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ORIGINAL ARTICLE

Educational inequalities in smoking over the life cycle: an analysis by cohort and gender

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Abstract
Objectives The study investigates the life cycle patterns of educational inequalities in smoking according to gender over three successive generations.
Methods Based on retrospective smoking histories collected by the nationwide French Health Barometer survey 2010, we explored educational inequalities in smoking at each age, using the relative index of inequality.
Results Educational inequalities in smoking increase across cohorts for men and women, corresponding to a decline in smoking among the highly educated alongside progression among the lower educated. The analysis also shows a life cycle evolution: for all cohorts and for men and women, inequalities are considerable during adolescence, then start declining from 18 years until the age of peak prevalence (around 25), after which they remain stable throughout the life cycle, even tending to rise for the most recent cohort.
Conclusions This analysis contributes to the description of the "smoking epidemic" and highlights adolescence and late adulthood as life cycle stages with greater inequalities.

Keywords Life cycle · Inequalities · Smoking · Cohort · France

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Introduction

Risk-related behaviours, and in particular tobacco smoking, are major causes of avoidable morbidity and mortality (Khaw et al. 2008). Smoking is also more widespread in less privileged environments, in France (Peretti-Watel et al. 2009a) and in other European countries (Mackenbach et al. 2008), and it contributes markedly to health-related social inequalities (Balia and Jones 2008; Stringhini et al. 2010; Balia and Jones 2011; Cutler et al. 2011; Mackenbach 2011; Tubeuf et al. 2012). Compared to other countries such as the UK, social inequalities have been increasing in France since 2000 (McNeill et al. 2015). Measuring social inequalities in smoking and understanding the dynamics involved are important steps towards defining policies to reduce smoking, as well as health inequalities.

The socioeconomic literature has proposed various mechanisms explaining the relationship between social status and smoking (Cutler and Lleras-Muney 2010;

Pampel et al. 2010). Education could affect health because of better knowledge and better ability to use this knowledge to invest in health. The better-off individuals are also encouraged to invest in their health. Thus, the opportunity cost associated with health events increases with income, which could explain less frequent smoking initiation or earlier cessation for those who initiate. This protective effect of income may be outweighed by the effect of budget constraints which make tobacco more accessible to the better-off. Finally, social inequalities in smoking could be related to factors explaining both smoking and social situation, such as social background, risk-taking, social norms, genetic factors and cognitive abilities. These factors could contribute to changes in social inequalities in smoking with age, and also across generations.

Several studies have explored social inequalities towards tobacco use at different stage of the life cycle, in particular differences relating to educational status. They have shown that in adolescent populations the transition from experimentation to daily use was more frequent among young people from socially disadvantaged backgrounds (Gilman et al. 2003; Etilé 2007; Legleye et al. 2011a). It has also been found, using retrospective data among adults, that this more frequent transition from experimentation to daily use was also associated with less frequent cessation among the least educated (Fernandez et al. 2001; Schiaffino et al. 2003; Jefferis et al. 2004; Schulze and Mons 2006; Federico et al. 2007; Legleye et al. 2011b; Bricard and Jusot 2012; Maralani 2013). Those findings thus suggest that social inequalities accumulate in the course of the transition from adolescence to adulthood, with disparities in smoking initiation compounded by disparities in smoking cessation.

Further studies are needed to fully investigate the evolution of social inequalities in smoking over the life cycle, and explore whether the life cycle patterns have changed across generations. The theoretical reference framework is that of the "smoking epidemic", a model that conceptualises the process of initiation and adoption of smoking according to socioeconomic status, gender and generation (Lopez et al. 1994; Pampel 2005). Following this theoretical model, numerous studies have described the evolution of educational inequalities in smoking across generations (Schiaffino et al. 2003; Jefferis et al. 2004; Schulze and Mons 2006; Federico et al. 2007; Legleye et al. 2011b). In France, inequalities towards smoking appear more marked among men than among women, and recent work has shown an increase in inequalities in the most recent cohorts, for both smoking initiation and cessation (Peretti-Watel et al. 2009b; Legleye et al. 2011b). This pattern suggests that France is in the last phase of the smoking epidemic, during which prevalence declines and the social gap widens. In these studies, the evolution across cohorts for men and women was based on retrospective data on age at initiation and cessation, but the patterns of inequalities across the life cycle were not explored.

