Social Science & Medicine 127 (2015) 41–50

Contents lists available at ScienceDirect

Social Science & Medicine

journal homepage: www.elsevier.com/locate/socscimed

Cohort changes in educational disparities in smoking: France, Germany and the United States

Fred Pampel [a], Stephane Legleye [b, c, d], Céline Goffette [b], Daniela Piontek [e], Ludwig Kraus [e, f], Myriam Khlat [b, *]

[a] University of Colorado, Boulder, USA
[b] Institut national d'études démographiques, Paris, France
[c] Inserm U669, Paris, France
[d] University Paris-Sud and University Paris Descartes, UMR-S0669, Paris, France
[e] IFT Institut für Therapieforschung, Munich, Germany
[f] Centre for Social Research on Alcohol and Drugs, SoRAD, Stockholm University, Stockholm, Sweden

ARTICLE INFO

Article history:
Available online 21 June 2014

Keywords:
Cohort
Gender
Education
Smoking
Tobacco epidemic
France
USA
Germany

ABSTRACT

This study investigates the evolution of educational disparities in smoking uptake across cohorts for men and women in three countries. Nationally representative surveys of adults in France, Germany and the United States in 2009–2010 include retrospective measures of age of uptake that are compared for three cohorts (born 1946–1960, 1961–1975, and 1976–1992). Discrete logistic regressions and a relative measure of education are used to model smoking histories until age 34. The following patterns are found: a strengthening of educational disparities in the timing of uptake from older to younger cohorts; an earlier occurrence of the strengthening for men than women and for the United States than France or Germany; a faster pace of the epidemic in France than in the United States, and; a divide between the highest level of education and the others in the United States, as opposed to a gradient across categories in France. Those differences in smoking disparities across cohorts, genders and countries help identify the national and temporal circumstances that shape the size and direction of the relationship between education and health and the need for policies that target educational disparities.

As a major determinant of chronic disease and premature mortality, tobacco use remains central to individual and population health. The WHO estimates that in 2004 25% of male deaths and 7% of female deaths in the European region and 23% of deaths for both men and women in the United States came from tobacco use (WHO, 2012). Smoking and exposure to tobacco smoke harms people at all ages, causing respiratory diseases during childhood, increased cardiovascular disease in middle age, and higher rates of cancer at older ages. It remains the leading risk for disease in high-income North America and Western Europe (Lim et al., 2012).

Given its importance for health, the substantial decline in the prevalence of tobacco use in Western Europe, the United States, and many other countries throughout the world has been encouraging (Fiori and Baker, 2009) and in part reflects the success of anti-tobacco campaigns and public health programs (Joossens and Raw, 2006; Wilson et al., 2012). At the same time, smoking has increasingly become concentrated among lower socioeconomic status (SES) groups in high-income nations (Cavelaars et al., 2000; Giskes et al., 2005; Huisman et al., 2005; Pampel, 2002a). Of particular importance, the decline in smoking has occurred fastest among high educational groups, thus widening the gap with lower educational groups and contributing to growing educational disparities in mortality more generally (Jha et al., 2006). Widening inequality in tobacco use and its harm present a public health problem in protecting those who can least afford its financial or health costs.

Educational disparities in smoking reflect the lack of resources among disadvantaged groups but involve a diverse set of mechanisms (Cutler and Lleras-Muney, 2010). The fewer resources of disadvantaged groups produce a set of cumulative consequences: they increase stress that makes smoking an attractive coping strategy, limit access to health information, give groups with high mortality risks overall less incentive to avoid the harm of smoking, are associated with more limited time horizons, reduce the social capital available for help in avoiding smoking, and make it harder to

* Corresponding author.
E-mail address: khlat@ined.fr (M. Khlat).

http://dx.doi.org/10.1016/j.socscimed.2014.06.033

quit (Pampel et al., 2010). Yet, arguments for these mechanisms involve more in the way of theorizing than empirical evidence.

Macro-level variation across time and nations in the size and direction of disparities in smoking may give some insight into the relationship between education and health. Rather than an invariant feature of populations that consistently reflects the advantages of having more resources, educational disparities show surprising diversity. Even among nations with similarly high income, education is sometimes associated with greater rather than lower smoking (Huisman et al., 2005). This variation implies that the resources of highly educated groups can be used for unhealthy as well as healthy activities and that the risks to populations with low education can change substantially.

A framework based on the concepts of a smoking epidemic and diffusion of innovations has been used to make sense of cross-national and temporal variation in the relationship between education and tobacco use. The epidemic model of smoking (Lopez et al., 1994; Thun et al., 2012) posits a four-stage process of population change in tobacco use and associated mortality. The epidemic involves an initial but slow rise in smoking prevalence (stage 1) that is followed by a rapid rise in prevalence and a growing number of smoking-related deaths (stage 2). With the increase in smoking-related deaths, smoking prevalence begins to drop (stage 3), and continues to drop in larger numbers (but not disappear altogether), eventually reducing smoking-related deaths (stage 4). Perhaps because of gender inequality, traditional restrictions on activities of women, and ascription to gendered social roles and behaviors (Amos and Haglund, 2000), males adopt cigarettes first and females are affected by the epidemic of smoking after a lag (Harman et al., 2006; Pampel, 2002b).

To extend the epidemic model and account for variation by SES, a diffusion of innovations mechanism can be posited to underlay the patterns of change (Mackenbach et al., 2004). The temporal process begins with adoption of smoking by innovative, high SES groups, which tend in general to be the first to use innovations (Rogers, 2003). Diffusion of the innovation to lower SES groups follows, which tends to eliminate the initial positive SES-smoking gradient. A later innovation, rejection of smoking and adoption of healthy behaviors, again begins with high SES groups and leads to the initial emergence and subsequent growth of a negative SES-smoking gradient in the most recent decades. Thus, a positive SES gradient in smoking at the very early stages of the epidemic is replaced by a weak gradient and later by a negative gradient at the latest stages of the epidemic (van der Heyden et al., 2009). Although it will take many more decades (Fiori and Baker, 2009), rejection of smoking may eventually diffuse throughout the population.

In this paper, we use a comparative approach to examine patterns of cohort change in smoking uptake by education across France, Germany, and the United States, three nations with different histories of tobacco use and policy contexts. The approach is used to address three questions: How does the educational gradient evolve across cohorts? Do the cohort-based changes vary for men and women? And do the patterns of change vary across nations? Previous studies have described the overall pattern of change in the epidemic but have done less to understand how it varies across contexts. In answering our questions, we add to the literature by considering country differences in the timing of the epidemic, the speed of change, and the structure of the educational inequality. Better describing the country-specific evolution of the smoking epidemic can improve the understanding of the relationship between education and health. Attending to the macro determinants of the relationship complements the more typical study of individual-level characteristics and can give some insight into the policies needed in different contexts to reduce disparities.

1. Study framework

The temporal pattern of change posited by the epidemic and diffusion model implies variation across cohorts, genders, and countries. The adoption of smoking is strongly influenced by cohort membership and the smoking environment at the time a cohort reaches late adolescence and early adulthood (Preston and Wang, 2006). High education groups appear more likely to take up the habit when it is relatively rare but reject the habit when it is relatively common, whereas low education groups tend to do the opposite (Legleye et al., 2011a; Pampel, 2005). Hence, older cohorts should show a weak positive SES-smoking gradient and, reflecting a reversal in the direction of disparities, newer cohorts should show a strong negative SES-smoking gradient. Moreover, since women tend to adopt smoking later than men, the cohort shift in the gradient should occur more recently among females than males.

