Title

Gender, Tobacco Control Policies, and Persistent Smoking Among Older Adults: A Longitudinal Analysis of 11 European Countries.

Journal

Nicotine & tobacco research : official journal of the Society for Research on Nicotine and Tobacco, 24(8)

ISSN

1462-2203

Authors

Gao, Manjing
Lee, Chioun
Park, Soojin

Publication Date

2022-07-01

DOI

10.1093/ntr/ntac023

Peer reviewed

Nicotine and Tobacco Research, 2022, **24**, 1247–1256
https://doi.org/10.1093/ntr/ntac023
Advance access publication 29 January 2022
Original Investigation

Gender, Tobacco Control Policies, and Persistent Smoking Among Older Adults: A Longitudinal Analysis of 11 European Countries

Manjing Gao MA[1], Chioun Lee PhD[1], Soojin Park PhD[2]

[1]Department of Sociology, University of California-Riverside, Riverside, CA, USA
[2]Graduate School of Education, University of California-Riverside, Riverside, CA, USA

Corresponding Author: Chioun Lee, PhD, 1207 Watkins, 900 University Ave., Riverside, CA 92521, USA. Telephone: +1 952-827-4411; E-mail: chiounl@ucr.edu

Abstract

Introduction: Little is known about sociodemographic and macro-level predictors of persistent smoking when one has developed a health condition that is likely caused by smoking.

Aims and Methods: We investigate the impact of gender, education, and tobacco control policies (TCPs) on persistent smoking among older Europeans. Respondents (aged 50 +) with a smoking history and at least one smoking-related health condition were pooled from the Survey of Health, Aging and Retirement in Europe (SHARE) and the English Longitudinal Study of Ageing (ELSA) from four waves from 2004 to 2013. We fitted gender-specific logistic regression models with two-way fixed effects (country and year) and tested interaction terms between gender, education, and TCPs.

Results: Although women are less likely to smoke than men, they were more likely to smoke persistently. The effects of education and general TCPs on persistent smoking were significant for women only. Compared to women with low levels of education, those with moderate education (odds ratio [OR] = .63; .49–.82) and high education (OR = .57; .34–.98) are less likely to be persistent smokers. TCPs are associated with a reduced risk of women's persistent smoking (OR = .70; .51–.95) and the association is stronger for those having less education.

Conclusions: Older women, particularly those with low levels of education, are vulnerable to persistent smoking. TCPs might be effective in reducing persistent smoking for older women, with greater effects for less-educated women. Future studies are needed to understand mechanisms that explain gender differences in responsiveness to TCPs.

Implications: Persistent smoking is a particularly harmful smoking behavior as it is associated with greater risks of comorbidity and mortality. By employing the framework of the multilevel social determinants of health, this study examined the behavior of persistent smoking among older adults in European countries. Women, especially women with low levels of education are vulnerable to persistent smoking. Moreover, TCPs, in general, are significantly related to a reduction in persistent smoking among older women only and the negative association is stronger for those having less education, indicating gender and socioeconomic differences in responsiveness to TCPs.

Introduction

Despite decades of progress in curbing tobacco use, smoking causes more than 8 million deaths per year worldwide.[1] The causal association between smoking and several health conditions (eg, coronary heart disease [CHD], lung cancer) has been well established.[2] Quitting smoking reduces the risk of developing cardiovascular disease, stroke, and cancer,[3] yet a substantial proportion of individuals, for example, 21% of CHD patients, continue to smoke despite having developed smoking-related conditions (referred to as persistent smoking).[4] Persistent smoking is associated with expedited disease progression, worsening outcomes, increased complication rates, and reduced treatment compliance; those who smoke persistently, therefore, are likely to have a greater risk of comorbidity and mortality.[5] Given the high prevalence and lethality of persistent smoking, more work is needed to facilitate smoking cessation interventions among people who persistently smoke. Yet, we have little knowledge about the social determinants that are associated with the risk of persistent smoking.

Previous studies suggest that gender is associated with various characteristics of smoking. For example, compared to men, women are less likely to smoke, but among people who currently smoke, men are more likely to quit smoking.[6,7] Few studies, thus far, have investigated gender differences in persistent smoking, and previous findings are mixed. Some studies demonstrate that, after being diagnosed with health conditions, the continuation and relapse of smoking are more common among women than men,[4] some find a null effect of gender,[8] and others report the opposite effect.[9] In addition to gender, education is a well-known predictor of smoking initiation, cessation, and relapse.[10] Further, prior studies have shown that low levels of education are associated with elevated risk of persistent smoking.[4] When confronted with emerging health conditions, those with higher levels of education are more likely than their less-educated counterparts to make and adhere to health behavior changes, such as smoking cessation and physical activity participation, perhaps because they are better able to adapt to new health information.[11]

How gender plays a role in the association between education and persistent smoking is an open question. Resource substitution theory suggests that education has a greater influence on health for marginalized groups (eg, women) than

Received: July 2, 2021. **Revised:** October 15, 2021. **Accepted:** January 25, 2022

for more advantaged social groups (eg, men) as the former may have fewer alternative resources to rely on.[12] Further, women, particularly highly educated women, are more likely to participate in health preventive behaviors, such as annual routine physical exams, screenings, and seeking out health information.[13,14] Therefore, we expect a stronger inverse association between education and persistent smoking among women than men. Thus far, only one study that we are aware of has found a significant gender difference in the association between education and smoking cessation after a hypertension diagnosis, with a larger effect for women than men.[15] However, this study was conducted in the US context and whether this finding is robust in other cultural and societal settings is unknown.

