Contribution of lifetime smoking habit in France and Northern Ireland to country and socioeconomic differentials in mortality and cardiovascular incidence the PRIME study

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Contribution of lifetime smoking habit in France and Northern Ireland to country and socioeconomic differentials in mortality and cardiovascular incidence: the PRIME Study

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ABSTRACT

Background This study examines the contribution of lifetime smoking habit to the socioeconomic gradient in all-cause and smoking-related mortality and in cardiovascular incidence in two countries.

Methods 10 600 men aged 50—59 years were examined in 1991—4 in centres in Northern Ireland and France and followed annually for 10 years. Deaths and cardiovascular events were documented. Current smoking habit, lifetime smoking (pack-years) and other health behaviours were evaluated at baseline. As socio-occupational coding schemes differ between the countries seven proxy socioeconomic indicators were used.

Results Lifetime smoking habit showed marked associations with most socioeconomic indicators in both countries, but lifetime smoking was more than 10 pack-years greater overall in Northern Ireland and smoking patterns differed. Total mortality was 49% higher in Northern Ireland than in France, and smoking-related mortality and cardiovascular incidence were 93% and 92% higher, respectively. Both lifetime smoking and fibrinogen contributed independently to these differentials, but together explained only 42% of the difference in total mortality between countries, adjusted for both biological and lifestyle confounders. Socioeconomic gradients were steeper for total and smoking-related mortality than for cardiovascular incidence. Residual contributions of lifetime smoking habit ranged from 6% to 34% for the seven proxy indicators of socioeconomic position for total and smoking-related mortality. Socioeconomic gradients in cardiovascular incidence were minimal following adjustment for confounders.

Conclusion In Northern Ireland and France lifetime smoking appeared to explain a significant part of the gradients in total and smoking-related mortality between socioeconomic groups, but the contribution of smoking was generally small for cardiovascular incidence.

Socioeconomic differentials in mortality have been a long-standing concern of public health since the 19th century. More recently, social gradients in mortality and cardiovascular disease have been described in France[1 2] and in many other European countries.[3] In a previous report in this cohort of middle-aged men from France and Northern Ireland we showed a strong relationship between cardiovascular morbidity and poorer material circumstances, unemployment, less full-time education and other indicators of socioeconomic disadvantage.[4]

Other cohort studies have examined socioeconomic gradients in cardiovascular mortality, and the possible contribution of conventional risk factors and health behaviours is typically estimated at between 15% and 40%,[5] and the individual contribution of current and former smoking has been indirectly estimated at 66% in the UK[6] and 50% in Canada, Poland and the USA.[7] In Australia the contribution of smoking to the socioeconomic gradient (defined using educational level) was 36%.[8] A similar proportion was estimated for Scotland.[9] However, we know of no previous study that has examined lifetime smoking habit measured in pack-years and socioeconomic gradient in cardiovascular risk. In the present report, we examine the contribution of lifetime smoking habit and socioeconomic position to the 10-year risk of a cardiovascular event in a large cohort of men aged 50—59 years from France and Northern Ireland. All-cause mortality and smoking-related mortality were also examined.

METHODS

Study population

The PRIME Study is a multicentre, prospective cohort study designed to identify risk factors for cardiovascular disease and to attempt to explain the substantial difference in cardiovascular mortality and incidence between France and Northern Ireland. Men aged 50—59 years from the general population were recruited between 1991 and 1993 in Lille, Strasbourg and Toulouse in France, and in Belfast, Northern Ireland.

A detailed medical and lifestyle questionnaire was completed at the baseline examination. Lifetime smoking history was obtained to permit the calculation of lifetime cigarette consumption (pack-years=number of years smoking×average number of packs of 20 cigarettes per day). A potential marker for this, plasma fibrinogen,[10] was also measured. Other health behaviours assessed were physical activity,[11] alcohol consumption[4] and diet (fruit and vegetable score).[12] Socioeconomic data included length and type of education, home ownership, car ownership, marital and employment status.