Arguments about the diffusion of tobacco use apply to both uptake dynamics and cessation dynamics as contributors to smoking prevalence inequalities. However, the two processes differ substantially, with cessation proving more difficult and requiring more resources than initiation. Although educational disparities in cessation are strong (Reid et al., 2010), initiation is an important contributor to the patterns of educational inequality in adult smoking (Maralani, 2013). Despite calls for more study of initiation (Schaap and Kunst, 2009), however, most studies examine disparities in uptake for one nation (e.g., (Legleye et al., 2011a; Schulze and Mons, 2006)). We focus on cross-national comparisons of the timing of initiation, an event that precedes cessation in temporal order and provides a context for other studies of the timing of cessation.

The focus on initiation across cohorts, genders, and nations adds to the more typical study of educational disparities in smoking prevalence. Studies of prevalence find greater disparities among younger than older cohorts in single nations (e.g. Pampel, 2005) and in international comparisons (Cavelaars et al., 2000; Giskes et al., 2005; Huisman et al., 2005; Pampel, 2002). While prevalence mixes initiation and cessation, measures of the age of initiation capture additional information on timing.

Cross-national studies of smoking typically rely on education as a measure of socioeconomic position (Cavelaars et al., 2000; Giskes et al., 2005; Huisman et al., 2005), as education more strongly predicts smoking than income or occupation (Barbeau et al., 2004). Since smoking begins early in life, uptake should be more influenced by success in school, academic goals, and completed education than by later occupational and income attainment. While education remains stable for most after young adulthood, occupation and income change greatly over the life course and are less easily measured for those not working. Further, the International Standard Classification of Education (ISCED) allows for meaningful comparisons across nations (UNESCO, 2006).

2. Research hypotheses

Specific hypotheses may be formulated in relation with the relative degree of advancement in the epidemic of the three countries subjected to comparison.

1. Timing of emergence of a negative gradient and size of disparities.

Based on the timing of the smoking epidemic, countries differ in cohort changes in smoking disparities (van der Heyden et al., 2009). The sooner the epidemic begins in a country, the farther it advances over time and the larger the disparities will be. Given its location as a source of tobacco farming, the invention of machines to mass

produce cigarettes, and aggressive advertising by tobacco companies (Kluger, 1996), the United States began the tobacco epidemic relatively early. Additionally, due to special commercial efforts, female consumption was especially valued and encouraged in the United States in the 1920's, leading to an early and rapid development of tobacco smoking among women (Amos and Haglund, 2000). In Germany and France, smoking was adopted in large numbers later. As evidence, figures on sales of manufactured cigarettes (Forey et al., 2013) show a peak in 1963 for the United States, 1976 for Germany, and 1985 for France. Another measure takes advantage of the divergence of male and female smoking in early stages and the convergence in later stages (Gallus et al., 2006). Using figures in (Eriksen et al., 2012), the ratio of female to male smoking-attributable mortality equals 0.20 in France (5% versus 25%), 0.41 in Germany (9% versus 22%), and 1.00 in the United States (23% versus 23%). Given the earlier start of the epidemic in the United States, we can expect to see a negative educational gradient in smoking emerge earlier than in France and Germany. The peak year in cigarette sales suggests that Germany will fall between the United States and France in the size of the disparities.

2. Pace of change across countries and across genders

The variation across countries in timing of the epidemic suggests another component of the diffusion process: The rate of change in the cycle may be faster for countries that start later. The early rise of cigarette use in the United States, which occurred well before a scientific consensus on the harm of tobacco emerged, may extend the process of change in disparities. The later start in France and Germany means that the process of change occurred in an environment of more extensive knowledge of the harm of smoking, which should speed the decline in tobacco use among the highly educated and the growth of disparities. Also, policies in the United States emerged slowly in a decentralized fashion, whereas they occurred later but more quickly and comprehensively in Europe under the guidance of the Framework Convention on Tobacco Control (Eriksen and Cerak, 2008). Along with earlier emergence of the negative gradient in the United States, then, we can expect to see a slower pace of change in the strengthening of the gradient than in France or Germany. Also based on an earlier start, men should show a slower pace of change than women.

3. Pattern of educational disparities

The pattern of cohort change in educational disparities in smoking may be influenced as well by the structure of the educational systems. In the United States, a college education tends to define a strong dividing line for a wide variety of outcomes (Fisher and Hout, 2006). The high proportion of the population 25 and over attaining tertiary education (38.3% for men and 39.9% for women (UNESCO, 2013) may serve to downgrade the value of other degrees and create a gap between the college educated and others that can affect smoking. In France, where university attendance is more selective and attainment of a tertiary education less common (24.2% of men and 24.7% of women (UNESCO, 2013)), intermediate positions in the hierarchy may moderate differences between college graduates and others. Tertiary educational attainment in Germany resembles that in France but with a larger gender difference (29.6% of men and 19.2% of women complete tertiary education (UNESCO, 2013)). Thus, we expect a stronger contrast between college graduates and other groups in the United States and a more continuous gradient in educational disadvantage in France and perhaps in Germany, especially for women in this latter country.

3. Data and methods

Data come from three comparable surveys: 1) the French Health Barometer 2010, a representative nationwide telephone survey of the non-institutionalized population aged 15–85 (Beck et al., 2011), 2) the 2009 German Epidemiological Survey of Substance Abuse, a representative survey of the German-speaking non-institutionalized civilian population aged 18–64 that uses a mixture of paper-and-pencil questionnaires, telephone interviews and internet questionnaires (Kraus and Pabst, 2010), and; 3) the 2010 U.S. National Health Interview Survey Adult Sample, a representative nationwide face-to-face survey of individuals ages 18 and older within households and non-institutional group quarters (National Center for Health Statistics, 2013). For the population studied here, men and women at ages 18–64 with complete education and smoking data, the sample sizes equal 21,504 in France, 21,818 in the United States, and 7887 in Germany.

In France, the survey used a two-stage simple random sample: household (with random digital dialing and including mobile and internet phones) and then one person within the household (Kish method based on the age and gender composition of the household). The response rate was 60.5%. Weights adjust for survey design, non-response and the proportion of mobile phones and use a calibration process based on age, sex, diploma, employment status and region to match the distribution of the last national Labor Force Survey. In Germany, the survey used two-stage probability sampling, first with the selection of communities proportional to population size and second with the selection of individuals from residents' registration office. The design oversampled younger birth cohorts. The response rate was 50.1%. Weights adjust for sampling design and the national distribution of age, gender, federal state, and size of the community. In the United States, the survey used a stratified multistage procedure that oversamples minority groups. The response rate was 60.8%. Weights adjust for design, non-response, and post-stratification adjustment (to match the age-sex-race/ethnicity distribution in the census).

