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Tord F. Vedøy

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Abstract

This study examined if temporal variations in daily cigarette smoking and never-smoking among groups with different levels of education fit the pattern proposed by the theory of diffusion of innovations (TDI), while taking into account the separate effects of age, period and birth cohort (APC). Aggregated data from nationally representative interview surveys from Norway from 1976 to 2010 was used to calculate probabilities of smoking using an APC approach in which the period variable was normalized to pick up short term cyclical effects. Results showed that educational differences in smoking over time were more strongly determined by birth cohort membership than variations in smoking behavior across the life course. The probability of daily smoking decreased faster across cohorts among higher compared to lower educated. In contrast, the change in probability of never having smoked across cohorts was similar in the two education groups, but stronger among men compared to women. Moreover, educational differences in both daily and never-smoking increased among early cohorts and leveled off among late cohorts. The results emphasizes the importance of birth cohort for social change and are consistent with TDI, which posits that smoking behavior diffuse through the social structure over time.

Keywords: Smoking, Education, Diffusion, Socioeconomic position, Cohort, APC

1. Introduction

The negative effects of smoking on public health are indisputable. Smoking is one of the largest causes of preventable death in most developed countries, and because many smoking-related diseases have a delayed onset, smoking will continue to be a major health problem in decades to come, even though smoking prevalence has declined steadily throughout the second half of the 20th century (Danaei et al., 2009; Peto and Lopez, 2001; Vollset et al., 2006).

The popularity of cigarettes has changed dramatically over time. From being almost non-existent in the late 1800s, cigarette consumption in the United States rose exponentially, peaking in the early 1960s with yearly per capita consumption of cigarettes just under 4000, before declining sharply (Pampel, 2004: 293). The pattern was similar in Norway, although peak cigarette consumption was lower and occurred more than 10 years later (around 2100 cigarettes per year in 1975). Given the shape of the cigarette consumption and the cigarette smoking prevalence curves over time, the rise and fall of cigarette smoking has typically been described as an epidemic (Lopez et al., 1994; Thun et al., 2012).

In most developed countries, there has been a persistent relationship between smoking, gender and various measures of socio-economic position (SEP). Cigarettes first became popular among urban male elites in the late 1800s. However, at some point the positive socioeconomic gradient reversed and in more recent decades, cigarette smoking has been increasingly concentrated among groups with low education, manual laborers and those with low incomes (Layte and Whelan, 2009; Pampel, 2005; Schaap et al., 2008).

In the case of education, differences between groups are evident in North America (de Walque, 2010) and most European countries, although most noticeable in Northern Europe (Huisman et al., 2005). Norwegian figures from 2012 showed that 25% of men and women whose formal education ended in primary school smoked daily, whereas only 6% of those with high school or university education were smokers (Statistics Norway, 2013).

The figures in the United States were similar (Centers for Disease Control and Prevention, 2013).

In this article, I use an age-period-cohort approach developed by Deaton (1985) to investigate whether educational differences in smoking behavior are produced by smoking decisions thought the life course (related to ageing) or, instead, a product of social forces shaping smoking decisions at the time when people pick up smoking (related to birth cohort). At the center of the analysis lies the question whether differences in the likelihood of smoking between men and women with different levels of education fit the pattern predicted by the theory of diffusion of innovations (Rogers, 2003).

In many ways, Norway can be regarded as a particularly interesting case. A comprehensive ban on advertising of cigarettes and other tobacco products has been in place from 1975, and from 1989 introduction of new products containing nicotine or tobacco has been banned. The Norwegian tobacco market has traditionally been, and still is, dominated by a handful of brands, including a few local brands. It is therefore possible to examine social variations in smoking behavior without having to be very concerned about changes in the tobacco market.

In addition, the Norwegian population is fairly homogenous and smoking behavior has yet only been modestly affected by immigration. One important consequence of this is that having low education is not (strongly) confounded with immigration, as may be the case in British or U.S. data.

2. Diffusion of cigarette smoking behavior

What can explain the rise and fall of cigarette smoking and the sequential adoption and rejection of smoking among men and women with different levels of SEP? As discussed by Ferrence (1989), the explosive growth in cigarette smoking fits the pattern predicted by the theory of diffusion of innovations (TDI), outlined by Rogers (2003).

TDI predicts that certain new social phenomena, or innovations, spread through the social structure in a predictable pat- tern. The innovation can be a product, norm, habit, belief, etc. In the beginning only a few people will adopt the innovation (early adopters), but if a sufficient number of people take up the innovation (early majority), the phenomenon gains critical mass and spreads through the social structure and, with time, most of the group members will adopt the innovation (late majority and laggards).

The success of diffusion depend on several factors, such as the availability, likability or usefulness of the innovation and the distance and quality of communication between those who first discover the innovation (innovators) and the rest of the social system.

In most cases of diffusion, the different adopter categories are closely linked to socio-economic position. Studies have shown that earlier adopters tend to have higher social status and more years of education than do later adopters. Early adopters are also more cosmopolitan, more socially active and have greater exposure to mass media (Ferrence, 1989; Rogers, 2003). If successful, diffusion creates a cycle of adoption in which the social phenomenon spreads from the highest educated and most cosmopolitan groups to those in lower social positions (Pampel, 2002).

Much like the increased popularity of cigarette smoking in the first half of the 20th century, it has been argued that the decline in smoking in the second half is the result of diffusion of a new phenomenon displacing smoking, a “smoke-free life- style”, driven by health concerns, but also by social class distinction processes (Pampel, 2002). Some authors have hypothesized that through strategies such as changing the nicotine content of the cigarettes or limiting possibilities of profiting from selling cigarettes, an endgame for cigarettes may be within reach (U.S. Department of Health and Human Services, 2014).