A summary variable termed 'material condition' was constructed based on home ownership and the number of cars, baths/showers and toilets.[11] Low material condition was defined by rental accommodation with one or fewer cars, baths/showers and toilets; high material condition was defined as home ownership with two or more cars and, either two or more baths/showers, or two or more toilets; the remaining subjects were classified as living in a mid-range material condition.

A cardiovascular screening examination included a detailed history of previous cardiovascular disease and completion of the London School of Hygiene chest pain questionnaire to define effort angina. Resting blood pressure and a 12-lead ECG were also obtained. A blood sample was taken after an overnight fast; lipid levels and fibrinogen were assayed for all subjects at two central laboratories.

Ethics approval for baseline examination and for follow-up was obtained at each study centre.

Follow-up

Men have been followed up annually by questionnaire and, for all subjects reporting a possible cardiovascular event, clinical information was sought directly from the hospital or general practitioner records. All details of ECG, laboratory and radiological diagnostic tests and surgical interventions were collected. When possible, circumstances of death were obtained from the subject's practitioner or his family. A medical committee comprising a medical investigator from each PRIME centre and three independent cardiologists was established to provide validation of cardiac events. A separate committee was established with an independent neurologist to validate the stroke events. Follow-up is now complete for 10 years, with only 2.9% of men lost, the majority of whom refused further follow-up. Details of the recruitment, baseline examination, follow-up and validation of cardiovascular events have been published in detail elsewhere.[13] In the present report cardiovascular events include validated myocardial infarction and/or stroke (fatal and non-fatal). Death certificates were obtained for all men who died and causes of death were classified using the International Classification of Diseases, 9th revision. Smoking-associated deaths were separately categorised from diseases well established to be linked with smoking.[14] The relevant codes are as follows: 410–417, 430–444 (cardiovascular), 480–487, 490–496, 510–514 (respiratory), 140–149, 150, 157, 161–163 and 188 (oral, oesophageal, pancreatic, respiratory and bladder cancers).

Statistical methods

The distribution of pack-years of smoking was heavily skewed and was summarised using median and IQR. Lifetime smoking was expressed in five categories: never smoked; smoked other than cigarettes; smoked less than 15 cigarette pack-years; smoked 15 or more but less than 30 cigarette pack-years and smoked 30 or more cigarette pack-years. Alcohol intake was also expressed as five categories: none; 1–128; 129–265; 266–461 and 462 ml or more per week. Fruit and vegetable consumption (portions of fruit, fruit juice and vegetables per day), and total physical activity (in metabolic equivalent scores per week) were positively skewed, and a square root transformation was applied to each before analysis.

Cox proportional hazards models were used for analysis of mortality and cardiovascular incidence data. The socioeconomic factors marital status (married/cohabiting vs single/married/divorced/widowed/separated), living accommodation (mortgaged or co-owned/owner vs rented) and economic activity (working vs sick/disabled/retired/unemployed) were regrouped into two categories before inclusion in the model. For the remaining socioeconomic factors a test for trend across the categories was used. A supplementary table (available online only) shows the trends in the original groupings for socioeconomic indicators.

The extent to which gradients in mortality or cardiovascular incidence between countries and between socioeconomic groups could be explained by smoking was estimated using the expression $100(b_0-b_1)/b_0$, where b_0 was the coefficient for country or socioeconomic group on a logarithmic hazard scale in the Cox regression model without smoking, and b_1 was the coefficient in the corresponding model with smoking.[15] This approach therefore provided an estimate of the residual percentage contribution of smoking and/or fibrinogen after adjustment for other risk factors that were in the model. These residual contributions were only calculated if the country or socioeconomic gradient coefficient, b_0, was significant before smoking and/or fibrinogen was added to the model; otherwise these residual contributions could reflect what might simply be random variation. Bootstrap re-sampling was used to obtain a 95% CI for each residual contribution estimate. This analysis was performed using Stata release 9, whereas the remainder was performed using SPSS version 17.