3.1. Measures

Each data set includes measures of the age at smoking uptake for those who had ever smoked regularly. In the French data, uptake refers to regular smoking with a follow-up probe on daily smoking for uncertain respondents ("A quel âge avez-vous commencé à fumer régulièrement, i.e. tous les jours?"). This question was asked to current regular or former regular smokers (who had been smoking at least six months). In the German data, uptake refers to age of starting to smoke daily ("Wie alt warenSie, alsSiebegonnenhabentäglichzurauchen?"). This was asked to individuals who had smoked at least 100 cigarettes in their lives. In the U.S. data, uptake refers to regular smoking; "How old were you when you FIRST started to smoke fairly regularly?" This question was asked to current or former smokers (who had smoked 100 cigarettes in their lifetime). In addition, the French and German data sets, but not the U.S. data set, have measures of age first tried smoking, a precursor to regular smoking.

Age in 2010 is used to define three cohorts for comparison: ages 50–64 (born 1946–1960), ages 35–49 (born 1961–1975), and ages 18–34 (born 1976–1992). Cohorts born earlier and excluded from the analysis are subject to recall problems and high levels of differential mortality. To make the comparisons of smoking meaningful across cohorts, the ages of initiation for the older cohorts are restricted to age 34, the upper bound of the youngest cohort. Initiation after those ages is considered censored. To control for the sometimes different smoking patterns of immigrants, two

dichotomous measures equal one for born in the country and one for citizen of the country. Controls for race and ethnicity, which are available only in the U.S. data, do not change the results. Effects of education in the U.S. with the controls are similar or slightly larger than without controls, but the extra controls were not used in the tables to make the results comparable to the other nations.

Education is measured in four categories. To be comparable across countries, these categories are coded from national diploma typologies using ISCED 1997 standards (UNESCO, 2006): 1) ISCED 0, 1 and 2 levels: below upper secondary education (Low); 2) ISCED 3 and 4: upper secondary education and post-secondary non tertiary education (Medium); 3) ISCED 5B: first level of tertiary education (High-short); 4) ISCED 5A and over: tertiary education (High-long). In the USA, the category "some college, no degree" is often recorded in surveys and reported in official reports, even if it is not a credential. Since the highest diploma held by individuals with some college is a high school diploma, those individuals might be classified with high school graduates (i.e., ISCED 3). However, following Kerckhoff et al. (2002), we consider "some college" as a kind of American credential that is classified in the first level of tertiary education (High-short). Descriptive statistics for the key variables are presented in Table 1.

Based on the four categories, we use a relative measure of education to take into account the fact that cohorts did not experience the same educational conditions. For each gender, cohort, and country, a measure of relative educational position based on diploma level is computed using ridit scoring (Bross, 1958). The ridit assigns to each individual the proportion of the overall population that has a higher education plus half of the proportion of the individuals having the same educational level. The ridit is therefore a continuous measure of relative education ranging from 0 to 1 (0 and 1 excluded), with individuals in the lowest educational group (Low) having the highest score, and individuals in the highest educational group (High-long) having the lowest score. Mackenbach and Kunst (1997) refer to the regression-based coefficient for the ridit as the Relative Index of Inequality (RII).

Table 1
Descriptive statistics (weighted sample).

	France $n = 21{,}818$	Germany $n = 7887$	USA $n = 21{,}054$
Ever smokers (%)	50.1	48.5	37.9
Age at smoking uptake or censored: Mean (SD)	29.6 (14.8)	41.6 (12.8)	30.9 (13.2)
Age at smoking uptake (Not censored)[a]: Mean (SD)	18.6 (4.3)	18.2 (4.2)	17.6 (4.06)
Age 50–64 (%)	31.3	30.9	30.3
Age 35–49 (%)	34.6	37.3	32.7
Age 18–34 (%)	34.1	31.8	37.1
Male (%)	49.1	50.8	49.4
Education level: Low (ISCED 0, 1, 2) (%)	26.6	10.4	12.8
Education level: Medium (ISCED 3, 4) (%)	48.2	53.0	25.9
Education level: High-short (ISCED 5B) (%)	11.9	11.5	28.0
Education level: High-long (ISCED 5A and over) (%)	13.3	25.2	33.3
Born in country (FR/DE/US) (%)	88.9	90.3	82.0
Citizen of country (FR/DE/US) (%)	94.6	95.5	90.6

[a] $n = 10{,}653$ (France); 4066 (Germany); 8064 (USA).

3.2. Data analysis

Smoking patterns by cohort, gender, and education for each country are described by failure curves from ages 11–34. The curves plot the cumulative proportion of smokers in each educational category who began regular smoking at each age.

Multivariate discrete-time regression was used to model age at smoking initiation, with never smokers being right censored. The hazard models control for the relative measure of education, current age, years followed from age 10 and their quadratic, and dummy variables for native born and citizenship. Gender also serves as a control, but interaction terms allow for the effects of education to vary across men and women. The odds ratio for men relative to women and the odds ratio of the effect of relative education for men relative to women come from models with men and women combined. The former equals the coefficient for gender and the latter equals the coefficient for an interaction term for gender times the ridit measure of relative education. We systematically tested the interactive effects of country, cohort and gender and found that most of them were significant. For this reason, we provide, compare and comment only the results of the models ran by country and cohort (eventually gender) separately. Although age at first cigarette was not available in the U.S. data, separate models with and without the covariate were also examined for France and Germany. Analyses using weights do little to change the results, and the unweighted results are presented here, while the weighted results can be found in Supplementary Table S1.

To both depict and summarize the educational gradients in initiation across cohorts and nations, the figures list the odds ratios for the ridit measure of education (or the RII) from the multivariate discrete-time survival models that adjust for the covariates. The full tables for the logistic regressions are included in Supplementary Tables S2–S4 and the results for interactions of country, cohort and gender -and other three-ways interactions combining gender, education, cohort and country- are shown in Supplementary Table S5.