Yet, there are some signs that smoking among low-SEP groups is more resilient to anti-smoking measures than previously predicted (Thun et al., 2012). Even though smoking has decreased among all socio-economic groups, some studies have found that differences between groups have remained stable or even increased over time (Escobedo and Peddicord, 1996; Giskes et al., 2005; Peretti-Watel et al., 2009), which suggest that that diffusion has been blocked or delayed. Following this line of thought, Dixon and Banwell argued that the smoking epidemic model should include a fifth stage marked by "sedimentation of smoking in successive low SES cohorts" (Dixon and Banwell, 2009).

3. Age, period and cohort, and social change

From a TDI perspective, the process in which new birth cohorts adopt already existing cigarette smoking patterns can be regarded as an example of diffusion between cohorts (inter-cohort diffusion). This differs from most phenomena examined by TDI which focus on intra-cohort diffusion, that is, how individuals adopt behavior from other similarly aged individuals (see, for example Coleman et al., 1957). To determine the nature of SEP differences in smoking over time and whether they follow the pattern predicted by TDI, it is therefore necessary to take into account the reciprocal relationship between the three temporal dimensions age, period and cohort membership (APC).

Within the framework of APC models, age effects refer to variations associated with the process of physical ageing and corresponding social roles (Reither et al., 2009), and are often assumed to be relatively stable over time (Deaton, 1997:123; Ryder, 1965). The rationale behind this is that age-related variations reflect opportunities and limitations linked to different life stages. For example, almost all people begin to smoke in adolescence. Likewise, the effect of growing old on smoking behavior is likely to be stable across cohorts. In general, most studies have concluded that smoking prevalence increases sharply during adolescence, after which it declines (Pampel, 2003; Piontek et al., 2010).

Studies on social inequalities in health argue that education may increase knowledge of health risks and improve access to resources that may improve health (Link and Phelan, 1995). In the case of smoking this may result in more correct perceptions of the risk posed by smoking and better strategies to increase the likelihood of quitting. Also, given that higher educated on average live longer than groups with lower education, higher educated have relatively more to lose, in terms of health, by smoking (de Walque, 2010; Pampel, 2007). As a result, higher educated should stop smoking at a faster rate and/or at an earlier point in the life course compared to groups with lower education. This would manifest itself as intra-cohort change.

In contrast, cohort effects are variations between groups of people sharing an experience at a specific point in time, such as being born or graduating from college in the same year. As argued by Ryder (1965), each new birth cohort enters society with “a distinctive composition and character reflecting the circumstances of its unique origination and history”. This distinct character will follow the cohort through its life course.

Studies have shown that smoking behavior depends strongly on birth cohort (Harris, 1983; Maralani, 2013). Almost all smokers report that they started smoking in their teenage years (U.S. Department of Health and Human Services, 1994) which suggests that society’s opinions on smoking at the time when adolescents pick up smoking is crucial for the future distribution of smoking.

Arguably, the most important factor for cigarette smoking decisions among successive birth cohorts in the latter half of the 20th century has been the growing information about its negative health effects. Consequently, people born around 1950 had different beliefs about smoking than those born in the 1980s. In addition, later birth cohorts grew up in societies in which smoking was increasingly associated with lower socio-economic positions and marginalization.

Due to the early onset of smoking, individuals’ own education cannot have direct effect on smoking initiation. However, since each new generation embodies the knowledge of earlier generations, they will have a higher initial level of human capital compared to earlier generations. And, since there is more accumulated knowledge in late cohorts, the benefits of schooling are higher in later cohorts compared to earlier cohorts (Weiss and Lillard, 1976). Consequently adolescents from higher SEP backgrounds should have access to more or different information about the health effects of smoking or can draw upon more resources when making smoking decisions than adolescents with lower SEP.

Moreover, and from a social distinction perspective, adoption of smoking by groups with lower social status may encourage groups with higher social status to abandon the very same phenomenon, thereby reinforcing symbolic boundaries (Pampel, 2002). This should manifest itself in different cohort profiles for groups with different levels of education.

Period effects can be defined as events and circumstances that influence all age groups simultaneously at specific points in time (Hanoch and Honig, 1985; Reither et al., 2009; Yang, 2008). Period effects are most often assumed to be a result of contextual changes such as changes in price or market restrictions or, for some phenomena, natural or social disasters which affect all individuals in a society. In the case of cigarette smoking, examples of events that could decrease overall smoking prevalence are tobacco control initiatives such as media campaigns, increased tax on tobacco and restrictions on where smoking is allowed. In contrast, increased purchasing power, introduction of new tobacco products like “light” or “mild” cigarettes and better access to cheaper cigarettes from neighboring countries could be examples of period effects that could increase consumption.

Taking the theory of diffusion of innovations as a starting point and addressing concerns about a widening socioeconomic gap in smoking, the aims of this study are: First, to examine the relative importance of age and birth cohort for daily and never-smoking using a pseudo-panel approach developed by Deaton (1985). Second, if uptake and rejection of smoking follow the pattern proposed by TDI, differences between social groups should increase and then decrease with age (in the case of intra-cohort diffusion) or birth cohort (in the case of inter-cohort diffusion) as groups that are lagging behind in the diffusion process catch up with groups that were quicker to adopt new smoking patterns.

4. Methods

4.1. Data

The data were drawn from two consecutive surveys of smoking behavior, the Norwegian Labor Force Survey (LFS) (1976–1991) and Statistics Norway's Omnibus Survey (1992–2010). Both surveys were conducted by Statistics Norway and included a total of 157,582 respondents aged 16+. All surveys from 1976 to 1993 were conducted in the fourth quarter. From 1994 to 2010, surveys were conducted in all quarters except for Q1 and Q4 in 1994, Q3 in 1998 and Q2 in 2000.

