.06 (1.48–2.87)	1.29 (0.92–1.83)	1.15 (0.92–1.45)

^a Model 1: unadjusted^b Model 2: adjusted for age^c Model 3: adjusted for age, body mass index, and physical activity^d Model 4: adjusted for age, body mass index, physical activity, and socioeconomic groups (income and education)

study), no interaction effect of socioeconomic conditions and smoking on poor fruit and vegetable consumption was observed (results not shown).

Discussion

In this study of an unselected middle-aged urban population in Germany, smoking was strongly related to poor consumption of fruits and vegetables. The risk of poor consumption of all four items concerning fruits and vegetables was significantly increased among smoking compared to non-smoking men after adjusting for socioeconomic conditions. A similar trend was observed among smoking women where significant effects were evident for two out of four items, fruits and raw vegetables/salad.

Associations of smoking with low intake of fruits (Larson et al. 2007; Magretts and Jackson 1993; Marangon et al. 1998) and vegetables (Larson et al. 2007; Whichelow et al. 1988) were reported previously although other studies found no associations with vegetable consumption (Whichelow et al. 1988). To our knowledge, this is one of the first reports of unfavorable effects of smoking on consumption of fruits and vegetables that provides a systematic analysis of the role of socioeconomic conditions where a consistent elevation of odds ratios was observed after adjustment for socioeconomic variables.

In addition, the results of this study showed an association of socioeconomic groups, as measured by educational degree, with poor fruit and vegetable consumption where

less favorable education was related to poor intake frequencies. In men, but not in women, socioeconomic groups were additionally related to smoking behavior. Associations of socioeconomic conditions with poor consumption of fruits and vegetables were less consistent in case of income, thus supporting the importance of attitudes and behaviors triggered by education, such as information seeking and processing with relevance to diet (Rutten et al. 2006; Tu and Cohen 2008), or implementation of respective knowledge into every day life (Wardle et al. 2000; Moser et al. 2005).

Why is smoking associated with poor fruit and vegetable consumption? One answer points to a general health neglect of smokers that includes a lack of knowledge about diet and failing motivation towards health-promoting behavior (Woodward et al. 1994). A second answer concerns differential taste preference according to smoking status where chronic nicotine inhalation impairs gustatory sensitivity (Redington 1985), reducing taste preference for fruits and fruit juices while enhancing preference for unhealthy food such as fried food or white bread (Grungberg 1982; Marangon et al. 1998). Early life conditions may offer an additional explanation (Power and Kuh 2006), but it was not possible to test any of these potential explanations in this study.

Social desirability in reporting dietary habits among lower income and educational groups may be one reason for some inconsistency of reported results. It has been observed that socially desired answering is more prevalent in people with low socioeconomic groups (Pryer et al.

1997). Yet, if this was the case, reported associations tend to be underestimated. Another potential reason for the inconsistent association of income with fruit and vegetable consumption may be due to the fact that high income groups (mostly working men and women) have less time to purchase fresh fruits and vegetables and prepare healthy meals, or often eat apart from home. These conditions were related to poor diet quality (Le Francois et al. 1996).

This study has several limitations. Findings are based on cross-sectional data, thus preventing any conclusion about causal association. Second, the sample of this study may not be fully representative of middle-aged urban people in Germany. Analysis of non-responding patterns showed that people in lower socioeconomic groups were slightly underrepresented in the sample and that the same holds true for smokers (Stang et al. 2005). It cannot be excluded that under-representation of smokers in low socioeconomic groups in the analysis of this study may restrict the generalization of the findings. In addition, the size of groups with different socioeconomic conditions varied widely, specifically in case of education where the group with lowest educational degree was particularly small. A further limitation concerns the use of a food frequency questionnaire where retrospective reporting bias cannot be excluded. Estimates of mean intake frequency may vary according to socioeconomic groups and, thus, account for some part of the observed association. Imprecise measurement is an additional query as the size of single portions or the precise amounts of fruits and vegetables consumed were not assessed.

Despite these limitations, this study has several strengths. The study population is based on a large community sample rather than on some selected group, and data meet high quality standards. Two different internationally established indicators of socioeconomic groups were introduced, and associations were analyzed on the basis of multivariate regression analysis, taking important confounders into account. Four variables describing fruit and vegetable consumption were assessed, thus allowing a differential exploration of consumption habits. Finally, the overall response rate of this study was similar to other population-based investigations in this field (Stang et al. 2005).