RESULTS

As men with clinical evidence of cardiovascular disease may have modified their smoking habit or another health-related behaviour, we excluded 891 men with clinical evidence of coronary disease or previous stroke at baseline examination and 9709 men were included in subsequent analyses.

A current cigarette smoking habit was more common in Northern Ireland (31.3%) than in France (26.4%), but more men in Northern Ireland had never smoked during their lifetime than in France (35.2% in Northern Ireland and 27.8% in France). The socioeconomic gradients in the proportions never smoking were greater and more consistent in Northern Ireland than in France, suggesting a different pattern of smoking initiation in the two societies. Lifetime smoking reflects average consumption during adult life and, among current and ex-smokers, median values for pack-years of smoking were markedly higher in Northern Ireland than in France (27.6 pack-years in Northern Ireland compared with 17.4 pack-years in France).

Lifetime smoking consumption showed significant socioeconomic gradients in both France and in Northern Ireland as shown in table 1. The strongest gradients in lifetime smoking consumption were for educational level; in France there was a difference of 9.4 pack-years between men educated to primary level only compared with those with higher level education. In Northern Ireland there was a corresponding difference of 14.9 pack-years.

As there were clear differences between the pattern of smoking in France and Northern Ireland we first examined whether these differences accounted for part of the differences in mortality and cardiovascular incidence between the two countries.

During follow-up there were 538 deaths, of which 218 were from smoking-associated causes, and 440 cardiovascular events in the 9709 men. In table 2 we show the hazard ratio (HR) for the all-cause and smoking-associated mortality and cardiovascular incidence in Northern Ireland relative to that in France. These analyses were restricted to 9237 men with complete data on all risk factors. Five separate models were constructed with different levels of adjustment in order to establish the independent contributions of lifetime smoking habit and fibrinogen.

Table 1 Smoking characteristics in subgroups defined by socioeconomic variable for 9709 men from Northern Ireland and France who were free of cardiovascular disease at entry