Nevertheless, the life cycle pattern of smoking inequalities is of great interest since it reveals critical ages for social differentiation in cigarette use. Our study is based on the assumption that smoking inequalities are variable across the life cycle and that patterns have evolved across generations. We expected variations in the life cycle pattern of smoking inequalities arising from differences in the timing of both initiation and cessation across social groups. We also expected changes in this pattern with generations following the smoking epidemic and the decrease in smoking in the privileged groups. Exploring these changes could contribute to a better understanding of both life cycle and generational dynamics in smoking inequalities.

This study aims to analyse the patterns of educational inequalities in smoking according to age and gender, over three successive generations (or cohorts), using smoking histories collected by the French Health Barometer 2010. This approach provides an overview of the whole life cycle of the individuals in each cohort, and enables comparisons of trends in the proportions of smokers according to age and educational level. Since this work describes the evolution of inequalities in smoking in a historical perspective covering the last five decades, it can provide valuable insights for designing prevention policies.

We will first describe trends in the prevalence of smoking at different ages according to gender and birth cohort. We will then set these smoking dynamics against educational level. Finally, we will provide a parametric analysis of inequalities towards smoking according to educational level, gender and birth cohort.

Methods

Data

This study used data derived from the Health Barometer 2010. This nationwide random telephone survey implemented by the national Institute for health education and prevention (INPES) ($n = 27{,}653$) is representative of the French-speaking population aged 15 to 75 living in France (Beck et al. 2011). A post-stratification weighting procedure was used to correct for total non-response. The variables considered were sex × age (8 categories), town size (6 categories), educational level (6 categories), and region of residence (9 categories).

The questionnaire made it possible to retrospectively date the age of initiation of daily smoking ("At what age did you start to smoke regularly or daily?") and the age at the time of smoking cessation ("How long is it since you stopped

smoking?"). Individuals with missing values for these ages were discarded ($n = 79$, 0.3 %). Assuming a continuous spell of smoking from the age the respondent started until the age s/he quit (ex-smokers) or the year of the survey (current smokers), we constructed a smoking indicator for every year between the age of 14 and the age at interview, scored one if a respondent smoked or zero otherwise.

The sample analysed was restricted to respondents who were at least 25 at the time of the survey, so as to integrate the final educational level reached, and to respondents under 70 to minimise any selection bias resulting from mortality. Three cohorts were analysed separately: those born between 1941 and 1955 (aged 55 to 69 at the time of the survey), those born between 1956 and 1970 (aged 40 to 54), and those born between 1971 and 1985 (aged 25 to 39).

Respondents' social situations were obtained from the highest educational level reached. Educational level falls into 4 categories coded according to the International Standard Classification of Education (ISCED) 2011: 1/ISCED 0, 1, 2 levels: below upper secondary education (low); 2/ISCED 3 and 4: upper secondary education and post-secondary non-tertiary education (medium); 3/ISCED 5: short-cycle tertiary education (high-short); 4/ISCED 6 and over: at least a Bachelor's degree or equivalent level (high-long). Descriptive statistics show an increase in the educational level with cohort, first in the middle cohort from an increase in the proportion of medium and high-short groups of education and then in the youngest cohort from an increase in the proportion of highly educated (Table 1).

Empirical strategy

There is a debate on the measurement of social inequality over time and in particular on the characteristics of indicators to be used (Wagstaff et al. 1991; Mackenbach and Kunst 1997). We chose to measure social situation through educational level to have a stable indicator during the life cycle thus providing a proxy for life conditions in childhood and also a major determinant of social status during the life cycle (Cutler and Lleras-Muney 2010).

We focus first on the life cycle evolution of prevalence by level of education to describe the evolution of the social gradient in smoking. Given the different ages of cohort respondents at the time of the survey, retrospective information was used to describe the smoking itinerary between 14 and 39 years for the 1971–1985 cohort, between 14 and 54 years for the 1956–1970 cohort and between 14 and 69 years for the 1941–1955 cohort, for men and women and by educational level.