In both sets of surveys, respondents were randomly selected from the National Population Register. Response rates in the LFS were above 85% for all survey years (Thomsen and Villund, 2012). The omnibus survey included 8000 respondents annually (8500 from 1992 to 1994) and response rates varied around 65% from 1992 to 2007 and around 60% from 2008 to 2010. The sample drawn from the population was adjusted to ensure that the gender and age distribution of respondents was approximately equal to the corresponding distribution in the general Norwegian population.

4.2. Measures

Questions about smoking behavior were identical over time and between surveys. Respondents were asked *Do you ever smoke?* Respondents answering *Yes* were then asked if they smoked *Daily* or *Occasionally*. For this study, smokers were defined as those who answered *Daily*. Those who answered that they did not smoke and had never smoked daily were defined as never-smokers. Information about never-smoking was only available from surveys conducted in the fourth quarter.

For both sets of surveys, information about education was taken from the National Education Register. Over the years, education has been measured with varying degrees of precision. However, all surveys distinguished between those having completed up to 12 years of education (primary and/or secondary) and those with at least three years of high school or university education (tertiary). Although it is a crude measure, this operationalization of the education variable serves the purpose of isolating the group that most likely resembles early adopters as described by the theory of diffusion of innovations – in this case, those with three or more years of high school or university education. In addition, a dichotomous measure produces larger cell sizes and more robust results.

Respondents younger than 25 years of age and older than 64 years were excluded from the analysis. The younger respondents were excluded to ensure that all of the study participants were old enough to have been able to complete at least three years of tertiary education, whereas respondents above 64 were excluded due to differential mortality between education groups.

Given the small number of women born in the late 1800s and early 1900s who had tertiary education, the study excluded all respondents born before 1917. The total number of respondents included in the analyses was 86,200 for daily smoking and 43,902 for never-smoking.

4.3. APC models and the "identification problem"

The inherent identification problem of age-period-cohort models has generated much debate (Glenn, 2005; Rodgers, 1982). Given that each variable is a perfect linear function of the other two, simultaneous estimation of the effect of age, period and birth cohort is not possible without breaking the linear relationship. At the same time, when working with cross-sectional data over time, exclusion of one or two of the dimensions may lead to misspecification of the model because the age profile within a given survey year is confounded with the cohort effects (Deaton, 1997: 123).

Several solutions to identification problem have been proposed and involve either placing restrictions on one or more of the three variables or eliminating the linear relationship between age, period and cohort in some other way (see, for example O'Brien, 2000; Winship and Harding, 2008; Yang and Land, 2006).

However, given the lack of a purely technical solution to the identification problem, APC model specification should be guided by theory (Glenn, 2005). In this article I employ a solution suggested by Deaton (1985) in which temporal change is decomposed into a cohort and an age profile, while period effects are regarded as exogenous shocks which sum to zero in the long run. This approach shares a basic assumption with Ryder's idea that long term social change is primarily a result of two relatively stable processes: ageing or the intra-cohort temporal development throughout the life cycle, and the inter-cohort temporal differentiation that arises from the process of "personnel replacement" as new cohorts enters the social system (Ryder, 1965). The emphasis placed on age and cohort membership stems from the acknowledgement that these dimensions are more than background factors for individual's actions, but constantly affects behavior over the life course (Riley, 1987).

In contrast, period effects contribute to the overall change in smoking by "synchronously but temporarily move all cohorts off their profiles" (Deaton, 1997: 124). It is important to note that this approach does not remove the period effects, but allocates temporal trends to variations in age or cohort. Thus, time in itself does not have a persistent effect on smoking, but must be regarded as a context within which people from different cohorts age (Suzuki, 2012).

A necessary premise for this approach is that there are no cumulative period effects in the long run, either because there are no period effects or because positive effects are offset by negative effects. In the case of cigarette smoking, period effects may have led to both decreased and increased consumption.

In theory, health warnings on cigarette packaging (1975), laws banning smoking in pubs and bars (2004) and new technological innovations such as nicotine replacement products may have contributed to a downward shift in cigarette consumption, although studies indicate that such measures have likely been more effective for reducing smoking initiation among adolescents than having a synchronous effect on all age groups (Cummings and Hyland, 2005; Hammond, 2011). Conversely, introduction of "light" or “mild” cigarettes in the 1980s and increased access to imported cigarettes may have contributed to increased opportunities for smoking.

The arguably best example of a period effect on smoking is the repeatedly increased excise tax on cigarettes. However, it has been shown that cigarettes in Norway and some other developed countries actually have become slightly cheaper over the last decades due to a strong increase in purchasing power (Blecher and van Walbeek, 2009). It is therefore assumed that, in the long run, factors that decrease cigarette consumption among all cohorts and age groups will be offset by factors that increase consumption.

4.4. Analysis

In the absence of panel data, it is still possible to follow groups such as birth cohorts from one survey to another using aggregated cross-sectional data, often referred to as pseudo-panels (Deaton, 1985). Moreover, by using dummy variable regression, controls are placed on all time invariant (fixed) effects (O’Brien, 2000). Yet, as shown by Deaton (1985), if individual fixed effects are correlated with any of the other explanatory variables, the standard fixed effects estimator will be biased. This will also be the case after aggregation because the cohort averages will be “error-ridden measurements of the true cohort means”.

It has been shown that this problem can be ignored and that cohort data can be treated as genuine panel data if the number of individuals in each cohort is above 100–200 (Verbeek and Nijman, 1992). In my data, the average number in each education/gender/cohort cell was above 2000 for men and women with primary education and around 1000 for men and women with tertiary education. The only cohort with less than 100 individuals was the oldest female cohort with tertiary education (N = 72).

To examine daily and never-smoking across education levels, gender-specific regression age-period-cohort (APC) models were constructed with Stata 12 using aggregated cross-sectional data. The data were aggregated over *gender*, *education*, and 5-year groups of *age* and *survey year*.