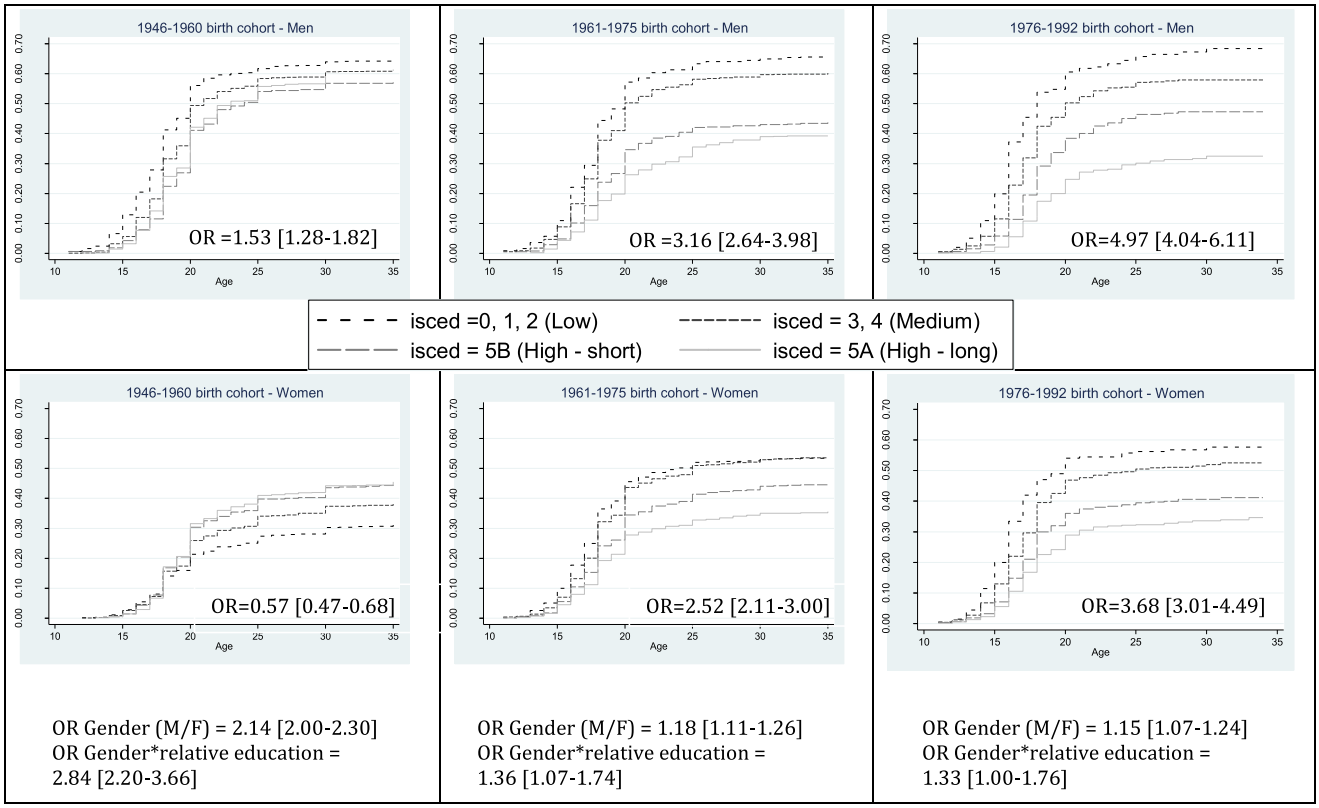
4. Results

4.1. Uptake of regular smoking

The hazard curves by cohort, gender, and country reveal differences in the educational gradient in uptake of regular smoking. For the oldest cohort of men in France, the curve rises fastest for the least educated group and slowest for the highest educational group (Fig. 1). The cumulative hazard of smoking uptake increases quickly during adolescence but changes little after age 20. For the youngest cohort of men in France, the hazard curves reveal the emergence of a strong gradient. By the early twenties, the cumulative hazard for the lowest educational group reaches a plateau of nearly 70% of ever smokers compared to a maximum of 32% for the highest educational group.

The odds ratio for relative education summarizes the change in the educational gradient. For the oldest cohort of men in France, the odds ratio for the lowest to the highest education level of 1.53 shows a modest gradient. For younger cohorts, odds of uptake of regular smoking are 4.97 times higher for the lowest educational group than the highest. In Germany (Fig. 2), the gradient in uptake of regular smoking changes little across cohorts, staying at relatively low levels for men of 1.69, 2.15, and 1.38.

In the United States (Fig. 3), a pattern of change similar to that found for France appears, but the odds ratio for education is higher for the oldest cohort in the United States (2.97) than in France (1.53). For the youngest cohort, the gradient is similarly large in the United States (5.18) as in France (4.97).



Isced=0, 1, 2 (Low) to 5A(High - long): educational level (see Measures section)
OR = adjusted OR for relative education with controls (age in 2010, follow-up, follow-up², native born, and citizen), i.e. RII
OR Gender (M/F) = adjusted OR for gender (male relative to female) with controls (and relative education)
OR Gender* relative education= adjusted OR for gender*relative education with controls (i.e., RII for males relative to females)

Fig. 1. Proportion having ever smoked regularly by age in the different educational groups – France.

For smoking uptake among women, the gradient of the oldest cohort in France is in the opposite direction of men. The odds ratio for education of 0.57 indicates faster uptake among more educated women rather than less educated women (Fig. 1). However, the positive gradient shifts across cohorts to favor more educated women. For the youngest cohort, the odds in France are 3.68 times higher for the least educated than the most educated women. The cohort pattern for women in Germany (Fig. 2) resembles that for France. The odds ratio increases from near one for the oldest cohort to 2.15 for the youngest cohort. In the United States, the gradient for women changes in the same direction but differs from the other two countries for the oldest cohort (Fig. 3). Unlike France and Germany, the odds ratio for the oldest cohort of 1.96 reveals a greater hazard among less educated women. For the youngest cohort, the odds ratio of 3.82 for the United States is similar to the odds ratio of 3.68 for France and larger than the odds ratio of 2.15 for Germany.

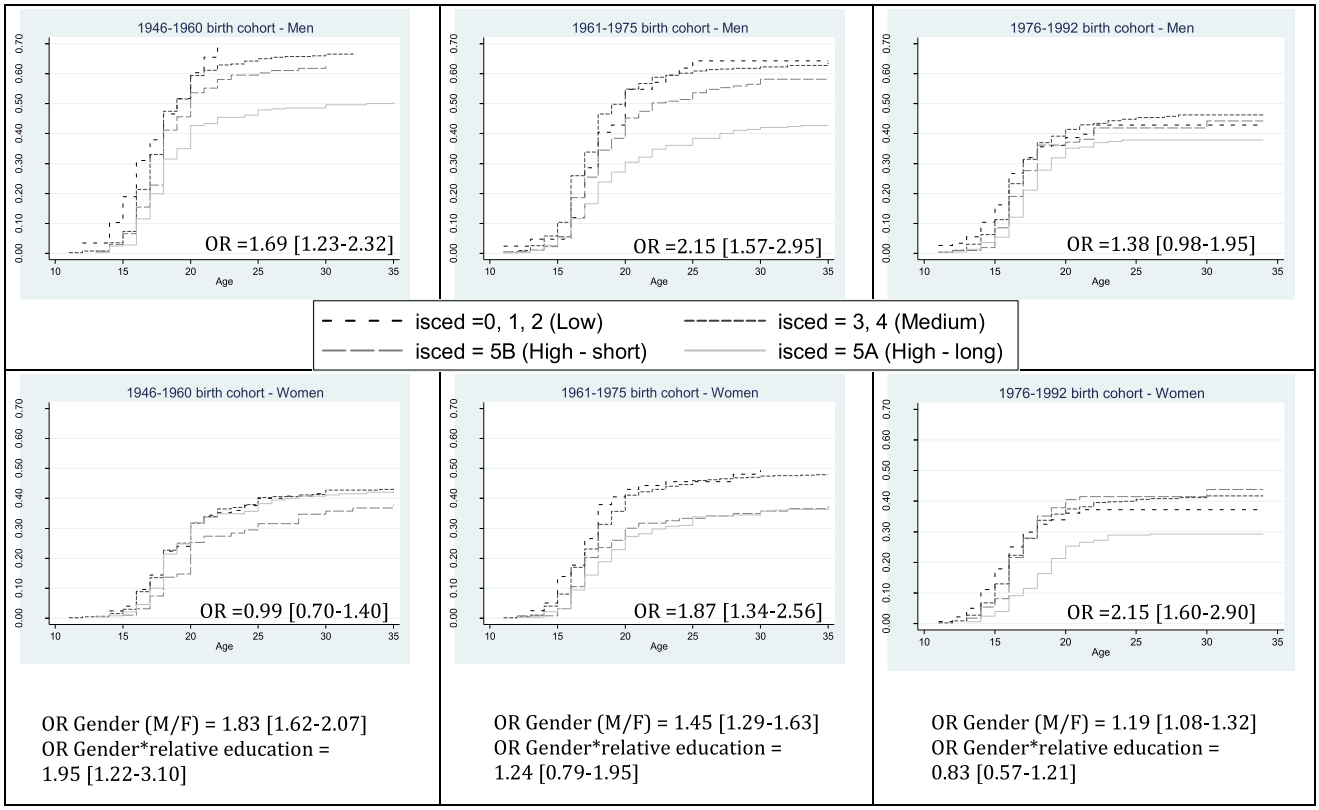
Comparisons across countries reveal noticeable differences. Among both men and women in the youngest cohort in France, a gradient appears with each educational trajectory being roughly equidistant from the one below and above. Among the youngest cohort of men and women in the United States, the three lowest education groups cluster together, defining a large gap with the highest category. For Germany, the pattern is mixed with some cohorts showing a large gap and others showing a gradient.