We then studied smoking inequalities in relation to educational level at each retrospective age using a synthetic indicator, the relative index of inequality (RII) (Mackenbach and Kunst 1997; Hayes and Berry 2002). This indicator is based on the construction of a rank variable according to educational level, ranging from the most to the least educated. The rank variable was calculated separately for each gender and for groups corresponding to each year of birth. The RII is then obtained by the odds ratio associated with the rank variable in a logistic regression and can be interpreted as the excess risk for smoking associated with the lowest educational level in comparison with the highest level.

There are mainly two advantages in using this rank variable. First, it integrates the whole distribution of educational levels in the population at a given time, and enables calculation of a gradient instead of a mere comparison between two given educational levels. Second, it largely escapes the problem of the devaluing of educational diplomas by taking account of their distribution over time (Table 1). To do this, the rank variable was calculated separately for each gender and for the groups corresponding to each year of birth.

As the RII is a relative rather than an absolute indicator of inequality, it enables an analysis that is not dependent on

Table 1 Description of the sample according to educational level, cohort and gender—France, Health Barometer 2010

Educational level	Cohort 1941–1955		Cohort 1956–1970		Cohort 1971–1985	
	Men ($n = 2790$) (%)	Women ($n = 3848$) (%)	Men ($n = 3286$) (%)	Women ($n = 3925$) (%)	Men ($n = 3249$) (%)	Women ($n = 3842$) (%)
Low education (ISCED 0, 1, 2): below upper secondary education	35.7	46.1	26.4	30.0	17.8	18.7
Medium education (ISCED 3, 4): upper secondary education and post-secondary, non-tertiary education	43.2	37.4	51.0	47.9	50.3	42.1
High-short education (ISCED 5): short-cycle tertiary education	8.3	6.8	10.4	11.1	14.9	18.2
High-long education (ISCED 6 and over): at least a Bachelor's degree or equivalent level	12.8	9.7	12.2	11.1	17.0	21.0

ISCED International Standard Classification of Education

the evolution of the average prevalence with age. The overall RII by cohort and by gender was estimated in a simple logistic model adjusting for the rank variable, year of birth (as a continuous variable to capture the smoking differential within the 15 years of the birth cohort under study), and a vector of dummy variables of retrospective ages to adjust for the life cycle evolution of smoking prevalence. Finally to explore the evolution of smoking inequalities over the life cycle (i.e. the evolution of RII with retrospective age), we then substituted the rank variable by a set of interactive terms between retrospective ages and the rank variable of education to build a "complete" model.

One simple model and one complete model were estimated for each gender and cohort. In each of these models, the successive observations for a given individual from the retrospective age of 14 to the age at the time of the survey are not independent. Consequently, logistic models were estimated with heteroscedasticity adjustment on individual clusters. To improve the clarity of the figures, 95 % confidence intervals and odds ratio estimates are not always provided in the graphs.