Few studies have examined how macro-level social context may influence persistent smoking. Constrained choice theorists argue that individuals' decisions and priorities concerning health are influenced by social context.[16] In the case of smoking, previous studies have suggested an important impact of tobacco control policies (TCPs) on smoking, such as cessation, intensity, and prevalence.[17,18] To our knowledge, only one study has found that smoking restriction policies in public places increase the likelihood of quitting among patients who smoke,[9] yet whether this finding from rural western China is transferable to other societies is questionable. Moreover, focusing on smoke-free policies in public spaces may overlook other TCPs, such as price policies and advertisement regulations, as TCPs contain multi-dimensional policy efforts. Following prior work demonstrating the heterogeneous effects of TCPs across socioeconomic groups,[17,18] we investigate whether TCPs contribute to a narrowing or widening of socioeconomic inequalities in persistent smoking.

Given that the development of chronic illnesses is common in midlife through old age, smoking cessation at older ages, particularly those with chronic diseases, can bring significant gains in life expectancy and quality of life,[18] for example, a 36% risk reduction in mortality in patients with established CHD.[19] Using older adults in Europe where various TCPs have been introduced in recent decades, this study has four aims: testing for (1) gender differences in the risk of persistent smoking among older adults, (2) whether education has an impact on persistent smoking and whether the effect varies across gender, (3) whether TCPs are inversely associated with persistent smoking, and (4) the extent to which the association between TCPs and persistent smoking varies by education and gender.

Methods

Data

We pooled data from two harmonized longitudinal studies on aging: the Survey of Health, Ageing and Retirement in Europe (SHARE), and the English Longitudinal Study of Ageing (ELSA).[20] The two surveys provide cross-national comparisons in Europe. In each survey, nationally representative samples of households with individuals aged 50 and over were drawn and information was collected from all age-eligible residents from the household and their spouses regardless of age. Detailed descriptions of SHARE and ELSA can be found elsewhere.[21,22]

Since not all waves include questionnaires related to smoking, we selected the survey waves that contain information on smoking. For SHARE, we used waves 1 (2004–05), 2 (2006–07), 4 (2010–11), and 5 (2012–13) for the 10 countries which participated in all four waves: Austria, Belgium, Denmark, France, Germany, Italy, Netherlands, Spain, Sweden, and Switzerland. For ELSA, corresponding waves were included, which were waves 2 (2004–05), 3 (2006–07), 5 (2010–11), and 6 (2012–13). We included respondents aged 50 years and older who participated in the baseline wave (2004–05) plus at least one other wave to obtain a longitudinal sample while preserving the most sample size. The pooled sample included 25 845 respondents and 84 266 observations. 3.7 % of respondents had missing values for at least one of the variables of interest due to item-specific non-response or missingness in survey weight (N = 961, N of observations [Nobs.] = 3220). After we restricted our sample to those with a smoking history and at least one of various smoking-related health conditions over at least two observational periods, 0.5% of data was missing. We conducted complete data analysis since with less than 1% of the missing rate the bias due to listwise deletion is minimal.[23] After listwise deletion, we had 24 716 observations for 8 231 respondents in our final longitudinal sample. For detailed information, see Figure 1 and analytic strategy below and Table S1 in Supplementary Materials.

Measures

Dependent Variable

To identify individuals who smoke persistently, we followed the logic developed by previous studies.[4,24] We used the three-stage process depicted in Figure 1. First, we obtained smoking status through a question asking whether the respondent had ever smoked cigarettes. We restricted our sample to those with a smoking history (Stage 1 of Figure 1). Next, among individuals who self-reported as people who ever smoked, we identified those who had ever been diagnosed by doctors with at least one of the following conditions which may be exacerbated by smoking: high blood pressure, diabetes, cancer, lung disease, heart problems, or stroke (Stage 2). Last, we identified people who smoke persistently as respondents who had a smoking history and smoking-related health conditions but indicated that they were currently smoking (Stage 3).

Explanatory Variables

Education is commonly used as a measurement of socioeconomic status. Given the differences in education systems across countries, we used a harmonized categorical variable derived from the International Standard Classification of Education (ISCED)-97 codes to standardize the educational level across countries by categorizing into three groups: *low* (less than upper secondary education), *moderate* (upper secondary education or vocational training), and *high* (tertiary education). **TCPs.** TCPs were measured by the tobacco control scale (TCS).[17,18] The TCS is an indicator that quantifies country-level TCPs across six domains: price of tobacco, smoke-free policies, budget for information campaigns, bans on tobacco advertising, health warning labels, and cessation support. It ranges from 0 to 100, with higher scores indicating a higher degree of tobacco control. The scale was developed by Joossens and Raw in 2005.[25] To ensure that the scores are comparable across years, we used the recalibrated scores calculated by Bosdriesz et al.[17,18] The TCS contains policies that had already been established at the beginning of each year.[18] To establish a temporal order between TCPs and smoking status in each country, the TCS scores prior to the survey period