In terms of public health policy implications two conclusions can be drawn from the findings of this study. First, as education is more strongly related to poor consumption of fruits and vegetables than income, health literacy and other mediators linking educational skills and capabilities with attitudes, motivations and behaviors concerning the intake of fruits and vegetables need to be targeted in primary prevention. Disproportionably high efforts should be directed towards people in low socioeconomic groups at all age levels. Second, health promoting activities in the field of smoking prevention and smoking cessation should pay

special attention to the risks of low consumption of fruits and vegetables that are associated with smoking. Among those who nevertheless continue to smoke dietary instructions and access to healthy foods such as fruits and vegetables should be encouraged.

In conclusion, results of this study confirm strong associations of smoking with poor consumption of fruits and vegetables in different socioeconomic groups. Given this co-occurrence, targeted interventions and preventive activities across the social gradient are required.

Acknowledgments The authors thank the Heinz Nixdorf Foundation (Chairman Dr jur G. Schmidt, Essen, Germany) for sponsoring the Heinz Nixdorf Recall Study and the German Research Council for supporting the additional assessment of psychosocial factors (DFG SI 236/8-1; 10-1). The authors are indebted to the investigative group and the study personnel of the Heinz Nixdorf Recall Study.

References

- Cavelaars A, Kunst A, Geurts J et al (2000) Educational differences in smoking: international comparison. *BMJ* 320:1102–1107
- Darmon N, Ferguson EL, Briend A (2000) A cost constraint alone has adverse effects on food selection and nutrient density: an analysis of human diets by linear programming. *J Nutr* 132:3764–3771
- Davey Smith G, Brunner E (1997) Socio-economic differentials in health: the role of nutrition. *Proc Nutr Soc* 56:75–90
- Ding EL, Mozaffarian D (2006) Optimal dietary habits for the prevention of stroke. *Semin Neurol* 26:11–23
- Donaldson MS (2004) Nutrition and cancer: a review of the evidence of an anti-cancer diet. *Nutr J* 3. <http://www.nutritionj.com/content/3/1/19> (Accessed 2 Nov 2009)
- Drewnowski A, Specter SE (2004) Poverty and obesity: the role of energy density and energy costs. *Am J Clin Nutr* 79:6–16
- Giskes K, Kunst AE, Benach J et al (2005) Trends in smoking behaviour between 1985 and 2000 in nine European countries by education. *J Epidemiol Community Health* 59:395–401
- Grungberg NE (1982) The effects of nicotine and cigarette smoking and food consumption and tastes preferences. *Addict Behav* 7:317–331
- Huijbrechts P, Feskens E, Rasanen L et al (1997) Dietary pattern and 20 year mortality in elderly men in Finland, Italy, and The Netherlands: longitudinal cohort study. *BMJ* 315:13–17
- Hulshof KF, Brussaard JH, Kruijzinga AG et al (2003) Socio-economic status, dietary intake and 10 y trends: the Dutch National Food Consumption Survey. *Eur J Clin Nutr* 57:128–137
- James WP, Nelson M, Ralph A et al (1997) Socioeconomic determinants of health. The contribution of nutrition to inequalities in health. *BMJ* 314:1545–1549
- Jarvis MJ, Wardle J (2006) Social patterning of individual health behaviours: the case of cigarette smoking. In: Marmot M, Wilkinson R (eds) *Social determinants of health*. Oxford University Press, Oxford, pp 224–237
- Johansson L, Andersen LF (1998) Who eats 5 a day?: intake of fruits and vegetables among Norwegians in relation to gender and lifestyle. *J Am Diet Assoc* 98:689–691
- Kant A (2000) Consumption of energy-dense, nutrient-poor foods by adult Americans: nutritional, health implications. The third National Health, Nutrition Examination Survey 1988–1994. *Am J Clin Nutr* 72:929–936