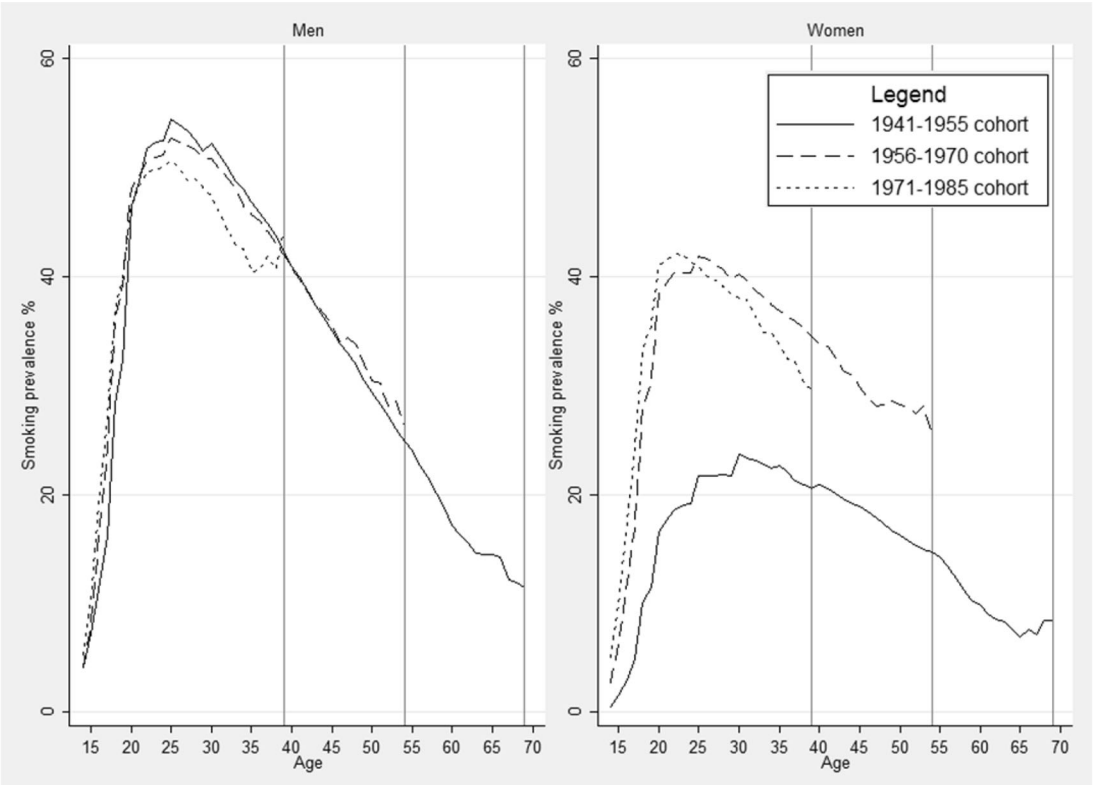
All statistics were weighted and computed with Stata/IC 11.2.

Results

Prevalence according to cohort, age and gender

Among men, smoking prevalence decreases slightly across generations from 54 % in the oldest generation to 51 % in the youngest (at 25), while it increases very markedly among women from 22 % in the oldest generation to 42 % in the middle generation, before falling off a little for the youngest generation to 41 % (at 25) (Fig. 1).

For all generations, the overall prevalence profile according to age shows a skewed bell-shaped curve: smoking prevalence increases rapidly between the ages of 14 and 20, continues to progress more slowly to the age of 25–30 and then decreases constantly. This profile is fairly similar for men and women, although the percentages of smokers are different. The smoking profile according to age does, however, show a slight evolution from one cohort to the next for men, and between the last two cohorts for women: smoking prevalence increases rapidly before the age of 20, but reduces faster after the age of 25 in the middle and youngest cohorts. Among men, the age of peak use does not vary noticeably from one cohort to the next



Note: smoking prevalence according to age are calculated per cohort and per gender via reconstruction of smoking histories
Population concerned: French men and women aged 25 to 69 at the time of the survey.
Source: National Institute for Health Education and Prevention (INPES), Health Barometer 2010, France.

Fig. 1 Prevalence of smoking according to age—men and women in the 3 cohorts (1941–1955; 1956–1970; 1971–1985) - France, Health Barometer 2010, retrospective data on smoking

(about 25), but there is a clear change for women (age 30 for the 1941–1955 cohort, 25 for the 1956–1970 cohort and 22 for the 1971–1985 cohort).

Prevalence according to educational level, per cohort and gender

For the oldest generation, prevalence according to educational level (Fig. 2) shows a small social gradient among men, and a reverse social gradient among women. Among men, the least educated are more frequently smokers than the others, while the differences are only slight across the other levels of education. At age 25, 57 % of the men with low education were smokers, compared to 53 % among the most highly educated. This gradient is observed among men up to the age of 40, and then it decreases and levels off after 45. At older ages, there is a slight inversion of the gradient, indicating more frequent cessation after 60 among men with low education, possibly for health reasons. Among women, no social differences are visible up to the age of 18. Afterwards, there is a marked reverse social gradient, with highly educated women being more likely to smoke than those with low education. Thus at age 25, 18 % of the least educated women were smokers versus 30 % of those with the highest educational level. This reverse social gradient is observed through to the oldest age groups.