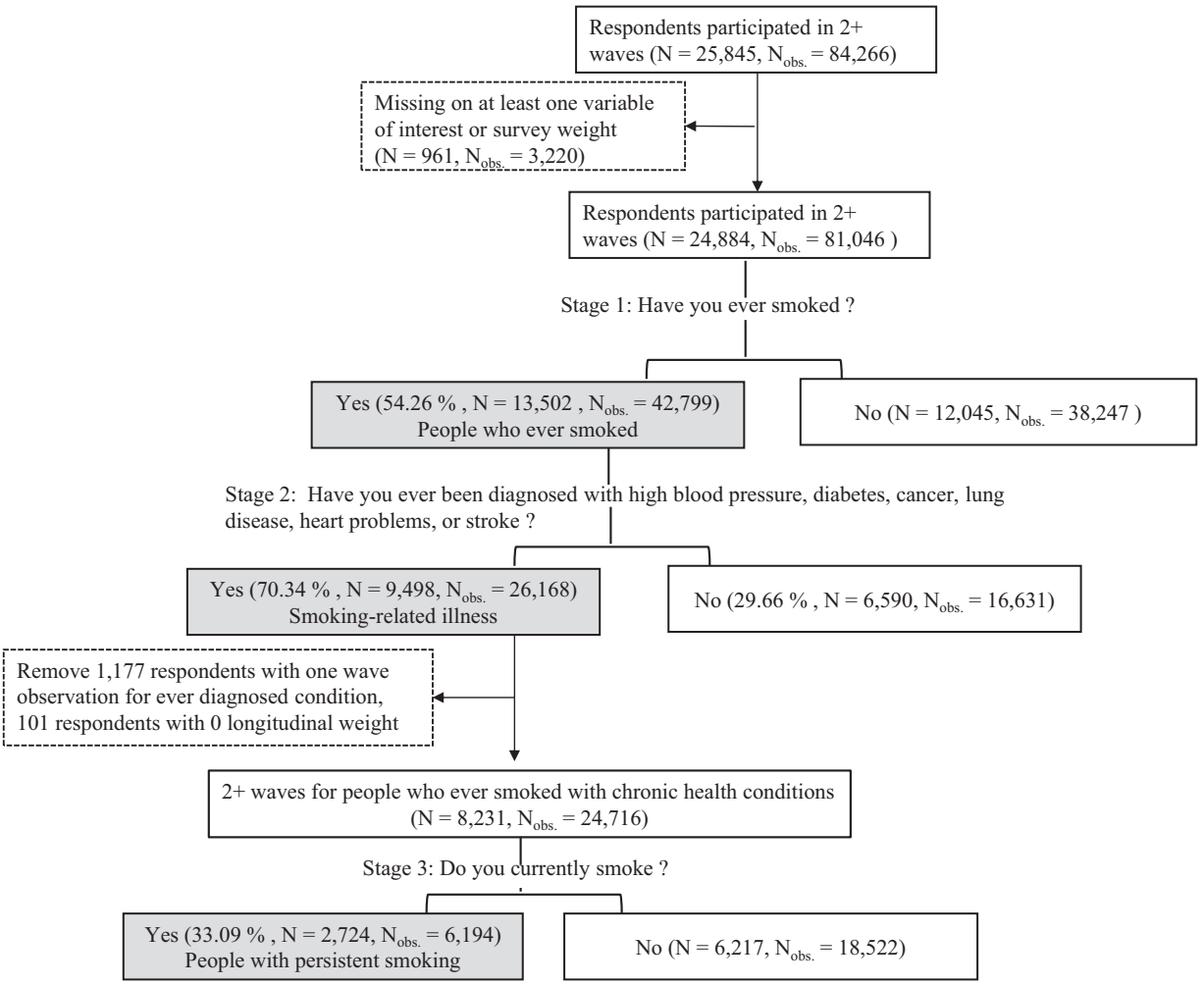

Figure 1. Sequential process to identify persistent smoking.

were assigned by country to all respondents from that country. The TCS scores for 2004, 2006, 2010, and 2012 were assigned to survey respondents in waves 2004–05, 2006–07, 2010–11, and 2012–13, respectively. To examine the effect of different TCPs, we divided the TCS into three dimensions following previous studies: pricing policies, smoke-free policies, and other TCPs.[18] The other policies include information campaigns, bans on advertisement, health warning labels, and cessation support to people who smoke.

Covariates

Consistent with previous research,[4] we controlled for respondent's **marital status** (1 = partnered, married, or cohabitating; 0 = separated, divorced, widowed, or never married), **age** as a continuous variable, and **gender** for gender-stratified models.

Statistical Analysis

For descriptive analysis, we calculated age-adjusted prevalence of persistent smoking per country by gender, to investigate the gender difference in persistent smoking (Aim 1). Next, to examine the association between the change in the TCS and the change in the prevalence of persistent smoking, we calculated Pearson's correlation coefficients and created a scatterplot. For the multivariate analysis, we conducted weighted logistic regression analysis with two-way fixed-effects.[26] In our dataset, each individual is nested within countries, and individuals are repeatedly measured across different years. Multilevel models are commonly used for such data. However, this method was inappropriate for our analysis as the small cases at the country level could lead to downwardly biased standard errors for country-level predictors and cross-level interactions.[27] To obviate these methodological concerns, we used two-way fixed effects estimators, which control for time-invariant unobserved country characteristics (eg, culture) and country-invariant unobserved wave effects (eg, economic recession).[26] We computed standard errors by clustering at both the individual and the country level to account for repeatedly measured individuals across different waves[18] and within-country correlation of individuals.[28]

The weighted logistic regression analysis with fixed effects was conducted in a stepwise approach. In Model 1, we regressed persistent smoking on education, controlling for country- and wave-fixed effects and other covariates (Aim 2). In Model 2, the TCS was added to analyze the association between TCPs and persistent smoking (Aim 3). In Model 3, to determine whether the association of TCPs with persistent smoking varies by education, we included a cross-level interaction between the TCS and education (Aim 4). All country-level predictors were standardized to have a mean of 0 and a SD of 1 for ease of interpretation. The analysis was stratified by gender, and gender differences were tested by pooling data

from both genders and testing gender interaction terms. All analyses were carried out using Stata version 16.0. Recently, some scholars have argued that the interpretation of the two-way fixed-effect coefficients is unclear.[29] Despite the argument, we decided to use the estimator since it is essential to account for country-fixed and time-fixed omitted variables in our analysis. For robustness check, we conducted country fixed-effect only models and found that the TCPs were marginally significant for women ($p < .1$). But other results remained essentially the same (see Table S2 in Supplementary Materials).

