

Transitions from and to roll-your-own tobacco, perceptions and health beliefs among smokers: findings from the EUREST-PLUS ITC Europe Surveys

Filippos T. Filippidis^{1,2}, Pete Driezen³, Christina N. Kyriakos^{4,5}, Paraskevi Katsaounou^{2,6}, Ioanna Petroulia², Charis Girvalaki⁵, Marcela Fu^{7,8,9,10}, Esteve Fernández^{7,8,9,10}, Ute Mons¹¹, Antigona C. Trofor^{12,13}, Tibor Demjén¹⁴, Krzysztof Przewoźniak^{15,16,17}, Witold A. Zatoński^{15,18}, Geoffrey T. Fong^{3,19}, Yannis Tountas², Constantine I. Vardavas^{4,5} on behalf of the EUREST-PLUS Consortium*

- 1 Department of Primary Care and Public Health, School of Public Health, Imperial College, London, UK
- 2 Center for Health Services Research, School of Medicine, National and Kapodistrian University of Athens, Athens, Greece
- 3 Department of Psychology and School of Public Health and Health Systems, University of Waterloo, Waterloo, Canada
- 4 European Network for Smoking and Tobacco Prevention, Brussels, Belgium
- 5 Laboratory of Toxicology, School of Medicine, University of Crete, Heraklion, Greece
- 6 First ICU Evaggelismos Hospital Athens, National and Kapodistrian University of Athens, Athens, Greece
- 7 Tobacco Control Unit, Catalan Institute of Oncology (ICO), L'Hospitalet de Llobregat (Barcelona), Catalonia
- 8 Tobacco Control Research Group, Bellvitge Biomedical Research Institute (IDIBELL), L'Hospitalet de Llobregat, Catalonia
- 9 School of Medicine and Health Sciences, Bellvitge Campus, Universitat de Barcelona, L'Hospitalet de Llobregat, Catalonia
- 10 Consortium for Biomedical Research in Respiratory Diseases (CIBER of Respiratory Diseases, CIBERES), Madrid, Spain
- 11 Cancer Prevention Unit and WHO Collaborating Centre for Tobacco Control, German Cancer Research Center (DKFZ), Heidelberg, Germany
- 12 University of Medicine and Pharmacy 'Grigore T. Popa' Iasi, Iasi, Romania
- 13 Aer Pur Romania, Bucharest, Romania
- 14 Smoking or Health Hungarian Foundation, Budapest, Hungary
- 15 Health Promotion Foundation, Warsaw, Poland
- 16 Maria Skłodowska-Curie National Research Institute of Oncology, Warsaw, Poland
- 17 Collegium Civitas, Warsaw, Poland
- 18 European Observatory of Health Inequalities, President Stanisław Wojciechowski State University of Applied Sciences, Kalisz, Poland
- 19 Ontario Institute for Cancer Research, Toronto, Canada

Correspondence: Filippos T. Filippidis, Department of Primary Care and Public Health, School of Public Health, Imperial College London, 310 Reynolds Building, St. Dunstan's Road, London W6 8RP, UK, Tel: +44 (0) 20 75 947142, Fax: +44 20 7594 0854, e-mail: f.filippidis@imperial.ac.uk

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Background: The prevalence of roll-your-own tobacco (RYO) in Europe has been increasing. The aim of this study was to investigate transitions between factory-made (FM) cigarettes and RYO in a longitudinal sample of European smokers, and their perceptions of relative harmfulness and knowledge of health effects. **Methods:** We used data collected from the EUREST-PLUS ITC 6 European Country (6E) Surveys in 2016 ($n = 6011$ smokers) and in 2018 ($n = 6027$) in Germany, Greece, Hungary, Poland, Romania and Spain. A total of 3195 cohort respondents were interviewed in both years. Use of RYO and FM, knowledge of health effects of smoking as well as perceptions about RYO were assessed. We used logistic regression models to explore sociodemographic correlates of transitions from one product to the other, of perceptions and knowledge related to smoking health effects. **Results:** Approximately 7.4% of exclusive FM smokers transitioned to RYO and 29.5% of exclusive RYO smokers transitioned to FM cigarettes from 2016 to 2018. RYO use in 2018 was more frequent among smokers of low education and income, but none of these factors were associated with transitions. Most RYO smokers perceived RYO as cheaper than FM and 21.7% of them considered RYO to be less harmful than FM. Knowledge of the health effects of smoking was not associated with type of product smoked. **Conclusions:** RYO is popular among European smokers; its lower cost seems to be a major factor for RYO users; reasons for transitions to and from RYO are less clear and need to be further investigated.