The 1956–1970 generation is different from the preceding one in that the social gradient appears more pronounced in men, whereas there is an inversion of the gradient for women. The accentuation of this gradient among men is mainly attributable to a large reduction in smoking prevalence among the better educated in comparison to the previous generation. Thus at age 25, the prevalence of smokers among the highly educated is 40 %, while it is still 60 % for the least educated. Among women, this gradient appears to be reversing, but in contrast with men, the evolution of the gradient among women derives mainly from a marked increase in smoking prevalence among the least educated in comparison with the preceding generation, while prevalence among the most highly educated increases only slightly. Thus at age 25, 43 % of the least educated women were smokers, against only 38 % among the best educated.

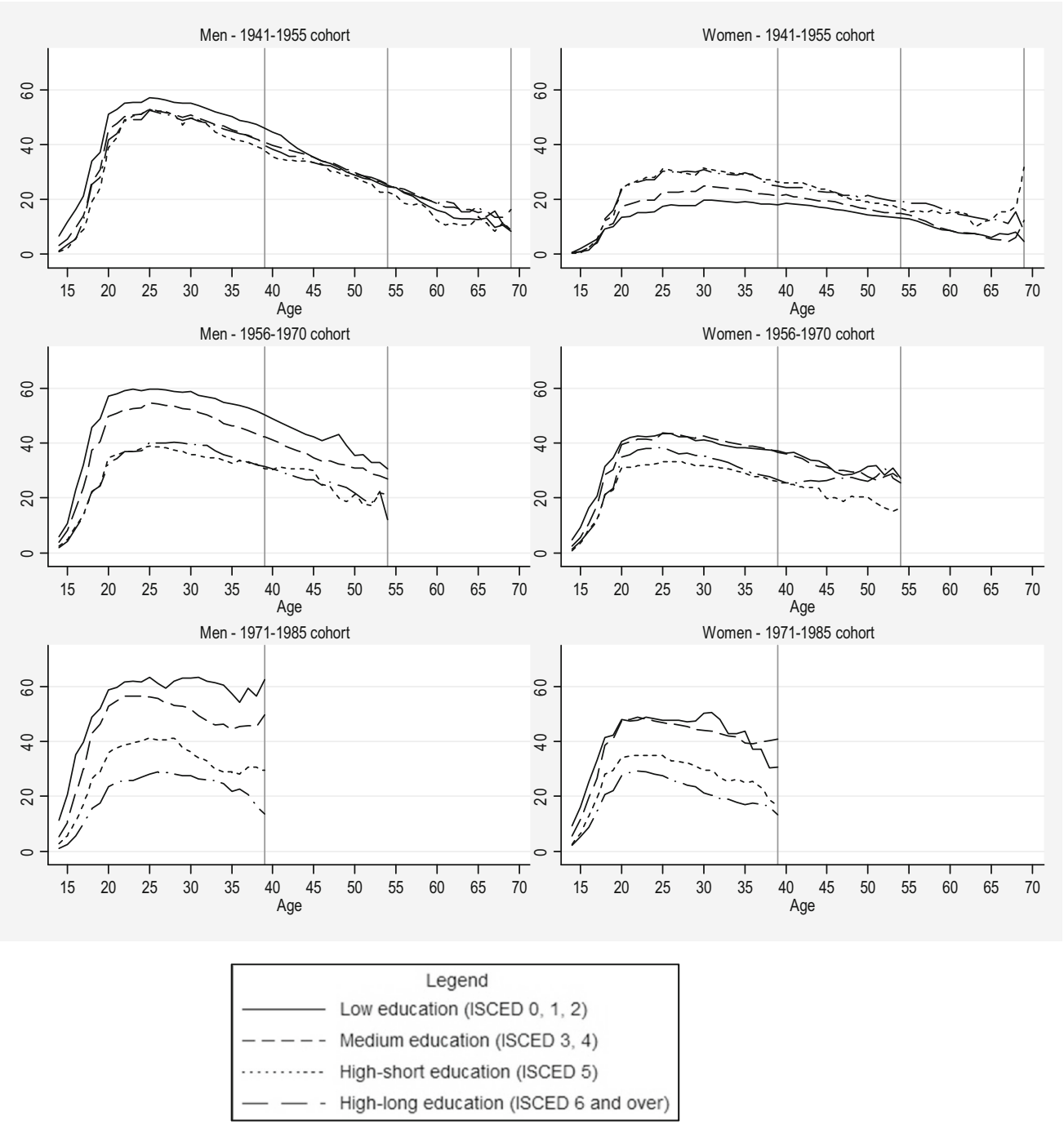
In the 1971–1985 generation, a very strong social gradient is observed among men and women alike, with the proportion of smokers decreasing constantly with the level of education, even at early ages. The gradient accentuates mainly among men via a decrease in smoking prevalence among the most educated, falling to 28 % at 25, and an increase in prevalence among the least educated, reaching 63 % at 25. The same pattern is observed among women, for whom the prevalence among the best educated falls to 28 % at 25, while it rises to 48 % among the least educated.