Attrition in longitudinal surveys can occur as a result of death, relocation, or nonresponse. Our findings will be biased if there are systemic differences between respondents who participated in the baseline wave only and those who followed up in at least one of the other waves. To adjust for potential attrition bias, we calculated inverse probability weights.[18] First, we calculated the probability of responding in 2+ waves (baseline wave + at least one of the other three waves) based on the following covariates: age, gender, education, smoking status, TCS at the year 2004, self-reported health status, number of physical limitations, and chronic conditions. Next, inverse probability weights were gained by the inverse of the predicted probability of responding in 2+ waves. Last, these weights were multiplied by the cross-sectional weights from the 2004–05 wave. The cross-sectional weights are designed to recover the countries' population aged 50 years old or older at the baseline wave. The inverse probability longitudinal weights were applied to all descriptive and multivariate analyses.

Results

Table 1 shows the characteristics of our longitudinal sample and the age-adjusted prevalence of persistent smoking among men and women per country. On average, the rate of current smoking was higher for men than women, whereas the opposite pattern was found for persistent smoking (prevalence of persistent smoking by each chronic condition, see Table S5). After controlling for all covariates, we found that women are more likely than men to engage in persistent smoking ($p < .001$, not shown). Next, we examined the variation of the prevalence of persistent smoking and the variation of the TCS scores (Table S3) and observed a negative association between the change in persistent smoking prevalence and the change in TCS (the Pearson's correlation = –0.47, see Figure S1).

Table 2 displays the results from two-way fixed effects logistic regression models to investigate the association between education, TCPs, and persistent smoking for men and women, after controlling for other covariates. In Model 1, we observed that education was inversely associated with the risk of persistent smoking only for women. For men, we found no significant effect of education. Specifically, the odds for women with moderate and high education engaging in persistent smoking were 37.0% (odds ratio [OR] = 0.63, confidence interval [CI] = .49 to .82) and 43.0% (OR = 0.57, CI = .34 to .98) lower than those with low levels of education. The results are illustrated in Figure S2 and the interaction between gender and education in the pooled sample was statistically significant ($p < .01$, see Model 1 in Table S4).

Model 2 shows that the association between the TCS and persistent smoking (after controlling for education) was not statistically significant for men but was significant for women (OR = 0.70, CI = .51 to .95). For women, after accounting for TCPs, education remained a significant predictor of persistent smoking. Model 3 displays the results of the cross-level interaction between the TCS and education. The interaction term was statistically significant for women. The negative association between the TCS and persistent smoking was weaker for women with moderate (OR = 1.22, CI = .98 to 1.52, $p = .068$) and high education (OR = 1.60, CI = 1.18 to 2.17), compared to those with low education, although this is only statistically significant for women with low education ($p < .01$) (see Figure S3). We tested the three-way interaction term between education, gender, and the TCS, but the interaction was not significant (see Model 2 in Table S4).

Last, we examined the effects of different types of policies and whether these effects are heterogeneous according to individuals' education level and gender. The results are presented in Table 3. In Model 1, we tested the association between different types of TCPs and persistent smoking. In Model 2 to Model 4, we tested for interactions between education and each of the three policies (price policies, smoke-free policies, and other policies), respectively, while controlling for the other types of policies. For men, the effect of price policies was negative overall but varied by education. Controlling for smoke-free and other policies, an increase in price policies was significantly associated with a reduced probability of persistent smoking (Model 1a, OR = 0.82, CI = .75 to .89). Moreover, the association between the price policies and persistent smoking was stronger (ie, less effect of the policies on smoking cessation) for men with high education (Model 2a OR = 1.29, CI = 1.03 to 1.61), compared to those with low education. No significant difference was found between those with moderate education and high education.

For women, similar to men, an increase in price policies was significantly associated with a lower overall probability of persistent smoking (Model 1b, OR = 0.73, CI = .62 to .85). Smoke-free policies and other policies were negatively associated with the risk of persistent smoking and significant at the 90% confidence level. Besides, the significant interaction effect between other policies and education indicates that other policies were associated with greater reduction of persistent smoking among women with low education, compared to women with moderate (Model 4b, OR = 1.34, CI = 1.14 to 1.58) and high education (Model 4b, OR = 1.80, CI = 1.25 to 2.60).

Discussion

Using a longitudinal sample of older Europeans (aged 50+) with a history of smoking and smoking-related health conditions from 11 countries, we investigated social determinants of persistent smoking. At the individual level, we replicated a finding in the existing literature of a gender difference in persistent smoking among older adults,[4] and expanded its generalizability by employing a longitudinal sample from 11 European countries. We found that compared to older men, older women are at higher risk of persistent smoking. This gender difference in persistent smoking may be due to gender differences in smoking cessation.[6] Psycho-pharmacological and social/environment contextual factors may play an important role in gender differences in smoking cessation.[6] Such factors may include hormone variation,[30] smoking cessation medication use,[31] nicotine dependence,[32] and gender pay gaps

Table 1. Characteristics of the Study Population and Prevalence of Persistent Smoking in the Sample