Introduction

Combustible tobacco is the main form of tobacco used globally,¹ with its health consequences well-established and well-known even among smokers, at least in Europe.² Factory-made (FM) cigarettes has been the dominant product in European and global tobacco markets with a market share of more than 90%.¹ In recent years,

European tobacco markets have changed with the introduction of novel tobacco products, such as electronic cigarettes and heated tobacco products and the rise in consumption of more traditional tobacco products, such as waterpipes and roll-your-own tobacco (RYO) whose popularity has increased.^{3–8} This has led to an increase in dual and polytobacco use in Europe, which may complicate attempts to quit and undermine the effectiveness of tobacco control measures.⁹

The case of RYO is particularly interesting; its rise in popularity is neither the result of a technological innovation nor a component of a harm reduction approach, although RYO is often falsely perceived as less harmful compared with FM by those who use it.^{10–12} Despite the fact that no one in the health community recommends use of RYO, such beliefs and perceptions may be associated with RYO use,¹² especially in Europe where FM cigarettes have been the main target of tobacco control policies and information campaigns for decades. RYO has been subject to lower taxation in Europe compared with FM^{5,10,13} and, only since the implementation of the recent Tobacco Products Directive (TPD) across the European Union (EU) in 2016,¹⁴ RYO products have to comply to the same regulations as FM regarding packaging, labeling and compulsory health warnings, which might impact RYO users' knowledge and perceptions.

The most common explanation for the increasing prevalence of RYO use is the price differential between FM and RYO; RYO are generally cheaper and deemed more affordable, which may be important for price-sensitive smokers. In almost all EU member states, the cost of RYO is lower than the cheapest FM.¹⁵ However, studies investigating the role of price, affordability and price differential in switching from FM to RYO are few and have produced conflicting results, with some suggesting that price differences between FM and RYO may drive increases in RYO use with others failing to find evidence of such an effect.^{7,16,17} Other factors, such as potential differences in knowledge of the health effects of smoking and perceptions of RYO may also influence decisions to switch. RYO users also cite efforts to reduce the number of cigarettes smoked or social and cultural factors as reasons for using this form of tobacco rather than FM, although these perceptions may not be backed by evidence.^{7,18–20} Another potential factor in the choice of tobacco products is taste²¹ which may vary between FM and RYO.²² However, these elements have not been researched much in Europe. The picture is complicated further by the fact that concurrent use of FM and RYO is frequent,²³ most studies use cross-sectional study designs, which limits the researchers' ability to investigate switching from FM to RYO and vice versa, as well as the factors that may be associated with such changes in smoking behavior.

The main aim of this study was to investigate switching from FM to RYO and vice versa in a longitudinal sample of smokers in six European countries. We also explored perceptions about RYO and beliefs regarding the health consequences of smoking and whether these were associated with the type of combustible tobacco product used.

Methods

Data source

Data were collected as part of the International Tobacco Control Policy Evaluation Six European Country (ITC 6E) Project. The ITC 6E is a two-wave European-focused cohort study aiming to measure the direct and indirect impacts of the EU TPD and policies of the World Health Organization (WHO) Framework Convention on Tobacco Control (FCTC) and was part of the 'European Regulatory Science on Tobacco: Policy Implementation to Reduce Lung Disease (EUREST PLUS)' project. Data were collected from June to September 2016 (wave 1) and February to May 2018 (wave 2) in Germany, Greece, Hungary, Poland, Romania and Spain.

Sampling was based on geographic strata created according to Nomenclature of Territorial Units for Statistics (NUTS) regions and degree of urbanization. Clusters proportional to population size were then selected by stratified random sampling. Within each cluster, up to two smokers (one female and one male) were interviewed face-to-face in each dwelling selected with the random walk method. At wave 2, we attempted to re-contact and interview all of the wave 1 respondents who had agreed to be re-contacted. Dropouts (ranging from 30 to 64%) were replaced by adult smokers recruited wherever possible by the same method as in wave 1 and in the same cluster, from dwellings not approached in wave 1.