Another difference emerges across countries such that the epidemic appears more compressed in France than the United States. In France, the education odds ratio for the youngest cohort is much larger than for the oldest cohorts (4.97 versus 1.53). In the United States, the education odds ratio for the youngest cohort is larger than for the oldest cohort (5.18 versus 2.97) but not to the same extent as in France. The cohort-based disparities thus appear to rise more quickly in France, where the epidemic is more recent. However, the results for Germany show relatively little change in the magnitude of disparities across cohorts compared to the situation for either France or the United States.

4.2. Gender differences in smoking uptake

To make gender comparisons more precise, Figs. 1–3 each list two more coefficients at the bottom: the odds ratio for men relative to women (labeled OR Gender (M/F)) and the odds ratio of the effect of relative education for men relative to that for women (labeled OR Gender*RII).

First, for gender differences in smoking uptake, the odds are significantly higher for males than females in all cohorts and countries. However, the odds ratio for the oldest cohort in France (2.14) indicates a large gender gap in uptake. In contrast, the odds ratios of 1.83 for Germany and 1.62 for the United States indicate a greater hazard for men than women but a smaller gap than for France. For the youngest cohorts, gender differences in smoking decline in all the nations to 1.15 in France, 1.19 in Germany and 1.46 in the United States. However, gender convergence in smoking uptake across cohorts occurs most clearly and quickly in France and Germany.



Isced=0, 1, 2 (Low) to 5A (High - long): educational level (see Measures section)
OR = adjusted OR for relative education with controls (age in 2010, follow-up, follow-up², native born, and citizen), i.e. RII
OR Gender (M/F) = adjusted OR for gender (male relative to female) with controls (and relative education)
OR Gender* relative education= adjusted OR for gender*relative education with controls (i.e., RII for males relative to females)

Fig. 2. Proportion having ever smoked regularly by age in the different educational groups – Germany.

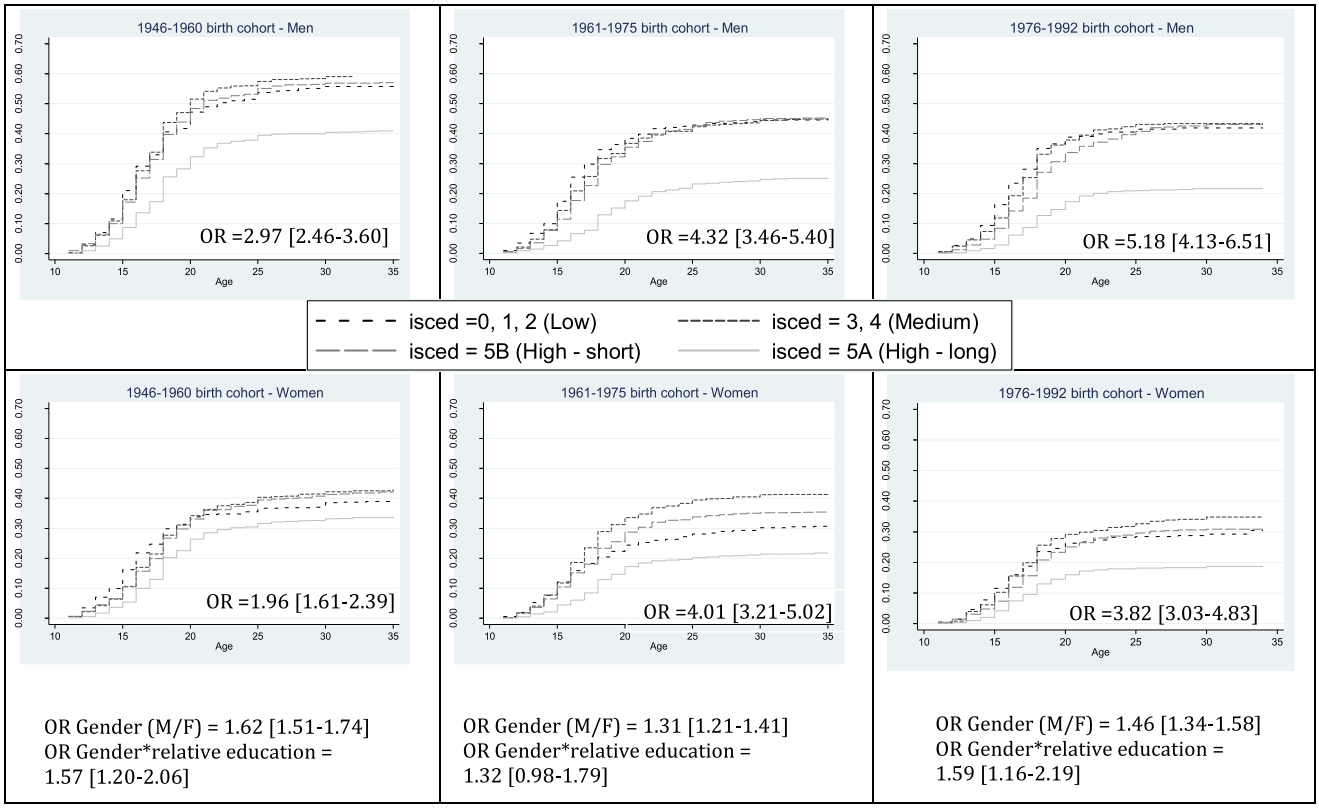
Second, for the educational gradient in smoking uptake, the largest difference between men and women occurs again for the oldest cohort in France. The odds ratio for education is 2.84 times greater for men than women in France. The corresponding odds ratios for Germany and the United States are, respectively, 1.95 and 1.57. For the youngest cohorts, the gradients for men and women show in odds ratios of 1.33 for France, 0.83 for Germany and 1.59 for the United States. In Germany, the effects of education on smoking tend to be opposite in males than females in the youngest cohort. Gender convergence in the association of smoking with education occurs across cohorts more clearly and quickly for France and Germany than the United States.

5. Discussion

Given the damage of tobacco use to health, the persistently high prevalence among socioeconomically disadvantaged groups relative to advantaged groups has become a serious public health problem. To help understand macro-level sources of tobacco disparities in education, we examined gender and cohort-based changes in tobacco uptake by education in France, Germany, and the United States. The effort extends existing comparative research by focusing on the timing of starting to smoke rather than prevalence and by making explicit comparisons across three nations with different starting points for the epidemic, rates of change in educational disparities, and educational divisions in smoking.