The dependent variable was the fraction of people in each *gender* x *education* x *age* x *year* cell who were daily or never-smokers. As the dependent variable was a fraction and included zero and one, the models were estimated using a generalized linear model (GLM) with a logit link function, binomial distribution of the dependent variable and robust standard errors (Papke and Wooldridge, 1996).

Independent variables included education (*primary/secondary* or *tertiary*), dummy variables for age and birth cohort (survey year minus age) and a set of normalized period dummies. For the model to run, the first two period variables ($d_{1976–1980}$ and $d_{1981–1985}$) were dropped. Because the period variables add to zero, the coefficients for the first two years could be calculated post-regression (see Deaton 1997: 407–408).

Interactions between level of education and age and between education and cohort were included to model the sequential decrease in smoking as predicted by the theory of diffusion of innovations. From these models, marginal mean probabilities of daily smoking and never-smoking across *age* and *birth cohort* were calculated.

In addition, to assess the average change in smoking behavior and differences between social groups over time, the percentage change in the probability of daily and never-smoking with a one-unit change in *cohort* (semi-elasticities) was calculated by replacing the cohort dummy variables with continuous measures of *cohort* and *cohort squared* while keeping the age dummy variables. The same procedure was used for calculating semi-elasticities for *age*. Semi-elasticities were preferred over average marginal effects because of the large real differences in smoking across education. Coefficients for *age squared* and *cohort squared* were significantly different from zero in all models ($p < 0.05$), with the exception of *cohort* for never-smoking among men.

5. Results

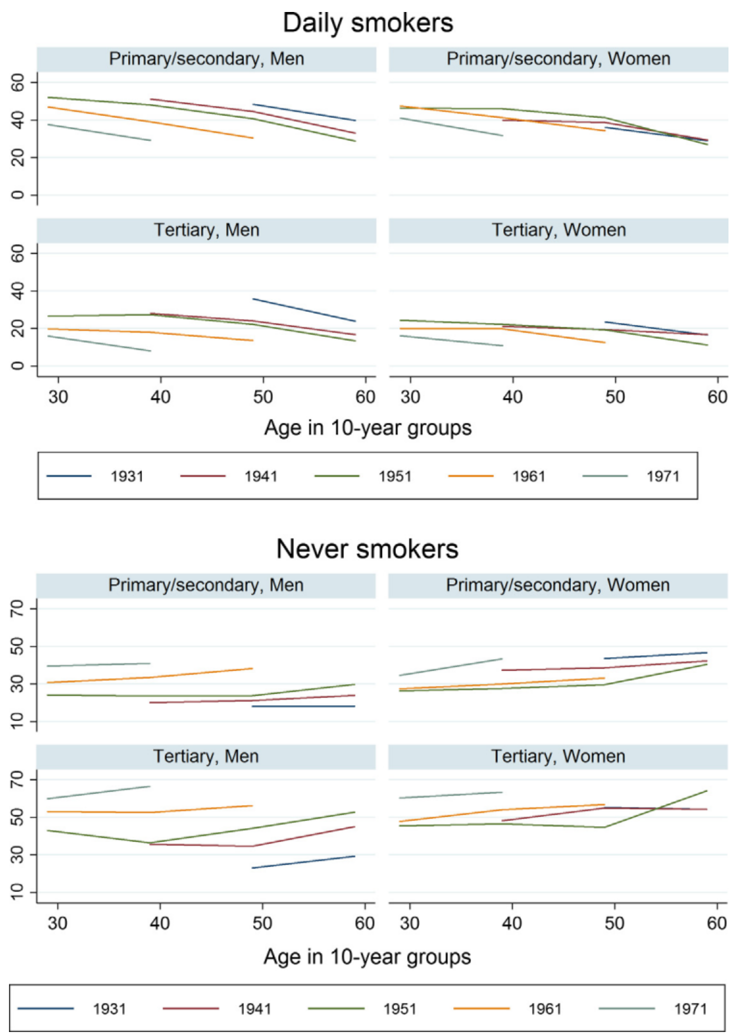
5.1. Cohort plots of daily and never-smoking prevalence from cross-sectional data

To provide a backdrop for the results from the APC-models, the unadjusted prevalences of daily and never-smokers within 10-year birth cohorts were plotted against age (Fig. 1). Note that the first and the latest cohorts, those born around 1921 and 1981, could not be plotted as data was only available for one age group.

The results highlighted two traits of smoking behavior. First, the figure showed that age variations in smoking behavior were similar across cohorts and that variations between cohorts were larger for never-smokers compared to daily smokers, most likely the result of fewer observations.

Second, the results indicated that differences between cohorts were a matter of level, not direction. On average, daily smoking prevalence was around 20% for men and women with higher education and around 40% among groups with lower education. In the case of never having smoked, variation within each group was larger, but the prevalence was on average higher among groups with tertiary compared to primary/secondary education.

Fig. 1. Percentage of daily and never-smokers across age among 10-year cohorts, men and women, Norway 1976–2010.



5.2. Age, period and cohort profiles and variations across education and gender

The mean probabilities of daily smoking (Pr(S)) and never-smoking (Pr(N)) from the gender-specific age-period-cohort models are shown in Fig. 2. Due to size, coefficients from the models are not shown, but are available from the author upon request.

Among men with tertiary education, Pr(S) increased from 0.26 at the age of 25–29 to 0.30 at the age of 30–34 ($p < 0.05$) before declining to less than 0.10 at the age of 60–64 ($p < 0.05$). Among men with primary/secondary education, the probability of daily smoking dropped from around 0.55 to 0.26 over the life course ($p < 0.05$). Age profiles among women were similar to men's: the probability of being a daily smoker fell from 0.46 to 0.25 across the life course among women with lower education ($p < 0.05$) and from 0.26 to 0.11 for higher educated ($p < 0.05$). For people above 35 years of age, gender differences were small.