Life cycle evolution of RII

The overall RII within cohorts in the simple models confirms that educational inequalities in smoking prevalence increased across cohorts for men and women, and that the relationship was reversed for women in the oldest generation (Table 2). The complete models show that inequalities vary significantly between ages 14 and 39 for the oldest cohort and the youngest cohort among men, and for all three cohorts among women (see tests of equality of coefficients, online Table S1). The RII at each retrospective age is presented in Fig. 3 (see online Table S2 and S3).

Among men, the RII level is very high until the age of 18 for all three cohorts. After 18, inequalities remain significant but their magnitude varies from one cohort to the other and according to age. For the 1941–1955 generation, inequalities are particularly marked at the start of the life cycle, and then reduce rapidly: the value of RII thus falls from 8.7 at 15 years to 1.4 at 25, and then remains much the same until the age of 39. For the 1956–1970 generation, the level of inequality remains constant over the life cycle, at a lower level than observed at younger ages in the preceding generation, but above the level observed among adults of that generation. Finally, for the 1971–1985 generation, the level of inequality remains very high (over 5) at all ages and there is a slight U-curve observed over the life cycle, since inequalities are very marked among the youngest (with values over 10) and after 37 (values between 7 and 15). After the age of 40, a slight decrease in inequalities is observed for the two older cohorts, but inequalities remain significant to the age of 52 for the middle cohort and to 42 in the oldest cohort.

Among women, the RII is well above 1 before the age of 18 for the three generations, suggesting that at a young age social inequalities have always been considerable. In the oldest generation, after the age of 18 there is a reversal and inequalities appear in favour of the less-educated women with a RII under 1. In this cohort, towards the age of 40, the RII increases slightly, approaching 1, on account of relatively more frequent smoking cessation among the best-educated women. In the middle generation, RII values are always very high, over 1, before the age of 20, and relatively stable thereafter, at about 3, with a slight rise after 35. Finally, for the most recent cohort the profile is fairly comparable with that observed for men: the RII remains overall high over the life cycle, but at a level that is above that observed for the preceding generations. However, there is a narrower-U profile among women: inequalities increase from age 30, compared to 36 among men. The inequalities remain significant up to the age of 45 for the middle cohort, while they are in favour of the less-educated women up to the age of 62 for the oldest cohort.



Note: the prevalence rates of smoking according to age are calculated per cohort and per gender by reconstruction of smoking itineraries according to educational level.