			Age-adjusted current smoking (%)		Age-adjusted persistent smoking prevalence (%)		Women (%)	Age		Education (%)		
	N	$N_{obs.}$	Men	Women	Men	Women		Mean	SD	Low	Moderate	High
Austria	235	659	18.4	15.0	31.5	46.7	37.0	67.4	0.4	29.5	45.5	25.0
Belgium	895	2660	19.5	11.2	24.3	35.4	32.3	68.5	0.2	49.7	27.5	22.8
Denmark	502	1498	27.4	24.2	36.0	37.6	48.7	68.7	0.3	27.5	46.0	26.6
France	537	1586	17.4	10.1	22.8	36.6	28.3	68.4	0.3	43.6	31.7	24.7
Germany	468	1292	19.8	14.2	28.1	38.3	39.4	66.6	0.3	12.0	58.2	29.8
Italy	546	1678	21.9	13.3	30.9	42.7	30.8	68.3	0.3	71.1	23.0	6.0
Netherlands	697	2045	22.9	19.4	26.7	36.1	42.9	67.9	0.2	56.7	25.3	18.1
Spain	417	1222	21.9	7.4	26.5	43.0	14.6	69.0	0.3	80.6	9.1	10.3
Sweden	738	2069	11.9	17.7	17.0	31.1	45.0	68.6	0.2	54.3	27.3	18.3
Switzerland	182	543	23.7	18.0	39.6	41.3	40.9	68.8	0.4	50.0	41.1	8.5
UK	3014	9464	13.6	13.7	18.2	22.4	45.6	70.9	0.1	48.8	40.3	10.9
Total	8231	24716	20.2	12.7	27.5	38.9	32.3	68.0	0.1	48.8	32.8	18.4

Statistics except for current smoking are based on respondents who were aged 50 years and older, with a smoking history and at least one of the following smoking-related health conditions. All the descriptive statistics were calculated using inverse probability longitudinal weights. The age-adjusted current smoking is from respondents who were aged 50 years and older.

Table 2. Estimates (Odds Ratio, 95% CI) for Two-Way Fixed Effects Models Predicting Persistent Smoking for Men and Women

	Men ($N_{obs.}$ = 14705)			Women ($N_{obs.}$= 10 011)		
Persistent Smoking	**Model 1**	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**
Low education (ref.)	—	—	—	—	—	—
Moderate education	1.12	1.12	1.03	0.63***	0.63***	0.69*
	(0.77 to 1.62)	(0.77 to 1.62)	(0.75 to 1.40)	(0.49 to 0.82)	(0.49 to 0.82)	(0.49 to 0.97)
High education	0.94	0.94	1.09	0.57*	0.57*	0.73#
	(0.77 to 1.14)	(0.77 to 1.14)	(0.88 to 1.34)	(0.34 to 0.98)	(0.33 to 0.98)	(0.50 to 1.06)
TCS		0.93	0.93		0.70*	0.62**
		(0.74 to 1.16)	(0.73 to 1.19)		(0.51 to 0.95)	(0.45 to 0.86)
TCS × moderate education			0.88			1.22#
			(0.58 to 1.35)			(0.98 to 1.52)
TCS × high education			1.23			1.60**
			(0.95 to 1.61)			(1.18 to 2.17)
Age	0.94***	0.94***	0.94***	0.95***	0.95***	0.95***
	(0.93 to 0.96)	(0.93 to 0.96)	(0.93 to 0.96)	(0.94 to 0.96)	(0.94 to 0.96)	(0.94 to 0.96)
Partnered	0.59**	0.59**	0.58**	0.58***	0.58***	0.58***
	(0.42 to 0.83)	(0.42 to 0.83)	(0.41 to 0.83)	(0.49 to 0.68)	(0.49 to 0.68)	(0.49 to 0.68)

TCS = tobacco control scale.
***$p < .001$.
**$p < .01$.
*$p < .05$.
#$p < .1$ (two-tailed tests).

Table 3. Estimates (Odds Ratio, 95% CI) for two-Way Fixed Effects Models Predicting Persistent Smoking With Types of TCPs

	Men ($N_{obs.}$ = 14705)				Women ($N_{obs.}$ = 10 011)			
Persistent Smoking	**Model 1a**	**Model 2a**	**Model 3a**	**Model 4a**	**Model 1b**	**Model 2b**	**Model 3b**	**Model 4b**
Low education (ref.)	—	—	—	—	—	—	—	—
Moderate education	1.12	1.11	1.11	0.74	0.63***	0.65*	0.63**	0.77#
	(0.77 to 1.63)	(0.73 to 1.69)	(0.76 to 1.61)	(0.50 - 1.09)	(0.49 to 0.82)	(0.46 to 0.93)	(0.47 to 0.84)	(0.57 to 1.05)
High education	0.94	1.02	0.95	0.96	0.57*	0.63#	0.58*	0.88
	(0.77 to 1.15)	(0.93 to 1.13)	(0.76 to 1.19)	(0.70 to 1.32)	(0.33 to 0.98)	(0.39 to 1.00)	(0.37 to 0.90)	(0.49 to 1.58)
TCS price	0.82***	0.82***	0.85**	0.77***	0.73***	0.70***	0.76***	0.74***
	(0.75 to 0.89)	(0.74 to 0.91)	(0.76 to 0.94)	(0.66 to 0.89)	(0.62 to 0.85)	(0.61 to 0.80)	(0.67 to 0.87)	(0.64 to 0.85)
TCS smoke free	0.91	0.91	0.89*	0.88	0.86#	0.86#	0.82#	0.87
	(0.79 to 1.04)	(0.78 to 1.05)	(0.81 to 0.98)	(0.74 to 1.06)	(0.73 to 1.02)	(0.73 to 1.02)	(0.66 to 1.01)	(0.74 to 1.03)
TCS other	1.12	1.13	1.11	1.4	0.83#	0.83#	0.84	0.69*
	(0.93 to 1.35)	(0.93 to 1.36)	(0.91 to 1.36)	(0.93 to 2.10)	(0.68 to 1.03)	(0.67 to 1.03)	(0.67 to 1.04)	(0.52 to 0.92)
Age	0.94***	0.94***	0.94***	0.94***	0.95***	0.95***	0.95***	0.95***
	(0.93 to 0.96)	(0.93 to 0.96)	(0.93 to 0.96)	(0.93 to 0.96)	(0.94 to 0.96)	(0.94 to 0.96)	(0.94 to 0.96)	(0.94 to 0.96)
Partnered	0.59**	0.59**	0.59**	0.58**	0.58***	0.58***	0.58***	0.58***
	(0.42 to 0.83)	(0.42 to 0.83)	(0.42 to 0.83)	(0.41 to 0.82)	(0.49 to 0.68)	(0.49 to 0.67)	(0.49 to 0.68)	(0.49 to 0.68)
TCS price × moderate education		0.95				1.09		
		(0.68 to 1.32)				(0.78 to 1.52)		
TCS price × high education		1.29*				1.44		
		(1.03 to 1.61)				(0.93 to 2.23)		
TCS smoke free × moderate education			1.03				1.09	
			(0.77 to 1.37)				(0.91 to 1.29)	
TCS smoke free × high education			1.14				1.22	
			(0.96 to 1.35)				(0.83 to 1.79)	
TCS other × moderate education				0.53*				1.34***
				(0.29 to 0.98)				(1.14 to 1.58)
TCS other × high education				0.84				1.80**
				(0.54 to 1.30)				(1.25 to 2.60)