	Northern Ireland (n=2390)				France (n=7319)			
	Never smokers n (%)	Ex-smokers n (%)	Current smokers n (%)	Pack-years median (IQR)	Never smokers n (%)	Ex-smokers n (%)	Current smokers n (%)	Pack-years median (IQR)
Marital status								
Married/cohabiting	732 (35.8%)	702 (34.3%)	611 (29.9%)	27.2 (12.3–40.1)	1783 (27.7%)	3041 (47.2%)	1615 (25.1%)	17.0 (5.2–30.4)
Single	68 (41.5%)	43 (26.2%)	53 (32.3%)	30.9 (13.5–38.6)	108 (34.2%)	98 (31.0%)	110 (34.8%)	17.5 (4.2–34.0)
Widowed/divorced/separated	41 (22.7%)	57 (31.5%)	83 (45.9%)	29.6 (17.1–43.2)	142 (25.3%)	211 (37.5%)	209 (37.2%)	23.3 (7.2–36.5)
No of people in household								
1	54 (29.8%)	46 (25.4%)	81 (44.8%)	31.5 (15.2–42.1)	148 (26.6%)	193 (34.7%)	215 (38.7%)	21.5 (4.7–37.0)
2–3	461 (34.8%)	454 (34.3%)	409 (30.9%)	28.4 (13.2–40.7)	1357 (26.8%)	2401 (47.5%)	1302 (25.7%)	17.6 (5.5–31.2)
4+	325 (36.8%)	300 (34.0%)	257 (29.1%)	24.9 (11.1–39.2)	527 (31.0%)	757 (44.5%)	416 (24.5%)	15.6 (4.1–29.8)
Accommodation								
Mortgaged/co-owned	488 (36.7%)	474 (35.6%)	368 (27.7%)	24.5 (10.2–38.6)	231 (25.3%)	445 (48.7%)	237 (26.0%)	17.0 (4.5–30.0)
Owned	269 (40.5%)	218 (32.8%)	178 (26.8%)	27.0 (11.0–40.4)	1437 (30.4%)	2172 (45.9%)	1123 (23.7%)	15.9 (4.6–29.4)
Rented	83 (21.1%)	109 (27.7%)	201 (51.1%)	34.1 (21.4–43.5)	364 (22.0%)	725 (43.7%)	569 (34.3%)	22.8 (7.3–36.5)
No of cars in household								
None	79 (23.1%)	85 (24.9%)	178 (52.0%)	34.5 (22.0–44.1)	78 (24.3%)	116 (36.1%)	127 (39.6%)	27.3 (10.8–44.7)
1	375 (32.6%)	397 (34.5%)	379 (32.9%)	28.0 (14.2–40.3)	806 (26.8%)	1364 (45.3%)	842 (28.0%)	19.8 (6.6–33.1)
2+	386 (43.2%)	318 (35.6%)	190 (21.3%)	21.2 (7.8–37.3)	1147 (28.9%)	1863 (46.9%)	960 (24.2%)	15.4 (3.9–28.5)
Years in full-time education								
<12	513 (32.1%)	545 (34.1%)	541 (33.8%)	29.6 (15.3–41.7)	1160 (28.6%)	1820 (44.8%)	1080 (26.6%)	20.0 (7.3–33.5)
12–14	188 (38.0%)	170 (34.3%)	137 (27.7%)	24.1 (7.2–36.4)	541 (27.4%)	912 (46.2%)	520 (26.4%)	16.7 (5.1–30.1)
15+	139 (47.3%)	87 (29.6%)	68 (23.1%)	18.2 (5.8–37.4)	332 (25.8%)	619 (48.2%)	334 (26.0%)	10.1 (1.1–23.3)
Educational level								
Primary	158 (25.8%)	205 (33.5%)	249 (40.7%)	34.4 (19.2–44.1)	432 (28.4%)	664 (43.7%)	424 (27.9%)	23.0 (10.5–36.5)
Secondary	94 (27.3%)	131 (38.1%)	119 (34.6%)	28.4 (13.8–39.6)	194 (25.3%)	369 (48.2%)	203 (26.5%)	16.4 (4.6–29.3)
Technical	290 (38.9%)	240 (32.2%)	216 (29.0%)	26.4 (11.6–37.8)	683 (28.0%)	1084 (44.5%)	668 (27.4%)	17.7 (6.2–31.2)
Higher	282 (44.8%)	207 (32.9%)	140 (22.3%)	19.5 (5.6–36.5)	646 (27.4%)	1129 (47.8%)	585 (24.8%)	13.6 (2.3–27.2)
Economic activity								
Working	774 (36.9%)	707 (33.7%)	619 (29.5%)	26.2 (10.8–39.2)	1592 (28.1%)	2587 (45.7%)	1480 (26.2%)	16.5 (4.4–30.0)
Sick/disabled/retired	25 (25.8%)	37 (38.1%)	35 (36.1%)	31.8 (18.4–43.6)	313 (29.3%)	505 (47.2%)	251 (23.5%)	20.2 (8.3–33.9)
Unemployed	42 (21.8%)	58 (30.1%)	93 (48.2%)	37.2 (25.0–49.0)	128 (21.7%)	259 (43.9%)	203 (34.4%)	24.1 (8.8–38.0)
Material condition								
Low	234 (25.9%)	300 (33.1%)	371 (41.0%)	31.4 (17.6–42.7)	316 (22.1%)	609 (42.5%)	507 (35.4%)	23.5 (8.0–36.6)
Medium	195 (37.3%)	184 (35.2%)	144 (27.5%)	23.9 (9.1–37.7)	224 (23.6%)	448 (47.2%)	277 (29.2%)	18.9 (4.3–32.7)
High	411 (42.9%)	316 (33.0%)	232 (24.2%)	23.9 (9.3–38.7)	1489 (30.4%)	2279 (46.5%)	1138 (23.2%)	15.6 (4.5–29.1)