Among the 6011 individuals interviewed across the six countries in wave 1, 3195 responded in wave 2. Including respondents recruited in wave 2 for the first time, a total of 6027 individuals were interviewed in 2018. Cross-sectional survey weights have been constructed for each of the survey waves, and longitudinal survey weights have been constructed for the two waves of data being examined in each country. More details regarding the sampling methodology and data collection have been described elsewhere.^{23,24}

Measures

By design, wave 1 included only smokers, defined as individuals who responded that they smoke FM or RYO cigarettes at least monthly. However, wave 2 also included a number of individuals who were smokers in wave 1 but had quit by the time they were re-interviewed in wave 2. In both waves, participants were asked 'Do you smoke factory-made cigarettes, roll-your-own cigarettes, or both?'. Responses included FM cigarettes only; RYO only and both. Those who responded 'RYO only' or 'both' were classified as RYO users. Smokers who used FM cigarettes only in wave 1 but reported use of RYO in wave 2, either exclusively or with FM cigarettes, were considered to have made a transition to RYO between the two waves. Similarly, exclusive RYO users in wave 1 who reported some or exclusive use of FM cigarettes in wave 2 were considered to have transitioned to FM cigarettes. Those who reported concurrent use of RYO and FM are referred to as dual users.

In wave 2, RYO users were asked 'Which of the following are important reasons for your smoking roll-your-own cigarettes?'. Participants could give one or more of the responses 'they are less expensive'; 'they taste better'; 'they are not as bad for your health' and 'they reduce the amount you smoke'. The abovementioned question was not asked to respondents who were not using RYO at the time. All smokers were asked to respond either 'Yes' or 'No' to whether they believed that smoking (any type of tobacco product) causes (in smokers) heart disease, heart attack, stroke, impotence in male smokers, blindness, lung cancer, mouth cancer, throat cancer, chronic obstructive pulmonary disease (COPD), bronchitis and tuberculosis.

Data were also collected on degree of urbanization (urban, intermediate, rural), sex (female, male), age group (18–24, 25–39, 40–54, 55+ years), marital status (not married, married/common-law, widowed, divorced), income (income not reported, low income, moderate income, high income), education [low education (primary, lower pre-vocational secondary, middle pre-vocational secondary); moderate education (secondary vocational, senior general secondary and pre-university); high education (higher professional and university bachelor, university master)] and the number of FM or RYO cigarettes smoked every day (≤ 10 ; 11–20; 21–30; ≥ 31).²⁵

Statistical analysis

The statistical analysis was conducted using SAS-callable SUDAAN (Version 11.0.1) to account for the complex sampling design and longitudinal sampling weights. Descriptive statistics are shown as weighted percentages with 95% confidence intervals (CI). The longitudinal sample was analyzed to describe transitions from FM cigarettes to RYO and vice versa. A logistic regression model was estimated among participants who were exclusive FM cigarette users in wave 1 and were re-interviewed in wave 2 to explore correlates of the transition from FM cigarettes to RYO. Independent variables were country, age, sex, degree of urbanization, marital status, income, education and number of cigarettes smoked per day. A similar model was estimated among exclusive RYO users of wave 1 to assess correlates of transition to FM cigarettes. Logistic regression results are presented as odds ratios (OR) with 95% CI.

A logistic regression model was fitted among participants of the most recent wave (wave 2) to assess the association between using RYO tobacco (dependent variable) and various independent variables including country, age, sex, degree of urbanization, marital status, income, education and number of cigarettes smoked per day.

We also analyzed data on smokers' perceptions about RYO tobacco and on knowledge of the health effects of smoking by country and product used in wave 2 only. Proportions within countries were compared with chi-square tests. The Cochran–Mantel–Haenszel test was used to test the association between product used and perception/health belief controlling for country. Additional cross-sectional multivariable logistic regression models were fitted to assess potential associations of type of tobacco product used (FM only, RYO only or dual use) with each of the perceptions about RYO (only among RYO users in wave 2) and health beliefs (among all smokers in wave 2). Models controlled for socio-demographic factors such as age, sex, degree of urbanization, marital status, income, education, country of residence and number of cigarettes smoked per day.