TCPs = tobacco control policies; TCS = tobacco control scale.
***$p < .001$.
**$p < .01$.
*$p < .05$.
#$p < .1$ (two-tailed tests).

which constrain women's access to adequate healthcare.[33] Given that the risk of dying from many smoking-related diseases, such as lung cancer and cardiovascular disease, is greater for women than men even when exposed to the same level of tobacco exposure,[34,35] women may encounter more problems from persistent smoking than men.

Our study also extends previous studies on education and smoking by investigating the association between education and a particularly harmful smoking behavior, that is, persistent smoking. We found a gendered effect of education on persistent smoking. For women, consistent with previous studies on education and smoking, education was inversely associated with the probability of persistent smoking. Highly educated adults might be less likely to engage in persistent smoking as they have more economic and social-psychological resources to facilitate cessation,[36] better knowledge of the hazards of smoking,[37] and more effective resources when attempting to quit.[38] Further, previous research has shown that after health shocks such as receiving a disease diagnosis, highly educated individuals are generally more likely to change their health behaviors than those with less education.[15] Our finding for women is consistent with these studies since those with lower levels of education were less likely to quit smoking, even when diagnosed with a smoking-related health condition. However, in elderly men, we did not observe such a clear pattern between education and smoking cessation, a finding that, while perplexing, is consistent with prior work using SHARE data.[39]

Consistent with resource substitution theory that sheds light on the role of education on health for marginalized groups,[12] our study showed that the association between education and smoking is stronger for women than men. These results may offer one explanation for the finding that there is a greater positive impact of education on health for women compared to men.[40,41] Moreover, our results reveal that less-educated women are at a greater risk of persistent smoking, possibly because they have less knowledge and resources available to them to modify their smoking behaviors. Smoking may be an important coping mechanism for socioeconomically disadvantaged women. Qualitative research has shown that despite knowing the health risks of smoking, socioeconomically disadvantaged women view smoking as a way to relieve stress, socialize with others, and an affordable recreational activity.[42]

At the macro level, we found that the effects of TCPs were heterogeneous. For men, TCPs, in general, were not associated with persistent smoking, but for women, an inverse association was observed. Additional analysis disaggregating the TCPs into different types of policies showed a gendered responsiveness to various TCPs. Studies on the gendered responsiveness of TCPs are relatively rare and the results have been mixed, with some indicating that responsiveness to price policies is gendered and some indicating a null impact of gender.[43–45] Our study contributes to this line of discussion by showing that gender, acting alone, influences the responsiveness to TCPs. Although price policies are effective means of preventing older men and women from engaging in persistent smoking, older men are not responsive to smoke-free and other policies. Smoke-free and other policies might matter more for older women if older women who engage in persistent smoking are more sensitive to smoking-related stigma promoted by TCPs than their male counterparts,[46] they may be more likely to quit smoking.[47] Future studies are needed to understand the mechanisms of the gender difference in responsiveness to TCPs.

Consistent with previous studies,[18] we observed an equalizing effect of TCPs for persistent smoking. For men, consistent with previous studies,[48] we observed a greater negative association between price policies and persistent smoking among men with low levels of education. For women, TCPs, in general, are more effective for those with low levels of education. The effect was driven by other policies, including information campaigns, bans on advertisement, health warning labels, and cessation support. There might be several reasons for this. First, as other TCPs spread more knowledge of the hazards of smoking, women with low education may obtain more knowledge of why they should quit smoking than highly educated women (who might be fully aware of the harms of smoking). Further, more cessation support services and interventions may be especially important for women with low levels of education, as they have limited access to services or resources for quitting smoking.[49,50] For price policies and smoke-free policies, although the direction of coefficients indicates that these policies have greater effects for women with low levels of education, the interactions did not reach statistical significance, possibly due to insufficient sample size.

Limitations

There are several limitations of our study. First, one should be cautious about making causal statements regarding the relationships between TCPs and persistent smoking. There is a possibility that the implementation of TCPs may be driven by national societal attitudes toward smoking.[18] To reduce the possibility of such reverse causality, we used the policy scores before the current smoking status was observed to establish a temporal order between the implementation of policies and persistent smoking. Further, we controlled for all unobserved time-invariant country differences and country-invariant year differences by including country- and year-fixed effects through a longitudinal design. However, we could not rule out the possibility that there still remains confounding that may vary across countries and years.