- Larson NI, Story M, Perry CL et al (2007) Are diet and physical activity patterns related to cigarette smoking in adolescents? Findings from project EAT. *Prev Chronic Dis* 4:A51
- Le Francois P, Calamassi-Tran G, Hebel P et al (1996) Food and nutrient intake outside the home of 629 French people of fifteen years and over. *Eur J Clin Nutr* 50:826–831
- Ma J, Betts NM, Hampl JS (2000) Clustering of lifestyle behaviors: the relationship between cigarette smoking, alcohol consumption, and dietary intake. *Am J Health Promot* 15:107–117
- Magretts B, Jackson A (1993) Interactions between people's diet and their smoking habits: the dietary and nutritional survey of British adults. *BMJ* 307:1381–1384
- Marangon K, Herbeth B, Lecomte E et al (1998) Diet, antioxidant status, and smoking habits in French men. *Am J Clin Nutr* 67:231–239
- Mensink G, Loose N, Oomen CM (1997) Physical activity and its association with other lifestyle factors. *Eur J Epidemiol* 13:771–778
- Moore LV, Diez Roux AV (2006) Associations of neighborhood characteristics with the location and type of food stores. *Am J Public Health* 96:325–331
- Moser RP, Green V, Weber D et al (2005) Psychosocial correlates of fruit and vegetable consumption among African American men. *J Nutr Edu Behav* 37:306–314
- Murray CJL, Lopez AD (1996) Evidence-based health policy: lessons from the Global Burden of Disease Study. *Science* 274:740–743
- Nuttens MC, Romon M, Ruidavets JB et al (1992) Relationship between smoking and diet: the MONICA-France project. *J Intern Med* 231:349–356
- Power C, Kuh D (2006) Life course development of unequal health. In: Siegrist J, Marmot M (eds) *Social inequalities in health: new evidence and policy implications*. Oxford University Press, Oxford, pp 27–53
- Prättälä R, Karisto A, Berg MA (1994) Consistency and variation in unhealthy behaviour among Finnish men, 1982–1990. *Soc Sci Med* 39:115–122
- Pryer JA, Vrijheid M, Nichols R et al (1997) Who are the 'low energy reporters' in the dietary and nutritional survey of British adults? *Int J Epidemiol* 26:146–154
- Redington K (1985) Taste differences between cigarette smokers and non-smokers. *Pharmacol Biochem Behav* 21:230–238
- Rutten LJ, Squiers L, Hesse B (2006) Cancer-related information seeking: hints from the 2003 Health Information National Trends Survey (HINTS). *J Health Comm* 11(Suppl 1):S147–S156
- Schaeffler V, Döring A, Winkler G et al (1996) Trends in food consumption in a south German population from 1984/85 to 1989/90: results from the WHO MONICA projekt Augsburg. *Ann Nutr Metab* 40:129–136
- Schmermund A, Mohlenkamp S, Stang A et al (2002) Assessment of clinically silent atherosclerotic disease and established and novel risk factors for predicting myocardial infarction and cardiac death in healthy middle-aged subjects: rationale and design of the Heinz Nixdorf RECALL Study. Risk Factors, Evaluation of Coronary Calcium and Lifestyle. *Am Heart J* 144:212–218
- Schrijvers CTM, Stronks K, van de Mheen HD et al (1999) Explaining educational differences in mortality: the role of behavioral and material factors. *Am J Public Health* 89:535–540
- Stang A, Moebus S, Dragano N et al (2005) Baseline recruitment and analyses of nonresponse of the Heinz Nixdorf Recall Study: identifiability of phone numbers as the major determinant of response. *Eur J Epidemiol* 20:489–496
- Stronks K, van de Mheen H, Looman CWN et al (1997) Behavioural and structural factors in the explanation of socioeconomic inequalities in health: an empirical analysis. *Sociol Health Illn* 18:653–674
- Tu HT, Cohen GR (2008) Striking jump in consumers seeking health care information. *Track Rep* 20:1–8
- UNESCO (1997) International standard classification of education (ISCED). UNESCO, Paris
- Wardle J, Parmenter K, Waller J (2000) Nutrition knowledge and food intake. *Appetite* 34:269–275
- Whicelow M, Golding JF, Trasare FP (1988) Comparison of some dietary habits of smokers and nonsmokers. *Br J Addict* 83:295–304
- Winkler G, Döring A (1998) Validation of a short qualitative food frequency list used in several German large scale surveys. *Z Ernährungswiss* 37:234–241
- Woodward M, Bolton-Smith C, Tunstall-Pedoe H (1994) Deficient health knowledge, diet, and other life-styles in smokers: is a multifactorial approach required? *Prev Med* 23:354–361