The similarity between men and women were also apparent for the likelihood of never having smoked. Among all groups, Pr(N) remained stable among all age groups between 25 and 54, slightly higher in the oldest age group ($p < 0.05$), and around 0.15 points higher among those with higher compared to lower education.

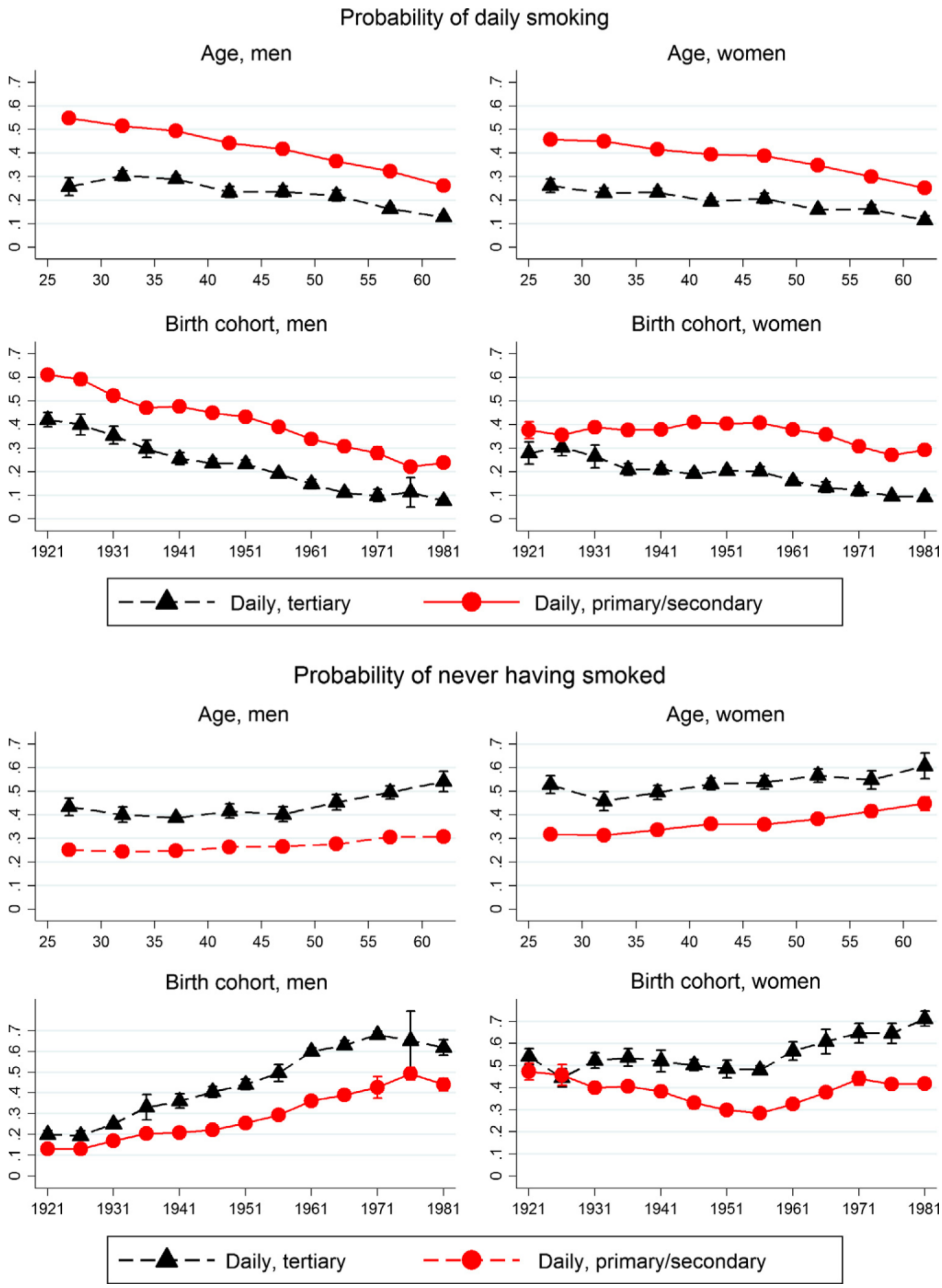
Tracing the probability of daily smoking among men across birth cohorts, the results showed a steady decline for both education groups. Among men with primary/secondary education, Pr(S) fell from just above 0.60 for those born around 1921 to around 0.20 for those born 60 years later ($p < 0.05$ for most adjacent pairs). Among men with tertiary education, Pr(S) decreased from around 0.40 to around 0.10 across cohorts ($p < 0.05$ for most adjacent pairs).

For women, the situation was different. Pr(S) among women with tertiary education was stable at around 0.30 for women born around 1921, and around 0.20 for women born between 1934 and 1958. Among women born after 1974, Pr(S) dropped to under 0.10 ($p < 0.05$ compared to all other groups). In contrast, for women with primary/secondary education born between 1917 and 1968, the probability of smoking remained stable between 0.35 and 0.40, before dropping under 0.30 for those born after 1974 ($p < 0.05$).

As expected, the likelihood of never having smoked among men with tertiary education increased strongly across cohorts from around 0.20 among those born around 1921 to around 0.70 among for born in the late 1960s ($p < 0.05$). The cohort pro- file for men with primary/secondary education was similar, but less pronounced. For both groups, the results indicate that Pr(N) reached a maximum in the mid-1970s, before levelling off.