Ethics review

For the ITC 6E Survey, study procedures and material including the survey questionnaire were approved by the ethics research committee at the University of Waterloo (Ontario, Canada), and ethics committees in Germany (Ethikkommission der Medizinischen Fakultät Heidelberg), in Greece (Medical School, University of Athens—Research and Ethics Committee), in Hungary (Medical Research Council—Scientific and Research Committee), in Poland (State College of Higher Vocational Education—Committee and Dean of the Department of Health Care and Life Sciences), in Romania (Iuliu Hatieganu University of Medicine and Pharmacy) and in Spain (Clinical Research Ethics Committee of Bellvitge, Hospital Universitari de Bellvitge, Catalonia).

Results

Sample characteristics

Sample characteristics of the cross-sectional and longitudinal samples, as well as their smoking behaviors are shown in [Supplementary tables S1–S4](#).

Transitions in type of cigarettes smoked

In the total longitudinal sample across all six countries, 13.9% of exclusive FM cigarettes users, 10.3% of exclusive RYO users and 7.2% of dual users quit between wave 1 and wave 2. Among exclusive FM cigarette users in wave 1, 4.4% (95% CI: 3.5%, 5.5%) reported exclusive RYO use and 3.0% (2.2%, 4.1%) dual use in wave 2. Among exclusive RYO users in wave 1, 18.2% (13.7%, 23.8%) reported exclusive FM cigarette use and 11.3% (7.7%, 16.5%) dual use in wave 2, although there was considerable variation between countries ([table 1](#)). In total, 5.6% of the total longitudinal sample transitioned from exclusive FM use to RYO or dual use between the two waves, while 3.2% of the total longitudinal sample transitioned from exclusive RYO use to FM or dual use in the same period.

FM cigarette users in Hungary were the most likely to have made the transition to RYO (OR = 2.27; 1.21, 4.26 compared with Spain) and users in Romania the least likely to have done so (OR = 0.06, 0.03, 0.15 compared with Spain). Compared with Spain, RYO users were more likely to have transitioned to FM cigarettes in Poland (OR = 3.19; 1.17, 8.71) and Germany (OR = 2.86; 1.12, 7.28). Given the small longitudinal sample size of exclusive RYO users in Romania ($n=6$), the estimated OR had a very wide 95% CI. None of the other factors were statistically significantly associated with transitions to FM cigarettes or RYO ([table 2](#)).

Correlates of RYO use

Among smokers in wave 2, RYO use (exclusive or dual) was more likely in those aged 25–39 years compared with those aged ≥ 55 (OR = 1.38), in individuals of moderate (OR = 1.85) and low income (OR = 2.08) compared with those of high income, as well as in those with low education compared with high education level (OR = 1.59) and in those who smoked 21–30 cigs/day compared with those who smoked >30 cigs/day (OR = 1.91) ([table 2](#)).