Progressive adjustment of the model produced successive reductions in the HR permitting estimation of the contribution of additional factors to the model. Model 1 shows the HR in Northern Ireland relative to France adjusted only for age. By comparing models 2 and 3 the contribution that a lifetime smoking habit made to this HR independent of biological and lifestyle risk factors was estimated from logarithms of the HR (see Statistical methods section) to be 32%, 30% and 12%, respectively, for all-cause and smoking-related mortality and for cardiovascular incidence. Model 4 (compared with model 2) examined the independent contribution of fibrinogen and model 5 (compared with model 2) the combined effect of lifetime smoking habit and fibrinogen. Although there is a modest correlation between fibrinogen levels and pack-years of smoking (Spearman's rank correlation coefficient r_s=0.16 and 0.11 in Northern Ireland and France, respectively) these results suggest that both lifetime smoking and fibrinogen contribute largely independently to the excess mortality and cardiovascular incidence in Northern Ireland.

Preliminary analyses revealed that small numbers meant that some socioeconomic factors were better reduced to two categories (see Statistical methods section), whereas others showed approximately linear relationships with mortality/cardiovascular incidence (see supplementary table, available online only), and were therefore tested in the Cox model as trends across three or four categories. For the former, the HR represent a straightforward comparison of two categories, whereas for the latter they represent the change in hazard associated with one step up the scale. Risks of death, smoking-associated death or of a cardiovascular event are shown in table 3 by individual socioeconomic categories in three columns; in the first column the 'crude' adjustment has been made for age and country only; in the second the data are adjusted for all biological and lifestyle risk factors except smoking; in the third further additional adjustment has been made for lifetime smoking habit.

In the analysis of total mortality the contribution of all seven primary socioeconomic indicators remained statistically significant after adjustment for age, country and biological and lifestyle factors. The median residual contribution of smoking in these seven analyses was 18%, similar to the analysis of the composite indicator material condition (residual contribution of smoking 24%). For smoking-related mortality, four of the seven socioeconomic indicators remained significant after adjustment for age, country, biological and lifestyle factors; in these analyses the median contribution of smoking was 25%, also similar to that seen in material condition (residual contribution of smoking 30%). For cardiovascular incidence only one of the seven socioeconomic indicators (economic activity) was significant after adjustment for age, country, biological and lifestyle

Table 2 Hazard ratios for total and smoking-related mortality and for cardiovascular events in Northern Ireland versus France showing the percentage of the country effect after adjustment for biological and lifestyle factors that can be explained by smoking and fibrinogen

	All causes of death		Smoking-associated deaths		Cardiovascular events	
	HR	(95% CI)	HR	(95% CI)	HR	(95% CI)
Factors adjusted for						
Model 1 Age	1.49***	(1.24 to 1.80)	1.93***	(1.45 to 2.55)	1.92***	(1.57 to 2.35)
Model 2 Age, biological, lifestyle	1.52***	(1.23 to 1.87)	1.90***	(1.39 to 2.62)	1.57***	(1.25 to 1.98)
Model 3 Age, biological, lifestyle, smoking	1.33**	(1.08 to 1.64)	1.57**	(1.14 to 2.17)	1.49***	(1.19 to 1.88)
Model 4 Age, biological, lifestyle, fibrinogen	1.43**	(1.15 to 1.76)	1.75***	(1.27 to 2.42)	1.45**	(1.15 to 1.83)
Model 5 Age, biological, lifestyle, smoking, fibrinogen	1.28*	(1.03 to 1.58)	1.50*	(1.09 to 2.08)	1.40**	(1.11 to 1.77)
	%	(95% CI)	%	(95% CI)	%	(95% CI)
Percentage of country effect in model 2 explained by						
Smoking (model 3 vs model 2)	32%	(18% to 72%)	30%	(16% to 63%)	12%	(3% to 27%)
Fibrinogen (model 4 vs model 2)	15%	(6% to 37%)	13%	(2% to 31%)	18%	(7% to 40%)
Smoking and fibrinogen (model 5 vs model 2)	42%	(23% to 95%)	37%	(20% to 82%)	26%	(12% to 54%)