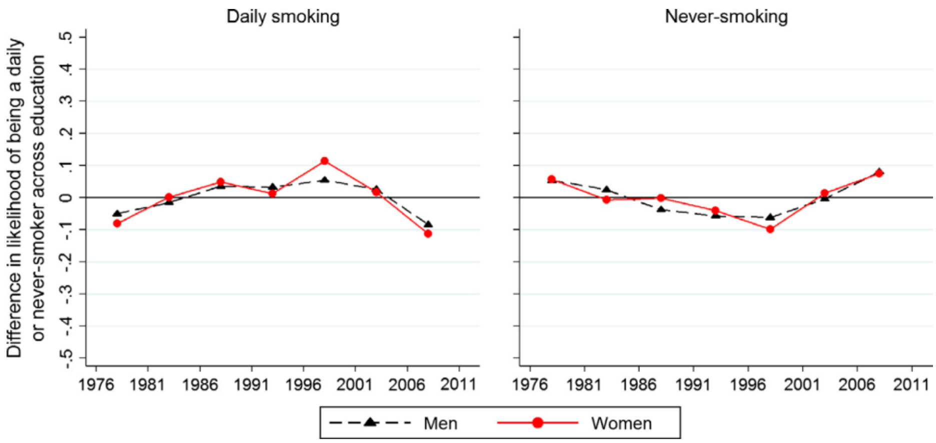
Among women, the likelihood of never having smoked among early birth cohorts was high compared to men for. How- ever, among women with tertiary education born between 1917 and 1958, Pr(N) remained stable around 0.50. Among women with primary/secondary education, Pr(N) decreased from 0.50 for cohorts born around 1921 to under 0.30 for cohorts born between 1949 and 1958, before increasing to around 0.40 among the three latest cohorts ($p < 0.05$ for all pairs).

Fig. 2. Predicted probabilities (95% CI) of daily and never-smoking among men and women with different levels of education across 5-year age groups and birth cohorts, Norway 1976–2010.



A visualization of the period effects, in the form of semi-elasticities, is shown in Fig. 3. The coefficients indicate the annual per cent change in the probability of daily and never-smoking from the mean (zero). The results showed that the likelihood of daily smoking was slightly lower at the beginning and at the end of the survey period. Similarly, the likelihood of never having smoking was relatively low during the 1990s compared to the 1970s and the last ten years of the survey period.

Fig. 3. Per cent change in the probability of daily and never-smoking across survey years, relative to the mean, men and women, Norway 1976–2010.



5.3. Age and cohort effects from models using continuous measures

Table 1 displays results from the gender-specific regression models with continuous measures of age and age squared, and cohort and cohort squared. The coefficients represent the average per cent change in the probability of daily and never-smoking with a 5-year increase in age or cohort (semi-elasticities).

In the case of daily smoking, the decrease in Pr(S) across age was almost identical among men with primary/secondary and tertiary education ($p = 0.99$). In contrast, the relative per cent decrease in Pr(S) across cohorts was almost twice as large for men with tertiary education relative to those with primary/secondary education ($p < 0.01$).

The same pattern was observed among women: Although the decline in the probability of daily smoking with age was not significantly different across education groups ($p = 0.14$), the per cent decrease in Pr(S) across cohorts was over seven times larger for women with tertiary education compared to women with primary/secondary education ($p < 0.01$).

For never-smoking, age profiles were weakly positive and similar across education, although the likelihood of never having smoked increased marginally faster with age among women with primary/secondary compared to tertiary education ($p = 0.05$).

Cohort profiles for never-smoking were less uniform. Among men, Pr(N) increased with just over 10% for each successive cohort, regardless of education. In contrast, Pr(N) among women was either stable across cohorts, as in the case of women with primary/secondary education, or weakly positive, as in the case of women with tertiary education.

Table 1: The per cent change in the probability of daily and never-smoking with 5-year increase in age or birth cohort, men and women with primary/secondary and tertiary education, Norway 1976–2010.

	Men			Women		
	ey/dx	SE	P	ey/dx	SE	P
Daily smoking						
Age						
Primary/secondary	-0.104	0.005	0.000	- 0.081	0.004	0.000
Tertiary	-0.104	0.014	0.000	-0.102	0.013	0.000
Cohort						
Primary/secondary	-0.084	0.005	0.000	- 0.012	0.004	0.008
Tertiary	-0.146	0.012	0.000	-0.090	0.011	0.000
Never-smoking						
Age						
Primary/secondary	0.041	0.008	0.000	0.049	0.007	0.000
Tertiary	0.050	0.009	0.000	0.028	0.008	0.001
Cohort						
Primary/secondary	0.117	0.007	0.000	-0.011	0.006	0.074
Tertiary	0.121	0.007	0.000	0.024	0.006	0.000

5.4. Differences in daily and never-smoking between education groups

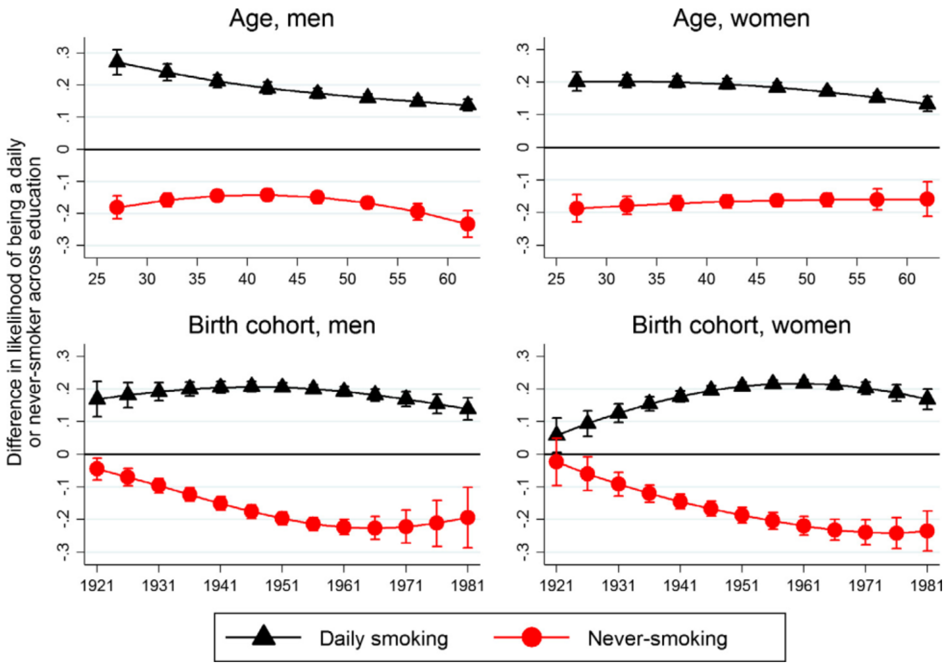
Although the relative changes over age groups and cohorts provide a picture of the overall trends in smoking behavior over time, they shed little light on variations between education groups at different points in time. To examine the question of whether smoking behavior in the two education groups have converged or diverged, absolute differences in the probability of daily and never-smoking between education groups were calculated for each age group and birth cohort (Fig. 4).