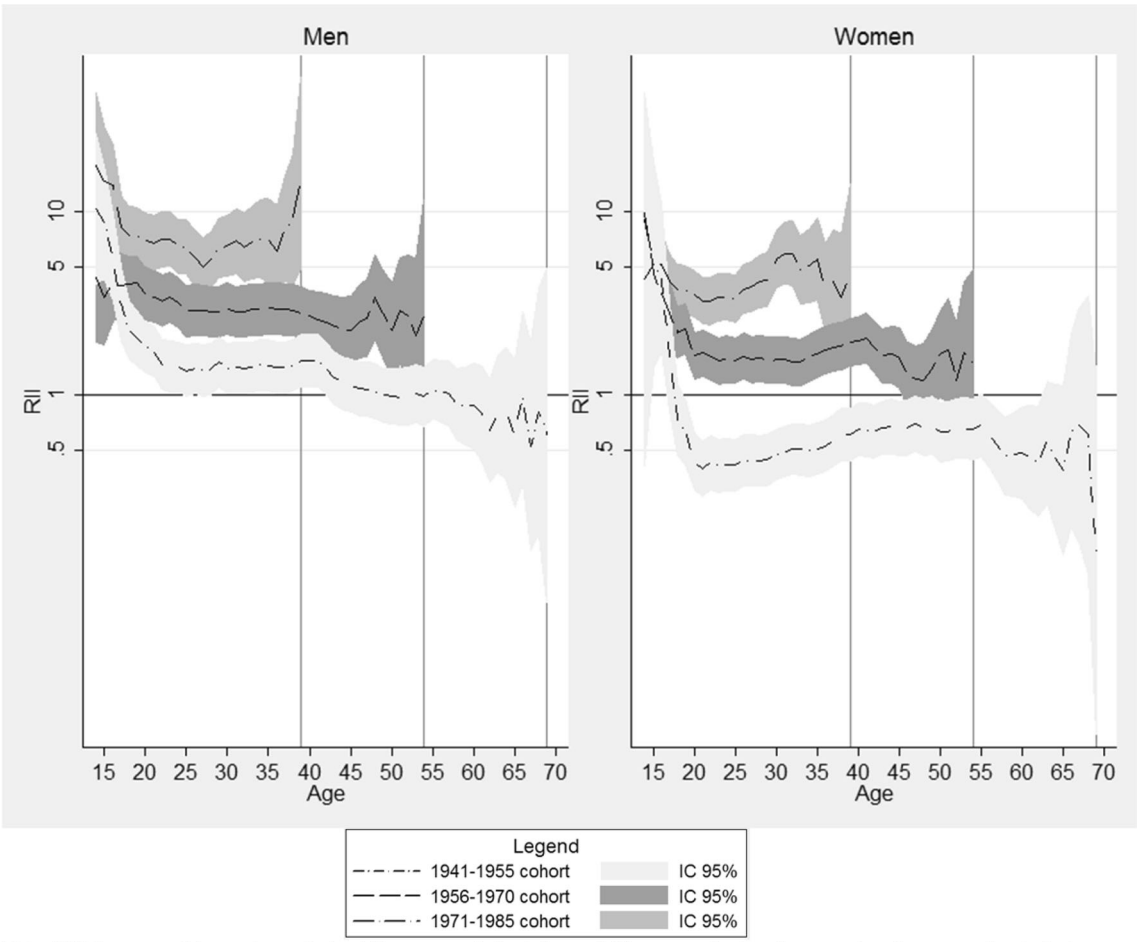
Population concerned: French men and women aged 25 to 69 at the time of the survey.

Source: National Institute for Health Education and Prevention (INPES), Health Barometer 2010, France.

Fig. 2 Prevalence of smoking according to age for the four educational levels: men and women in the 3 cohorts (1941–1955; 1956–1970; 1971–1985)—France, Health Barometer 2010, retrospective data on smoking

Table 2 Overall Relative Index of Inequality (RII) within cohorts: men and women in the 3 cohorts (1941–1955; 1956–1970; 1971–1985)—France, Health Barometer 2010, retrospective data on smoking

	Men			Women		
	RII	*p* value	95 % CI	RII	*p* value	95 % CI
Cohort 1941–1955	1.6	0.001	1.2; 2.1	0.5	0.000	0.4; 0.7
Cohort 1956–1970	3.1	0.000	2.4; 4.1	1.7	0.000	1.3; 2.3
Cohort 1971–1985	6.9	0.000	5.2; 9.3	4.0	0.000	3.1; 5.3



Note: RII shown on this graph are derived from separate logistic modelling per cohort and per gender; they are estimated via interaction between age and the reconstructed rank variable for educational level; they are represented by the odds-ratios associated with this variable, and therefore should be interpreted in relation to 1
Population concerned: French men and women aged 25 to 69 at the time of the survey.
Source: National Institute for Health Education and Prevention (INPES), Health Barometer 2010, France.

Fig. 3 Relative index of inequality (RII, logarithmic scale) according to age: men and women in the three cohorts (1941–1955; 1956–1970; 1971–1985)—France, Health Barometer 2010, retrospective data on smoking

Discussion

The aim of this study was to analyse the evolution of social inequalities in smoking across generations and over the life cycle. This study therefore contributes to knowledge on social inequalities in smoking and on the tobacco epidemic by providing new results on the precise dynamics of social inequalities by age, and highlights the evolution of this dynamic across generations. In particular, the use of individual smoking histories and the computation of RII for

each age in three different cohorts enable analysis of the historical evolution of the life cycle patterns of the social gradient in smoking.