Second, the limited number of observations at the country level may undermine the robustness of findings at the country level. We addressed the small sample size at the country level by pooling data across different waves, yet we cannot generalize our findings to other European countries or other contexts since countries in our sample were not randomly selected from all European countries. Future studies should replicate our analysis in other aging societies such as the United States and other developed countries to investigate whether TCPs reduce the risk of persistent smoking among older adults.

Third, there might be large heterogeneity among those who ever smoked with at least one smoking-related chronic condition. In particular, among those who smoked formerly, the duration of smoking before having chronic conditions might vary (eg, 1 year vs. 25 years). Timing of disease development might potentially affect an individual's decision to resume or continue smoking in later life. Due to no information on the timing of disease development, our analysis does not take such heterogeneity into account.

Policy Implications

Our results show that TCPs in general have the potential to reduce the risk of persistent smoking among women but not men. Decomposing policies further shows a gendered responsiveness

to different types of policies. While price policies are significantly associated with lower risks of persistent smoking among both genders, smoke-free and other policies seem to be effective only among women. Further, the stronger association between price policies and persistent smoking among less-educated men, and the greater association between overall TCPs and persistent smoking among less-educated women suggest that TCPs may also contribute to decreasing the adverse effect of social inequality on population health. The design of TCPs should consider gender and socioeconomic differences, as responsiveness to particular TCPs may differ across sociodemographic groups.

Supplementary Material

A Contributorship Form detailing each author's specific involvement with this content, as well as any supplementary data, are available online at https://academic.oup.com/ntr.

Funding

This work was supported by grants from the National Institute on Aging of the US National Institutes of Health [grant number R00AG052458].

Declaration of Interests

None.

Acknowledgments

We are grateful for Jizzo R. Bosdriesz for providing data on TCS, Dana A. Glei and Matthew C. Mahutga for their suggestions on early versions of methodological approaches on this manuscript.

Data Availability

Data are publicly available from the Survey of Health, Aging and Retirement in Europe (SHARE) (http://www.share-project.org/home0.html) and the English Longitudinal Study of Ageing (ELSA) (https://www.elsa-project.ac.uk/).

References

1. World Health Organization. *WHO Report on the Global Tobacco Epidemic, 2021: Addressing New and Emerging Products*; 2021. https://www.who.int/publications/i/item/9789240032842.
2. U.S. Department of Health and Human Services. *The Health Consequences of Smoking-50 Years of Progress: A Report of the Surgeon General*; 2014. https://www.cdc.gov/tobacco/data_statistics/sgr/50th-anniversary/index.htm.
3. U.S. Department of Health and Human Services. *Smoking Cessation: A Report of the Surgeon General*; 2020.
4. Lee C, Harari L, Park S. Early-life adversities and recalcitrant smoking in midlife: an examination of gender and life-course pathways. *Ann Behav Med*. 2020;54(11):867–879.
5. Siddiqi K, Dogar OF, Siddiqi N. Smoking cessation in long-term conditions: is there "an opportunity in every difficulty"? *Int J Popul Res*. 2013;2013:1–10.
6. Smith PH, Bessette AJ, Weinberger AH, Sheffer CE, McKee SA. Sex/gender differences in smoking cessation: a review. *Prev Med*. 2016;92:135–140.
7. World Health Organization. *10 Facts on Gender and Tobacco*. Geneva, Switzerland: World Health Organization (WHO); 2010. https://www.who.int/gender/documents/10facts_gender_tobacco_en.pdf
8. Rahman MA, Edward K-L, Montgomery L, *et al*. Is there any gender difference for smoking persistence or relapse following diagnosis or hospitalization for coronary heart disease? Evidence from a systematic review and meta-analysis. *Nicotine Tob Res*. 2016;18(6):1399–1407.
9. Fu H, Feng D, Tang S, *et al*. Prevalence of tobacco smoking and determinants of success in quitting smoking among patients with chronic diseases: a cross-sectional study in rural western China. *Int J Environ Res Public Health*. 2017;14(2):167.
10. Hiscock R, Bauld L, Amos A, Fidler JA, Munafò M. Socioeconomic status and smoking: a review. *Ann N Y Acad Sci*. 2012;1248(1):107–123.
11. Margolis R. Educational differences in healthy behavior changes and adherence among middle-aged Americans. *J Health Soc Behav*. 2013;54(3):353–368.
12. Ross CE, Mirowsky J. Gender and the health benefits of education. *Sociol Q*. 2010;51(1):1–19.
13. Ek S. Gender differences in health information behaviour: a Finnish population-based survey. *Health Promot Int*. 2015;30(3):736–745.
14. Deeks A, Lombard C, Michelmore J, Teede H. The effects of gender and age on health related behaviors. *BMC Public Health*. 2009;9(1):213.
15. Hernandez EM, Margolis R, Hummer RA. Educational and gender differences in health behavior changes after a gateway diagnosis. *J Aging Health*. 2018;30(3):342–364.
16. Bird CE, Rieker PP. *Gender and Health. The Effects of Constrained Choices and Social Policies*. New York, NY: Cambridge University Press; 2008.
17. Bosdriesz JR, Willemsen MC, Stronks K, Kunst AE. Tobacco control policy and socio-economic inequalities in smoking in 27 European countries. *Drug Alcohol Depend*. 2016;165:79–86.
18. Serrano-Alarcón M, Kunst AE, Bosdriesz JR, Perelman J. Tobacco control policies and smoking among older adults: a longitudinal analysis of 10 European countries. *Addiction*. 2019;114(6):1076–1085.
19. Critchley JA, Capewell SS. Smoking cessation for the secondary prevention of coronary heart disease. *Cochrane Database Syst Rev*. 2004;1:CD003041.
20. Lee J, Phillips D, Wilkens J; Team G to GAD. Gateway to Global Aging Data: Resources for cross-national comparisons of family, social environment, and healthy aging. *Journals Gerontol Ser B*. 2021;76(suppl 1):S5–S16.
21. Börsch-Supan A, Brandt M, Hunkler C, *et al*. Data resource profile: The survey of health, ageing and retirement in Europe (SHARE). *Int J Epidemiol*. 2013;42(4):992–1001.
22. Steptoe A, Breeze E, Banks J, Nazroo J. Cohort profile: the English longitudinal study of ageing. *Int J Epidemiol*. 2013;42(6):1640–1648.
23. Scheffer J. Dealing with missing data. *Res Lett Inf Math Sci*. 2002;3(1):153–160.
24. Edwards VJ, Anda RF, Gu D, Dube SR, Felitti VJ. Adverse childhood experiences and smoking persistence in adults with smoking-related symptoms and illness. *Perm J*. 2007;11(2):5.
25. Joossens L, Raw M. The Tobacco Control Scale: a new scale to measure country activity. *Tob Control*. 2006;15(3):247–253.
26. Wooldridge JM. *Econometric Analysis of Cross Section and Panel Data*. Cambridge, MA: MIT press; 2010.
27. Bryan ML, Jenkins SP. Multilevel modelling of country effects: a cautionary tale. *Eur Sociol Rev*. 2016;32(1):3–22.
28. Cameron AC, Miller DL. A practitioner's guide to cluster-robust inference. *J Human Res*. 2015;50(2):317–372.
29. Kropko J, Kubinec R. Interpretation and identification of within-unit and cross-sectional variation in panel data models. *PLoS One*. 2020;15(4):e0231349.
30. Weinberger AH, Smith PH, Allen SS, *et al*. Systematic and meta-analytic review of research examining the impact of menstrual cycle phase and ovarian hormones on smoking and cessation. *Nicotine Tob Res*. 2015;17(4):407–421.
31. Smith PH, Kasza KA, Hyland A, *et al*. Gender differences in medication use and cigarette smoking cessation: results from the