The results show that differences in daily smoking between education groups decreased linearly with age. Among men the absolute differences in Pr(S) between the two groups decreased from 0.27 points to 0.16 points between the ages 25 and 54 ($p < 0.05$ for each adjacent group). Among women, differences in Pr(S) remained stable around 0.20 points among age groups 25 to 39, before decreasing ($p < 0.05$ for all adjacent pairs from age 40–64). In the case of never-smoking among men, differences showed a weak curvilinear trend and varied between -0.18, -0.14 and -0.23 points. Among women, differences were stable around -0.17 points over the life course.

In contrast, differences in smoking behavior between the two education groups varied more with cohort membership, and most notably for never-smoking. Among men, educational differences in daily smoking increased marginally from 0.17 to 0.21 points among cohorts born in 1917 to 1948 ($p < 0.05$) before levelling off. Among women, differences increased rapidly from 0.06 points among cohorts born around 1921 to 0.22 points among women born in the early 1960s ($p < 0.05$) before levelling off.

The curvilinear trend is equally present for never-smoking. Among both men and women, educational differences in Pr(N) increased rapidly from around zero among cohorts born around 1921 to above 0.20 points among those born in the 1960s ($p < 0.05$), although maximum difference seem to take place around 10 years later among women compared to men. From then on differences seem to level off, but variations were difficult to assess due to large standard errors.

Fig. 4. Differences in the probability of daily and never-smoking between education groups across 5-year age groups and birth cohorts, men and women, Norway 1976–2010.



6. Discussion

The results from this study showed that daily smoking among men and women decreased with both age and birth cohort membership. And, while the likelihood of never having smoked increased marginally with age for both genders, the cohort effects on never-smoking were much stronger among men compared to women.

Given that 92% of the respondents in this study had started smoking before the age of 25, a decline in daily smoking with age can be interpreted as a measure of cigarette smoking cessation. Although the results showed that smoking cessation increased with age, the findings provided little support for the idea that higher educated are more likely to quit at earlier stages in the life course compared to groups with lower education (inter-cohort diffusion).

Instead, the findings emphasized the role of birth cohort membership for increased social inequality in smoking, and were consistent with inter-cohort diffusion: The overall decline in daily smoking across cohorts for men with high school/university education was stronger than for men with lower education and the educational differences in daily and never-smoking increased across cohorts born in the first half of the 20th century before levelling off.

The decline in smoking among women with primary/secondary education lagged decades behind all other groups. Indeed, the likelihood of being a daily cigarette smoking actually increased and the likelihood of never having smoked decreased for cohorts born between 1920 and the mid-1950s. In more recent decades, however, differences between women with higher and lower education remained stable.

However, some findings cannot be adequately explained by a diffusion of innovations approach. The positive relationship between never having smoked and age after controlling for birth cohort membership, and the curvilinear shape of the educational differences in never-smoking among men, seems at odds with the idea that the fraction of never-smokers among adults born in the same year should remain stable across age groups, as shown by Maralani (2013) or decrease.

The positive age effects in never-smoking could mean that the APC-model overstates the age effects at the expense of cohort effects. This possibility did not receive any support from an examination of the data which showed that the percent- ages of never-smokers within each cohort increased with age. Another explanation may be that because smokers have an increased risk of mortality compared to non-smokers, even among people in their 40s (Jha and Peto, 2014), the fraction of never-smokers increased with age.

Although, several studies of smoking have used a cohort approach, few have included the role of education (see, for example Keyes et al., 2013), and even fewer have taken the role of socio-economic position into account and estimating separate age, period and cohort effects.

One exception is a German study by Piontek et al. (2010), which examined the relationship between smoking and socio- economic status using a cross-classified random-effects model developed by Yang and Land (2006). Piontek's study found curvilinear age and cohort effects, but maximum smoking prevalence occurred later in life and among later cohorts com- pared with the present study.

Although differences in the methodologies may account for some of the differences, the studies also differed in two other important aspects. First, the German study did not separate men and women in the analysis. Given the form of the cigarette epidemic, this may have understated the role of birth cohort among early cohorts and overstated the role among later cohorts. Second, differences in smoking behavior between countries are not only a question of being in different phases of the cigarette epidemic. As shown by Pampel (2002), gender inequality can affect smoking behavior by limiting women's opportunities to smoke. Although Germany and Norway are similar in many ways, gender equality has traditionally been greater in Norway, which should produce stronger cohort effects on daily smoking for women in Norway compared to Germany.

Although variations in daily cigarette smoking fit the pattern predicted by TDI, the precise mechanisms behind educational differences in cigarette smoking have been the object of much debate (Cutler and Lleras-Muney, 2010; de Walque, 2007; Tenn et al., 2010). It is likely that different mechanisms have been important at different stages of the epidemic. In the early stages, technological innovations, increased economic and social opportunities and cigarette advertising were important (Ferrence, 1989; Pampel, 2002). In the later stages, the production and communication of health-related information, increased tobacco control and the increasingly negative symbolic content of cigarette smoking have all played a role (Collins, 2004: 339–340).