The results for uptake give evidence of strengthening educational disparities across cohorts in France and the United States for both men and women. In Germany, the same strengthening of disparities in uptake appears for women but less consistently for men. Despite the exception, the results generally match arguments that the adoption of smoking begins with higher educational groups but is followed by diffusion of smoking to lower educational groups and rejection of the habit by higher educational groups. For men, the data on cohorts do not go back far enough historically to capture the earliest stage of diffusion when uptake was consistently greater among high educational groups. Yet, the shift from a weak negative gradient to a strong negative gradient is consistent with the expected pattern of change. For women, the oldest cohorts show earlier uptake among the highest educational group in France, after which the gradient shifts direction as well as strengthens. The lag in emergence of the negative gradient shows that less educated women initiate more slowly and less often than more educated women. In most cases, differences between men and women in the timing of uptake and educational gradient in uptake converge across cohorts.

Regarding ***research hypothesis 1*** (timing of emergence of a negative gradient and size of disparities) our expectations are confirmed, as the results generally show earlier emergence and strengthening of disparities in uptake in the United States than France and Germany. For uptake among the oldest cohorts, the educational gradient is larger in the United States than the other two countries for both men and women. This result is consistent with the more advanced stage of diffusion. For the youngest cohorts, the patterns get closer as the epidemic in France and Germany catches up to that in the United States. For these cohorts, the



Isced=0, 1, 2 (Low) to 5A (High - long): educational level (see Measures section)
OR = adjusted OR for relative education with controls (age in 2010, follow-up, follow-up², native born, and citizen), i.e. RII
OR Gender (M/F) = adjusted OR for gender (male relative to female) with controls (and relative education)
OR Gender* relative education= adjusted OR for gender*relative education with controls (i.e., RII for males relative to females)

Fig. 3. Proportion having ever smoked regularly by age in the different educational groups – USA.

United States and France have similarly large gradients for both men and women, while Germany has a smaller gradient.

Regarding ***research hypothesis 2*** (pace of change across countries and across genders), our expectations are confirmed. The growth of the disparities appears to have occurred faster in France than the United States, offering some evidence of the compression for one country that started the epidemic later. The difference in the rate of change may stem from recent policy efforts to reduce smoking, the exposure of younger generations to widespread publicity about the harm of smoking, or factors unique to the countries. Although Germany does not fit the pattern, the results suggest some value from studying the varying lengths of the epidemic across countries.

Regarding ***research hypothesis 3*** (pattern of educational disparities), country divisions in the nature of educational differences in smoking appear in the results. France shows more of a gradient in educational differences in uptake of regular smoking, while the United States shows a gap between the highest level of education and the other three levels. Germany shows a mixed pattern that for some cohorts and genders resembles the United States and for others resembles France. Our findings therefore suggest that the divide occurs at the highest level of tertiary education (High-long) in the United States rather than at entry into college as initially expected.

Additionally, our results show that despite a convergence of the trends in educational gradients toward stronger inequalities in smoking in both genders but more gender-balanced prevalence across cohorts in the three countries, the current remaining differences between genders in the youngest cohort are meaningful. The difference in smoking uptake between genders are currently higher in the United States than in France or Germany. This reflects the ranking of these countries according to the Gender Inequality Index produced by the United Nation Development Programme: among all nation members, Germany is 6, France is 9, and the United States is only 42 (UNDP, 2013). This ranking is in contrast with the lower level of use in the United States, the initially more gender balanced prevalence in the older cohorts, and the earlier development of smoking among women there. It may be that the social value of cigarette and its place in the claim for gender equality is more important in the European countries. In this perspective, gender differences in smoking are an element reflecting global gender inequalities. Similar results have been shown for adolescent alcohol use in Europe (Legleye et al., 2011b). In spite of this, the gender difference in the educational gradient diminished in France and Germany (but not in the USA) and then converged in the three countries, meaning that education now affects genders in much the same way in regard to tobacco uptake.

The findings on initiation for cohorts, genders, and nations add to previous studies of educational disparities in smoking prevalence. They similarly support diffusion arguments but also add additional information on timing that is not captured by measures of current smoking. The results of this study show that cohort changes begin with differences in the uptake of smoking during younger ages. Consistent results across studies of prevalence and ages of starting are encouraging. Nonetheless, future research on uptake that includes additional countries would allow a more

thorough test of the epidemic and diffusion arguments and comparison of country historical and policy differences.

This pattern of change relates to the characteristics of tobacco initiation and cessation as innovations. Initiation has high trialability (Rogers, 2003), or ease of experimentation and low need for resources. The special characteristics of initiation may help speed the eventual adoption of cigarettes by all SES groups, including those with few resources. In contrast, cessation requires more effort and resources and has lower trialability. The need for more resources to quit smoking may lead to larger SES differences at later stages of the epidemic. The differences between initiation and cessation mean that additional research is needed to compare nations on educational disparities in the timing of cessation.

Given the importance of smoking to mortality and health, the findings have implications for understanding the broader relationship between education and health. Jha et al. (2006) report for 4 countries that up to 50% of educational disparities in mortality can be attributed to smoking. Our results show that the relationship between education and uptake of regular smoking – a key to tobacco harm – varies systematically across cohorts, genders, and countries and depends in good part on the stage of the cigarette epidemic. The implication is that the historical circumstances of countries that determine the start and peak of the epidemic shape disparities in both tobacco use and health overall. When attempting to understand the source of disparities, scholars need to take account of the macro-context of smoking defined in part by the stage of the smoking epidemic.

The cross-national comparisons present a perspective that complements more individual-oriented explanations of disparities. As already stated, those with less education and lower socioeconomic status may smoke because of greater stress, less understanding of the harm of smoking, shorter time horizons, more limited prospects for longevity, and fewer economic, social, and cultural resources to help avoid uptake and ease cessation. While important, these factors cannot explain the widening of inequalities over time in all three countries or the country and gender difference in timing of the widening. Individual motivations and resources operate within a context of broader macro-level, education-based changes in smoking.

Two key strategies of reducing smoking, raising cigarette prices and banning smoking in public places (Wilson et al., 2012), are based partly on the view that disadvantaged groups will respond most to the policies because they can least afford the added expense and inconvenience of higher prices and smoking restrictions (Thomas et al., 2008). Yet, disparities have grown rather than declined since the introduction of these policies (Pampel, 2009; Peretti-Watel et al., 2009). Given our results, policies may need to consider the stage of the tobacco epidemic in targeting education groups and devising strategies that appeal to the different circumstances and resources of the educational groups.

The analysis benefited from the use of a measure of education that adjusts for differences across cohorts, genders, and countries in the structure of education. The ridit measures each individual's educational attainment relative to that of persons in the same cohort, gender, and country. It thus controls for expansion of the educational system for younger cohorts, differences in educational opportunities for men and women, and the varied educational programs in France, Germany, and the United States.