International Tobacco Control Four Country Survey. *Nicotine Tob Res*. 2015;17(4):463–472.
32. Smith PH, Rose JS, Mazure CM, Giovino GA, McKee SA. What is the evidence for hardening in the cigarette smoking population? Trends in nicotine dependence in the US, 2002–2012. *Drug Alcohol Depend*. 2014;142:333–340.
33. Redmond P, McGuinness S. The gender wage gap in Europe: Job preferences, gender convergence and distributional effects. *Oxf Bull Econ Stat*. 2019;81(3):564–587.
34. Huxley RR, Woodward M. Cigarette smoking as a risk factor for coronary heart disease in women compared with men: a systematic review and meta-analysis of prospective cohort studies. *Lancet*. 2011;378(9799):1297–1305.
35. Kiyohara C, Ohno Y. Sex differences in lung cancer susceptibility: a review. *Gend Med*. 2010;7(5):381–401.
36. Phelan JC, Link BG, Tehranifar P. Social Conditions as Fundamental Causes of Health Inequalities: Theory, Evidence, and Policy Implications. *J Health Soc Behav*. 2010;51(suppl 1):S28–S40.
37. Montez JK, Zajacova A. Explaining the widening education gap in mortality among U.S. white women. *J Health Soc Behav*. 2013;54(2):166–182.
38. Reid JL, Hammond D, Boudreau C, Fong GT, Siahpush M. Socioeconomic 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*. 2010;12(Suppl 1):S20–S33.
39. Trias-Llimós S, Muszyńska MM, Cámara AD, Janssen F. Smoking cessation among European older adults: the contributions of marital and employment transitions by gender. *Eur J Ageing* 2017;14(2):189–198.
40. Uccheddu D, Gauthier AH, Steverink N, Emery T. Gender and socioeconomic inequalities in health at older ages across different European welfare clusters: Evidence from SHARE data, 2004–2015. *Eur Sociol Rev* 2019;35(3):346–362.
41. Ross CE, Masters RK, Hummer RA. Education and the gender gaps in health and mortality. *Demography*. 2012;49(4):1157–1183.
42. Stewart MJ, Greaves L, Kushner KE, *et al*. Where there is smoke, there is stress: Low-income women identify support needs and preferences for smoking reduction. *Health Care Women Int*. 2011;32(5):359–383.
43. Farrelly MC, Bray JW, Pechacek T, Woollery T. Response by adults to increases in cigarette prices by sociodemographic. *South Econ J*. 2001;68(1):156–165.
44. Borren P, Sutton M. Are increase in cigarette taxation regressive? *Health Econ*. 1992;1(4):245–253.
45. Chaloupka F. Clean indoor air laws, addiction and cigarette smoking. *Appl Econ*. 1992;24(2):193–205.
46. Evans-Polce RJ, Castaldelli-Maia JM, Schomerus G, Evans-Lacko SE. The downside of tobacco control? Smoking and self-stigma: a systematic review. *Soc Sci Med*. 2015;145:26–34.
47. Helweg-Larsen M, Pyakuryal M, Pisinger C. Reminders of a stigmatized status might help smokers quit. *Stigma Heal*. 2020;5(3):273–283.
48. Kalousova L, Levy D, Titus AR, *et al*. Cigarette taxes, prices, and disparities in current smoking in the United States. *SSM Popul Health* 2020;12:100686.
49. Stewart MJ, Kushner KE, Greaves L, *et al*. Impacts of a support intervention for low-income women who smoke. *Soc Sci Med*. 2010;71(11):1901–1909.
50. Greaves L, Hemsing N. Women and tobacco control policies: social-structural and psychosocial contributions to vulnerability to tobacco use and exposure. *Drug Alcohol Depend*. 2009;104(Suppl 1):S121–S130.