However, the persistence of educational differences in smoking found in this and other studies (Pampel, 2009) suggests that smoking is determined not only by proximal factors such as price, information or restrictions, but also by fundamental social forces. Pampel argues that the "stubborn resistance" to reduced smoking in low-SEP groups is consistent with the “fundamental causes of disease” argument presented by Link and Phelan (1995). In brief, Link and Phelan draw attention to the persistent link between nearly all measures of socio-economic position and most major causes of death, even though the specific mechanisms or proximal risk factors have varied over time, and argue that disparities are the result of high-SEP groups having better access to resources associated with good health.

In the case of smoking, such resources may include information, support from social networks or the economic means to experiment with treatment regimens or nicotine replacement therapy. However, and in light of the findings from the present study, if such fundamental causes produce educational differences in smoking, they must primarily be linked to smoking initiation and not quitting.

The important role of cohort membership and the less important role of age for educational differences in smoking have been noted in prior research (Maralani, 2013) and supports the idea that cohorts are vehicles of social change (Ryder, 1965). However, the deceleration of educational differences in daily and never-smoking across cohorts do not support the idea that differences in smoking behavior between people with different levels of education are widening or that there is a process of sedimentation (Dixon and Banwell, 2009) or hardening (Warner and Burns, 2003) of smokers among low-SEP groups.

6.1. Strengths and limitations

This study used data from two nationally representative surveys conducted over 35 consecutive years. The long unbroken chain of surveys is rare, and makes it possible to create a pseudo-panel which has several advantages over ordinary panel regression. First, cross-sectional data are not prone to attrition, as is often the case for panel data, especially over long periods of time. Second, panel data are scarce, whereas cross-sectional data are common and, in this case, repeated over a large number of time points. Third, aggregated data can easily be merged with other information sources such as official statistics (Deaton, 1985: 120). In addition, the APC framework developed by

Deaton is technically straightforward, compares well with other APC models (Browning et al., 2012) and can be theoretically justified.

However, as discussed by Bell and Jones (2013), trade-offs are inevitable when constructing APC models. Most cohort studies of cigarette smoking have avoided the identification problem by following separate cohorts over time (see, for example Kemm, 2001). Although this is methodologically sound, it does not enable the researcher to estimate trends in smoking across age groups and cohorts simultaneously.

The approach used in this study makes two assumptions that may be contested. First, similar to other APC models, the model does not include interactions between age, period or cohort. This means, for example, that the age gradient in smoking is assumed to be equal among early and late cohorts. The rationale behind this is that new information about the negative health effects of smoking and the introduction of new technologies to help people quit are likely to be equally (un)effective for smoking cessation among all adult age groups.

Yet, in a study by Pampel (2003), age profile of smoking among women varied between the early and late stages of cigarette diffusion. However, this study did not specifically control for age, period and cohort effects and it is therefore possible that age differences across time could be due to variations in cohort membership.

Second, the period variable was normalized to pick up cyclical fluctuations in smoking that averaged to zero over the long term. This can be regarded as a controversial assumption and, in the event of a temporal trend in the period effects, this approach would most likely result in exaggerated cohort effects.

In defense of this assumption I argued that most tobacco control policies have made cigarettes unattractive among potential young adopters rather than having a simultaneous negative impact across all age groups and that the potential effects from such policies should be regarded as cohort effects.

It should also be noted that other studies of smoking behavior or health consequences from smoking, and which used different approaches to the identification problem, have found little support for long term period effects (see, for example Carreras and Gorini, 2013; Chen et al., 2011; Murphy and Di Cesare, 2012). One exemption was the study by Piontek et al. (2010) which found relatively strong negative period effects on cigarette smoking. However, according to a recent simulation study (Bell and Jones, 2014), the APC approach used by Piontek et al. has been shown to produce biased results when there are cohort trends in the data.

As mentioned above, this study has demonstrated that educational differences in smoking have increased in the latter half of the 20th century, but does not provides support for the idea that differences will increase further or that a process of sedimentation of smoking has taken place. Yet, the present study may not have adequately addressed these processes. The youngest cohort in this study was born in 1980 and grew up in a society in which cigarette smoking still was prevalent and widely tolerated. Also, the measure of education used in this study may not be sufficiently nuanced to isolate those groups in which sedimentation of smoking would be most likely, such as the unemployed or people living in poverty.

The measurement of education as a dichotomous variable also implies several limitations. Even though it was necessary to combine individuals with primary and secondary education, because of the change in definition over time, this made it impossible to single out the most resistant group of smokers, those with primary education only. However, in a study by Cutler and Lleras-Muney (2010), the marginal effect of education on smoking was roughly the same for the first 10–11 years of education, which corresponds to the group with primary/secondary education in the present study.

A second limitation related to the measurement of education, concerns the changing composition of people across cohorts in the two education groups due to improved access to higher education. However, given that there is a causal link between education and smoking (de Walque, 2007; Kenkel et al., 2006), the importance of changing group composition is likely limited.

Nevertheless, to examine a possible impact of changed group composition on the results, all models were re-run using a measure of relative education that categorized respondents as having below- or above-average education within each age x gender x year group using the original education variable (primary, secondary or tertiary). Although this was a crude measure, the results showed that the semi-elasticities of smoking for groups with below-average education were nearly identical to groups with primary/tertiary education. A similar relationship was observed between above-average education and tertiary education.

Lastly, because the data was aggregated and the inclusion of additional variables would reduce cell size, the models were restricted to a relatively small number of control variables. The respondents' region of residence and yearly quarters were included in earlier versions of the models, but these variables did not show any association with cigarette smoking status, and were therefore not included.

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