The results for Germany fit less clearly into the pattern apparent for the United States and France. For men in particular, disparities grow from the older to the middle cohort but surprisingly then decline. The reunification of Germany may have produced some idiosyncratic changes in educational disparities in smoking. In their study of smoking prevalence, Westphal and Doblhammer (2012) find differences between the former East and West Germany in the trends in the educational gradient of women but not men. Our ability to check for differences is limited by the sample size, but a preliminary analysis suggests that the effects for the total sample are comparable to those obtained when restricting the analyses to West Germany. Still, different cultures of smoking in East and West Germany could limit the ability to identify a coherent pattern of change.

Limitations of the findings relate to the cross-sectional data. First, the self-reported retrospective measures of age of uptake may be biased by recall error. Although self-report measures of current tobacco use are generally found to be reliable (Kenkel et al., 2003), differences in recall by age could affect the cohort comparisons of age of onset. Colby et al. (2012) find high reliability of questions on age of onset but use a special series of questions to identify smoking milestones. Bright and Soulakova (2013) find that the time elapsed from smoking onset tends to increase the reported age, and Brigham et al. (2010) find mixed evidence for the accuracy of recall. We control for age at time of survey to adjust for potential bias, but older cohorts may overstate the age at which they started and thereby minimize cohort differences. Reporting on never having smoked is more accurate, with more than 90% of subjects giving consistent responses as youth when questioned 19.5 years later (Brigham et al., 2010).

Second, the cross-sectional nature of the data makes it hard to disentangle the causal relationships between education and smoking uptake. Many youth begin smoking before completing their education, requiring longitudinal data to draw causal conclusions about the relationship. It is clear, however, that the association is strong and has changed in meaningful ways.

Third, the cross-sectional samples of the populations at older ages exclude those who died at younger ages, a group disproportionately composed of smokers and those with less education. Although differential mortality may bias comparisons to the oldest cohort, limiting the analysis to persons under age 65 minimizes the problem (Christopoulou et al., 2011). Fourth, the data cannot separate the independent influences of age, period, and cohort. Analysis of the effects requires combined consecutive cross-sectional surveys. Fifth, differences in the surveys could account for some cross-country differences. The surveys vary somewhat in method of interview (phone, face-to-face, mixture) and measures of smoking (age of starting regular smoking among those ever smoking 100 cigarettes in the United States, the age of starting regular smoking among those having smoked 6 months in France, and the age of starting daily smoking in Germany among those who had smoked at least 100 cigarettes). Although these differences in methods may affect estimates of prevalence, they are unlikely to account for the pattern of findings. The bias would need to vary systematically across educational groups, genders, cohorts, and countries to spuriously produce the findings in support of the hypotheses.

Even with the limitations, the results offer a perspective from which to better understand the influence of public policies on smoking. We also checked that including the age at first cigarette use (in France and USA), a strong predictor of future tobacco addiction, did not alter the results (Supplementary Tables available on demand). At earlier stages of the epidemic, when disparities are weaker, smokers are a less select group. Policies addressing disparities at the early stage can be addressed with population-wide measures that can be expected to have broad effects across the population of smokers most prone to quit. At later stages of the epidemic, the lower prevalence and larger disparities in tobacco use suggest that smokers, particularly those with less education, are more strongly committed to tobacco. These "hard-core" smokers represent a challenge for tobacco control efforts (Emery et al., 2000). Policies may need to be targeted more specifically

on the high-risk, less educated groups (Frohlich and Potvin, 2008; Peretti-Watel et al., 2009). General strategies of advertising, tax increases, and restrictions on public smoking have had clear benefits but thus far are associated with reduced smoking among more advantaged groups. According to the *Tobacco Atlas* (Eriksen et al., 2012), the relative price for a pack of cigarettes (calculated as a percentage of annual per capita income needed to purchase 100 packs of cheapest cigarettes) is highest in France (1.68) and Germany (1.53), and lowest in the United States (1.32). Similarly, the percentage of excise taxes in the price of a pack of cigarettes is 64.3% in France, 60.7% in Germany, and 39.9% in the United States. Despite these differences in policies, educational disparities among the youngest cohorts are similarly large in the three nations. If disparities persist despite varied taxes on cigarettes, other policies targeted toward helping low socioeconomic groups to reduce their smoking will be needed.

Acknowledgments

This project received funding and administrative support from: the University of Colorado Population Center, which is funded by the Eunice Kennedy Shriver National Institute of Child Health and Human Development (grant NICHD R21 HD051146), and from the French Institut National d'Etudes Démographiques and Institut National du Cancer (COTCEDIS Project "Consommation de tabac et de cannabis: évolution et dynamiques de construction des inégalités sociales", Grant No. 2011-250).

Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.socscimed.2014.06.033.