This study shows the evolution of the diffusion of smoking among social groups and according to gender in the course of past decades. We demonstrate a significant increase in social inequalities in smoking prevalence across cohorts for men and women, including a reversal of the social gradient for women, in line with recent findings from initiation and cessation analyses in France (Legleye et al. 2011b). This reversal of the gradient derives from a sharp increase in smoking among the less-educated women who are catching up with men, for whom the trend occurred earlier, confirming the delay of one generation between men and women in the smoking epidemic. First in men, then in women, the increase in social inequalities mainly results from a continuous decline in smoking among the highly educated, in addition to its progression among the least educated.

The analysis also shows a life cycle evolution in social inequalities with large smoking inequalities before the age of 18, for all cohorts and for men and women. Starting from 18 years, the inequalities reduce until the peak age of prevalence (around 25) and then remain at a stable level throughout life or even tend to rise for the most recent cohort. The inequalities were systematically high during adolescence with no downtrend across cohorts, which confirms that smoking inequalities become established in this period of life (Maralani 2013). The considerable inequality during adolescence results from a faster initiation among the least educated resulting in earlier peak prevalence compared to the highly educated, and confirms marked resistance of the highly educated to the initiation of regular smoking. The persistence of a high level of inequalities at younger ages can also be linked to low family socioeconomic status, personal and family difficulties, possibly explaining both smoking initiation and subsequent lower level of education (Graham et al. 2006; Etilé 2007; Cutler and Lleras-Muney 2010; Legleye et al. 2011a). These increases in prevalence compounded by social inequalities at these ages show the inefficiency of French public policies to prevent smoking initiation during adolescence (Lermenier-Jeannet 2014), while it has been presented as an important issue for public policies.

The increase in smoking inequalities after the peak age of prevalence (around 25) for the younger cohort reflects earlier cessation by the highly educated and shows the importance of adopting a life cycle perspective, as inequalities persist in smoking cessation. This period of life corresponds to the end of the transition to adulthood which is a period of changes in health behaviours (Staff et al. 2010; Oesterle et al. 2011). Health behaviours, such as smoking, may be affected by the socioeconomic status reached at this time and the transition to adult activity and family roles which could explain differences in smoking across social groups (Pampel et al. 2014). The later widening of inequalities may be related to the timing of life course transitions influencing smoking, and to a more pronounced social gradient in smoking cessation during pregnancy for women (Graham et al. 2010; Lelong et al. 2011). Unfortunately, the ages of life course events and the trajectories of socioeconomic status were not recorded in our survey, preventing us from studying the contribution of these factors to patterns of smoking inequalities. This approach would be a promising line of research for future studies, to understand changes in the dynamics of smoking inequalities by educational level for men and women.

The use of retrospective data on smoking enables the study of social inequalities in smoking in both a historical and a life cycle perspective, but there are possible biases. First, differential mortality among smokers could lead to an underestimation of the prevalence of smoking for older cohorts. This mortality bias is minimised in our analysis by restricting the sample to individuals under 70 as suggested by a study testing the validity of retrospective data on smoking (Christopoulou et al. 2011). The use of retrospective data on smoking could also entail recall bias and reporting errors. It was demonstrated that these biases were lower for heavy smokers (Kenkel et al. 2004) but we cannot address this problem because of lack of information on the number of cigarettes that former smokers were smoking. These biases may vary with level of education and lead to underestimating educational inequalities in smoking in the case of under-reporting by the less educated. The reconstruction of smoking itineraries is also limited by the recall of a single smoking period per individual, not allowing for temporary quitting, which is commoner among the less educated, whose attempts to quit are more numerous and less successful (Kotz and West 2009; Caraballo et al. 2014). Nevertheless, the use of retrospective data on smoking avoids attrition and mortality with age which can be encountered with longitudinal studies.

Our findings support a focus on specific social groups and age groups by public policies concerning smoking, and in particular suggest the need to concentrate efforts on preventing of daily smoking initiation from very early ages among the least educated, and on help and encouragement to successfully stop smoking during the transition to adulthood.

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