*p<0.05; **p<0.01; ***p<0.001.
Biological factors: systolic blood pressure, diabetes, body mass index, cholesterol, high-density lipoprotein cholesterol, height.
Lifestyle factors: fruit and vegetable consumption, alcohol intake, total physical activity.
Analysis restricted to 9237 men disease-free at entry and with all risk factors available.

factors, and in this analysis the residual contribution of smoking was 18%. For this endpoint many of the HR lay close to 1.0, indicating that most socioeconomic gradients in cardiovascular incidence could be largely explained by adjustment for biological and lifestyle risk factors, with lifetime smoking making a modest contribution. As these socioeconomic gradients were non-significant the additional percentage contribution made by lifetime smoking could not be reliably assessed.

DISCUSSION

In this study of mortality and cardiovascular incidence in Northern Ireland and France there were clear differences in the lifetime consumption of cigarettes in men from the two populations; an average (median) of 28 pack-years in Northern Ireland compared with 17 pack-years in France among ever smokers. Men in Northern Ireland reported smoking initiation at a median age of 16 years and men in France 18 years, with only

Table 3 Hazard ratios for death from any cause, smoking-related death and for a cardiovascular event by socioeconomic gradient, and estimated proportion of that gradient explained by smoking habit alone

	Adjusted for age, country		Adjusted for age, country biological and lifestyle factors excluding smoking		Adjusted for age, country biological and lifestyle factors including smoking		Percentage of adjusted effect explainable by smoking
	HR	(95% CI)	HR	(95% CI)	HR	(95% CI)	Explained (95% CI)
All causes of death							
Marital status	2.04***	(1.66 to 2.51)	1.80***	(1.46 to 2.23)	1.75***	(1.41 to 2.16)	6% (0% to 14%)
People in household	0.72***	(0.62 to 0.85)	0.76***	(0.65 to 0.89)	0.79**	(0.67 to 0.92)	11% (3% to 36%)
Living accommodation	1.92***	(1.59 to 2.31)	1.66***	(1.37 to 2.01)	1.47***	(1.21 to 1.79)	24% (14% to 40%)
Cars in household	0.59***	(0.51 to 0.67)	0.66***	(0.58 to 0.76)	0.71***	(0.62 to 0.82)	17% (11% to 32%)
Years of education	0.79***	(0.69 to 0.89)	0.84**	(0.73 to 0.95)	0.88*	(0.77 to 1.00)	26% (11% to 83%)
Educational level	0.85***	(0.79 to 0.92)	0.89**	(0.83 to 0.97)	0.93	(0.86 to 1.00)	32% (16% to 89%)
Economic activity	1.68***	(1.38 to 2.05)	1.48***	(1.19 to 1.85)	1.38*	(1.11 to 1.73)	18% (8% to 40%)
Material condition	0.72***	(0.66 to 0.80)	0.78***	(0.70 to 0.86)	0.83***	(0.75 to 0.91)	24% (15% to 43%)
Smoking-associated deaths							
Marital status	1.74**	(1.24 to 2.45)	1.54*	(1.09 to 2.19)	1.47*	(1.04 to 2.08)	11% (−3% to 55%)
People in household	0.76*	(0.59 to 0.98)	0.80	(0.63 to 1.03)	0.84	(0.65 to 1.07)	–
Living accommodation	2.00***	(1.50 to 2.67)	1.72***	(1.27 to 2.32)	1.43*	(1.05 to 1.94)	34% (19% to 80%)
Cars in household	0.59***	(0.48 to 0.73)	0.67***	(0.54 to 0.84)	0.74**	(0.60 to 0.93)	25% (13% to 69%)
Years of education	0.73**	(0.59 to 0.89)	0.78*	(0.63 to 0.98)	0.84	(0.67 to 1.04)	26% (9% to 139%)
Educational level	0.87*	(0.78 to 0.99)	0.93	(0.82 to 1.05)	0.97	(0.86 to 1.11)	–
Economic activity	1.88***	(1.38 to 2.56)	1.70**	(1.20 to 2.41)	1.54*	(1.09 to 2.19)	18% (5% to 51%)
Material condition	0.69***	(0.59 to 0.80)	0.74***	(0.63 to 0.86)	0.81**	(0.69 to 0.95)	30% (17% to 62%)
Cardiovascular event							
Marital Status	1.14	(0.86 to 1.50)	1.03	(0.78 to 1.37)	1.03	(0.78 to 1.36)	–
People in household	0.97	(0.81 to 1.15)	1.00	(0.84 to 1.19)	1.01	(0.85 to 1.20)	–
Living accommodation	1.40**	(1.13 to 1.75)	1.20	(0.96 to 1.51)	1.14	(0.91 to 1.43)	–
Cars in household	0.80**	(0.69 to 0.93)	0.91	(0.78 to 1.07)	0.95	(0.81 to 1.12)	–
Years of education	0.81**	(0.71 to 0.93)	0.91	(0.78 to 1.05)	0.93	(0.80 to 1.07)	–
Educational level	0.92*	(0.84 to 1.00)	0.97	(0.89 to 1.06)	0.99	(0.91 to 1.09)	–
Economic activity	1.58***	(1.26 to 1.98)	1.28*	(1.00 to 1.66)	1.23	(0.95 to 1.58)	18% (3% to 131%)
Material condition	0.86**	(0.77 to 0.96)	0.91	(0.81 to 1.02)	0.94	(0.84 to 1.05)	–