References

Amos, A., Haglund, M., 2000. From social taboo to "torch of freedom": the marketing of cigarettes to women. Tob. Control 9, 3–8.
Barbeau, E., Krieger, N., Soobader, M., 2004. Working class matters: socioeconomic disadvantage, race/ethnicity, gender and smoking in NHIS 2000. Am. J. Public Health 94, 269–278.
Beck, F., Guignard, R., Richard, J., Tovar, M., Spilka, S., 2011. Les niveaux d'usage des drogues en France en 2010 – exploitation des données du Baromètre santé. Tendances, 6.
Brigham, J., Lessov-Schlaggar, C.N., Javitz, H.S., Krasnow, R.E., Tildesley, E., Andrews, J., et al., 2010. Validity of recall of tobacco use in two prospective cohorts. Am. J. Epidemiol. 72 (7), 828–835.
Bright, B.C., Soulakova, J.N., 2014. On evidence of telescoping in regular smoking onset age, Nicotine. Tob. Res. 16 (6), 717–724.
Bross, I., 1958. How to use ridit analysis. Biometrics 14, 18.
Cavelaars, A., Kunst, A., Guerts, J., Crialesi, R., Grötvedt, L., Helmert, U., et al., 2000. Educational differences in smoking: international comparison. Br. Med. J. 320, 1102–1107.
Christopoulou, R., Han, J., Jaber, A., Lillard, D., 2011. Dying for a smoke: how much does differential mortality of smokers affect estimated life-course smoking prevalence? Prev. Med. 52, 66–70.
Colby, S.M., Clark, M.A., Rogers, M.L., Ramsey, S., Graham, A.L., Boergers, J., et al., 2012. Development and reliability of the lifetime interview on smoking trajectories. Nicotine Tob. Res. 14 (3), 290–298.
Cutler, D., Lleras-Muney, A., 2010. Understanding differences in health behaviors by education. J. Health. Econ. 29, 1–28.
Emery, S., Gilpin, E., Ake, C., Farkas, A., Pierce, J., 2000. Characterizing and identifying "hard-core" smokers: implications for further reducing smoking prevalence. Am. J. Public Health 90, 387–394.
Eriksen, M., Cerak, R., 2008. The diffusion and impact of clean indoor air laws. Annu. Rev. Public Health 29, 171–185.
Eriksen, M., Mackay, J., Ross, H., 2012. The Tobacco Atlas. American Cancer Society, Atlanta, GA.
Fiori, M., Baker, T., 2009. Stealing a march in the 21st century: accelerating progress in the 100-year war against tobacco. Am. J. Public Health 99, 1170–1175.
Fisher, C., Hout, M., 2006. Century of Difference: How America Changed in the Last One Hundred Years. Russel Sage, New York.
Forey, B., Hamling, J., Thornton, A., Lee, P., 2013. International Smoking Statistics. Web edition. http://www.pnlee.co.uk/ISS3.htm.
Frohlich, K., Potvin, L., 2008. Transcending the known in public health practice: the inequality paradox: the population approach and vulnerable populations. Am. J. Public Health 98, 216–221.
Gallus, S., Schiaffino, A., La Vecchia, C., Townsend, J., Fernandez, E., 2006. Price and cigarette consumption in Europe. Tob. Control 15, 114–119.
Giskes, K., Kunst, A., Benach, J., Borrell, C., Costa, G., Dahl, E., et al., 2005. Trends in smoking behavior between 1985 and 2000 in nine European countries by education. J. Epidemiol. Community Health 59, 340–395.
Harman, J., Graham, H., francis, B., Inskip, H., 2006. Socioeconomic gradients in smoking among young women: a British survey. Soc. Sci. Med. 63, 2791–2800.
Huisman, M., Kunst, A., Mackenbach, J., 2005. Educational inequalities in smoking among men and women aged 16 years and older in 11 European countries. Tob. Control 14, 106–113.
Jha, P., Peto, R., Zatonski, W., Boreham, J., Jarvis, M., Lopez, A., 2006. Social inequalities in male mortality from smoking: indirect estimation from national death rates in England and Wales, Poland, and North America. Lancet 368, 367–370.
Joossens, L., Raw, M., 2006. The tobacco control scale: a new scale to measure country activity. Tob. Control 15, 247–253.
Kenkel, D., Lillard, D., Mathios, A., 2003. Smoke or fog? The usefulness of retrospectively reported information about smoking. Addiction 98, 1307–1313.
Kerckhoff, A.C., Ezell, E.D., Brown, J.S., 2002. Toward an improved measure of educational attainment in social stratification research. Soc. Sci. Res. 31 (1), 99–123.
Kluger, R., 1996. Ashes to Ashes: America's Hundred-year Cigarette War, the Public Health, and the Unabashed Triumph of Philip Morris. Alfred A. Knopf, New York.
Kraus, L., Pabst, A., 2010. Studiendesign und methodik des Epidemiologischen Suchtsurveys 2009 (Study design and methodology of the 2009 Epidemiological Survey of Substance Abuse). Sucht 2–3, 233–241.
Legleye, S., Khlat, M., Beck, F., Peretti-Watel, P., 2011a. Widening inequalities in smoking initiation and cessation patterns: a cohort and gender analysis in France. Drug. Alcohol. Depend. 117, 233–241.
Legleye, S., Morand, E., Garnier, B., 2011b. Influence de la parité économique et politique sur la différence genrée de consommation d'alcool chez les adolescents européens. Proceedings of the Journées méthodologie Stat. Paris: Insee (15 p.).
Lim, S., Vos, T., Flaxman, A., Danaei, G., Shibuya, K., et al., 2012. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet 380, 2224–2260.
Lopez, A., Collishaw, N., Piha, T., 1994. A descriptive model of the cigarette epidemic in developed countries. Tob. Control 3, 242–247.
Mackenbach, J., Huisman, M., Andersen, O., Bopp, M., Borgan, J., Borrell, C., et al., 2004. Inequalities in lung cancer mortality by educational level in 10 European populations. Eur. J. Cancer 40, 126–135.
Mackenbach, J.P., Kunst, A.E., 1997. Measuring the magnitude of socio-economic inequalities in health: an overview of available measures illustrated with two examples from Europe. Soc. Sci. Med. 44, 757–771.
Maralani, V., 2013. Educational inequalities in smoking: the role of initiation versus quitting. Soc. Sci. Med. 84, 129–137.
National Center for Health Statistics, 2013. 2010 National Health Interview Survey (NHIS) Public Use Data Release: NHIS Survey Description. ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2010/srvydesc.pdf.
Pampel, F., 2002b. Cigarette use and the narrowing sex differential in mortality. Popul. Dev. Rev. 28, 77–104.
Pampel, F., 2002a. Inequality, diffusion, and the status gradient in smoking. Soc. Probl. 49, 35–57.
Pampel, F., 2005. Diffusion, cohort change, and social patterns of smoking. Soc. Sci. Res. 34, 117–139.
Pampel, F., 2009. The persistence of educational disparities in smoking. Soc. Probl. 56, 526–542.
Pampel, F., Krueger, P., Denney, J., 2010. SES disparities in health behavior. Annu. Rev. Sociol. 36, 349–370.
Peretti-Watel, P., Constance, J., Seror, V., Beck, F., 2009. Cigarettes and social differentiation in France: is tobacco use increasingly concentrated among the poor? Addiction 104, 1718–1728.
Preston, S., Wang, H., 2006. Sex mortality differences in the United States: the role of cohort smoking patterns. Demography 43, 631–646.
Reid, J.L., Hammond, D., Boudreau, C., Fong, G.T., Siahpush, M., 2010. Socio-economic disparities in quit intentions, quit attempts, and smoking abstinence among smokers in four western countries: findings from the International Tobacco Control Four Country Survey. Nicotine Tob. Res. 12 (Suppl.), S20–S33.
Rogers, E., 2003. Diffusion of Innovations. Free Press, New York.
Schaap, M., Kunst, A., 2009. Monitoring of socio-economic inequalities in smoking: learning from the experiences of recent scientific studies. Publ. Health 123.
Schulze, A., Mons, U., 2006. The evolution of educational inequalities in smoking: a changing relationship and a cross-over effect among German birth cohorts of 1921–70. Addiction 101.
Thomas, S., Fayter, D., Misso, K., Ogilvie, D., Petticrew, M., Snowden, A., et al., 2008. Population tobacco control interventions and their effects on social inequalities in smoking: systematic review. Tob. Control 17, 230–237.
Thun, M., Peto, R., Boreham, J., Lopez, A., 2012. Stages of the cigarette epidemic on entering its second century. Tob. Control 21, 96–101.
UNDP, 2013. Human Development Report 2013. The Rise of the South: Human Progress in a Diverse World. United Nation Development Program, New York.

UNESCO, 2006. International Standard Classification of Education ISCED 1997. http://www.uis.unesco.org/Library/Documents/isced97-en.pdf.

UNESCO (Ed.), 2013. Cumulative Educational Attainment of the Population Aged 25 and Over. Institute of Statistics. http://stats.uis.unesco.org/unesco/ReportFolders/ReportFolders.aspx.

van der Heyden, J., Schaap, M., Kunst, A., Esnaola, S., Borrell, C., Cox, B., et al., 2009. Socioeconomic inequalities in lung cancer mortality in 16 European populations. Lung Cancer 63, 322–330.

Westphal, C., Doblhammer, G., 2012. The Diffusion of Smoking in East and West Germany: Smoking Patterns by Birth Year. Rostock Center, Rostock (Discussion Paper No. 30).

WHO, 2012. WHO Global Report: Mortality Attributable to Tobacco. World health Organization, Geneva. http://whqlibdoc.who.int/publications/2012/9789241564434_eng.pdf.

Wilson, L., Tang, E., Chander, G., Hutton, H., Odelola, O., Elf, J., et al., 2012. Impact of tobacco control interventions on smoking initiation, cessation, and prevalence: a systematic review. J. Environ. Public Health 2012 (2012), e961724.