*p<0.05; **p<0.01; ***p<0.001.
Biological factors: systolic blood pressure, diabetes, body mass index, cholesterol, high-density lipoprotein cholesterol, height.
Lifestyle factors: fruit and vegetable consumption, alcohol intake, total physical activity.
Alcohol consumption (five categories) and smoking (never, non-cigarettes and three pack-year categories) fitted separately to data from France and Northern Ireland.

small differences between the French centres. In addition, 91% of men from Northern Ireland reported inhaling their cigarette smoke, whereas only 61% of French men reported this. Predictably more men from France smoked 'dark brand' cigarettes than did men from Northern Ireland (51% vs 11%, respectively). As in many cohort studies, subjects were recruited as volunteers from the general population, but were shown to be representative of the socioeconomic distributions of the background populations in each city region, as described in detail elsewhere.[13] However, it is still possible that subjects with unhealthy behaviours such as cigarette smoking were underrepresented in this study.

We examined to what extent the large differences between Northern Ireland and France in all-cause and smoking-associated mortality and in cardiovascular incidence could be explained by the lifetime smoking habit and biological risk factors including an inflammatory marker, fibrinogen (table 2). In a previous report[16] from this cohort at 5 years of follow-up differences in population levels of fibrinogen explained 30% of the differences in cardiovascular incidence between the two populations. However, in the 10-year follow-up in the present report this is reduced to 18%, and the combined effect of lifetime smoking and fibrinogen levels is 26% for cardiovascular incidence but 42% for all-cause mortality. These results suggest that both lifetime smoking habit and plasma fibrinogen levels are useful epidemiological tools for examining population differences in mortality and cardiovascular incidence.

Much of the difference in mortality and cardiovascular incidence remains unexplained by health behaviours and biological risk factors, but a recent report from the same study populations suggests that the pattern of alcohol consumption affects coronary heart disease incidence in the two countries.[17]

In other large epidemiological studies smoking habit generally 'explains' the largest proportion of the socioeconomic gradient that can be attributed to lifestyle risk factors, although all reported studies indicate that a large proportion (often more than 50%) of the gradient in socioeconomic mortality or cardiovascular incidence remains unexplained by health behaviours alone. In a 13-year follow-up in the Whitehall study of British civil servants,[18] current smoking habit explained 19% of the inequality index in occupational grade for coronary heart disease incidence. The addition of other behavioural, classical and novel risk factors increased the percentage 'explained' to 56%. The addition of height, a proxy indicator of socioeconomic status in childhood[19] further increased the percentage 'explained' to 62%.

Findings from studies such as these raise issues of primary causality: ie, whether long-term health behaviours influence biological risk factors, how early in life these health behaviours may be established, and whether health behaviours in middle age accurately reflect earlier health behaviours. We were able to examine this in the present study because lifetime smoking habit was measured and this was found to be much more closely related to socioeconomic gradients than was current smoking habit, particularly in France. Education rather than material conditions appeared to explain the largest proportion of the socioeconomic gradient in mortality and cardiovascular incidence. The Whitehall II Study of British civil servants proposed education as the underlying determinant of socioeconomic position, which may both directly and indirectly influence material conditions, health behaviours and psychosocial factors.[18] Education rather than income, assets and occupation appeared to explain a larger proportion of the risk of acute myocardial infarction in a large international case–control study (INTERHEART).[20] In The Netherlands a population study found that material conditions including type of health insurance, financial problems and housing tenure contributed most to mortality differentials by education level but partly by psychosocial and behavioural mechanisms.[21] In Norway a longitudinal study in Oslo[22] found that, in the subpopulation aged 45–64 years, occupational class and housing conditions all appeared to predict all-cause mortality to a similar degree, but that household income was less important.

As shown in table 1 the gradient in pack-years of smoking is greater for educational variables rather than for those reflecting material conditions and those reflecting possible psychosocial stress (unemployment and single/separated status). This suggests that, in the two distinct cultures of France and Northern Ireland, educational experiences (both cultural and environmental) may be of primary importance in setting the pattern for lifetime smoking behaviour. Perhaps it should be also recognised that smoking habit, or continued smoking habit into middle age, may reflect a behavioural response to environmental stressors, which may also exert an independently causal effect on mortality. Indeed, reports from large cohort studies have shown cigarette smoking to be associated with suicide.[23] At the suggestion of a reviewer, we examined the association of lifetime smoking on deaths that were either causally unrelated or only weakly related to smoking habit. For table 2 (between-country differences) these deaths showed much weaker and non-significant associations compared with those shown for total and smoking-related mortality. For table 3 (socioeconomic gradients) the contributions were generally less than those shown for smoking-related mortality. These residual contributions could suggest that smoking habit may also act as a marker for unmeasured personal and environmental factors, possibly stress related, which contribute independently to the socioeconomic and country gradients discussed in this report. This suggestion requires testing in other studies and in other cultures.

The current report may underestimate the contribution of lifetime smoking habit on the health outcomes presented because men with evidence or history of cardiovascular disease at baseline (n=891, 8%) were excluded from the present analyses. Such men have a much greater mortality and cardiovascular incidence than the largely healthy remaining cohort; lifetime smoking habit will be expected to have contributed to premature disease in these men, and may increase the

What is already known on this subject

- Current and former smoking habits are usually associated with socioeconomic position.

What this study adds

- Lifetime smoking shows a consistent gradient across seven socioeconomic gradients in two countries with different patterns of smoking behaviour.
- Lifetime smoking habit explains approximately a third of the all-cause and smoking-related mortality differential between France and Northern Ireland, but only 12% of the difference in cardiovascular events.

socioeconomic gradient. Re-analysis of the data to include these subjects resulted in an increase in the HR for all socioeconomic gradients for mortality and cardiovascular incidence, but the average values for the percentage of these gradients 'explained' by lifetime smoking remained largely unchanged.

CONCLUSIONS

The substantial gradients in mortality and in cardiovascular incidence between Northern Ireland and France and between socioeconomic groups within those countries are only partly explained by lifetime smoking habit. Substantial proportions of these gradients remain unexplained by the biological and lifestyle risk factors studied.

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