Table 1 Transitions between tobacco products from wave 1 to wave 2

FM/RYO status in wave 1	FM/RYO status in wave 2							
	FM only		RYO only		Dual use		Quit smoking	
	<i>n</i>	% (95% CI)	<i>n</i>	% (95% CI)	<i>n</i>	% (95% CI)	<i>n</i>	% (95% CI)
Overall								
FM only	1872	78.8 (76.2, 81.1)	101	4.4 (3.5, 5.5)	70	3.0 (2.2, 4.1)	330	13.9 (11.9, 16.2)
RYO only	90	18.2 (13.7, 23.8)	333	60.1 (54.4, 65.5)	52	11.3 (7.7, 16.5)	59	10.3 (7.8, 13.5)
Dual use	103	39.2 (32.0, 46.9)	50	18.3 (13.3, 24.6)	108	35.3 (27.6, 43.8)	26	7.2 (4.4, 11.5)
Germany								
FM only	445	84 (78.1, 88.6)	10	1.4 (0.6, 3.0)	29	5.1 (2.9, 8.6)	51	9.5 (6.2, 14.2)
RYO only	15	26.7 (13.4, 46.2)	42	48 (32.7, 63.7)	14	20.1 (10.2, 35.9)	5	5.2 (1.9, 13.7)
Dual use	30	31.2 (20.0, 45.3)	11	11.2 (5.6, 21.0)	49	52.5 (38.4, 66.2)	6	5.1 (1.5, 16.0)
Greece								
FM only	219	80.5 (74.5, 85.3)	20	6.1 (3.7, 9.8)	3	0.9 (0.3, 3.0)	39	12.5 (8.4, 18.2)
RYO only	15	14.1 (6.3, 28.6)	84	65.8 (54.9, 75.2)	6	3.3 (1.4, 7.9)	19	16.8 (10.4, 25.9)
Dual use	1	8.2 (1.2, 40.0)	5	79.8 (47.6, 94.5)	1	5.9 (0.7, 37.0)	1	6.1 (0.7, 37.8)
Hungary								
FM only	103	63.4 (51.7, 73.7)	22	17.2 (10.8, 26.5)	6	3.4 (1.3, 8.5)	22	15.9 (9.1, 26.4)
RYO only	24	17.8 (10.7, 28.2)	113	67.1 (56.3, 76.4)	11	5.4 (1.9, 14.7)	22	9.6 (6.4, 14.3)
Dual use	13	42.6 (25.3, 62.0)	6	28.8 (11.7, 55.2)	10	19 (8.1, 38.6)	4	9.5 (3.5, 23.2)
Poland								
FM only	300	81 (74.9, 86.0)	7	1.7 (0.6, 4.4)	13	4.2 (2.2, 8.1)	42	13 (9.4, 17.8)
RYO only	6	9.4 (3.6, 22.4)	16	39.5 (23.8, 57.7)	15	51.1 (31.7, 70.2)	0	0
Dual use	13	21.5 (10.6, 38.9)	12	19 (10.7, 31.5)	31	55.3 (36.8, 72.5)	4	4.1 (1.3, 12.7)
Romania								
FM only	428	83.5 (78.3, 87.7)	3	0.5 (0.2, 1.2)	4	0.6 (0.2, 1.8)	79	15.4 (11.4, 20.6)
RYO only	3	54.9 (20.1, 85.5)	1	17.6 (2.2, 67.3)	1	10.0 (1.3, 48.8)	1	17.6 (2.2, 67.3)
Dual use	16	77.2 (58.5, 89.1)	2	8.6 (2.3, 27.6)	5	9.8 (2.7, 29.8)	2	4.4 (1.0, 17.6)
Spain								
FM only	377	70.6 (64.7, 75.9)	39	8.4 (6.1, 11.6)	15	3.4 (1.8, 6.3)	97	17.5 (12.6, 23.8)
RYO only	27	20 (13.1, 29.3)	77	61.5 (51.8, 70.4)	5	6.9 (2.8, 16.1)	12	11.6 (6.5, 19.9)
Dual use	30	54.5 (42.0, 66.4)	14	18.1 (9.7, 31.2)	12	13.6 (7.6, 23.1)	9	13.8 (6.5, 27.2)

Table 2 Factors associated with use of roll-your-own tobacco in wave 2 and with transition from FM to roll-your-own tobacco and from roll-your-own tobacco to FM between wave 1 and wave 2

Covariate	RYO user in wave 2 (yes vs. no) <i>n</i> = 5555		Transition from FM to RYO from wave 1 to wave 2 <i>n</i> = 2028		Transition from RYO to FM from wave 1 to wave 2 <i>n</i> = 472	
	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
Country						
Germany	0.62	(0.43, 0.89)	0.42	(0.22, 0.79)	2.86	(1.12, 7.28)
Greece	1.10	(0.81, 1.49)	0.49	(0.27, 0.89)	0.69	(0.27, 1.78)
Hungary	2.67	(2.01, 3.56)	2.27	(1.21, 4.26)	1.49	(0.61, 3.66)
Poland	0.88	(0.63, 1.24)	0.41	(0.19, 0.88)	3.19	(1.17, 8.71)
Romania	0.13	(0.07, 0.23)	0.06	(0.03, 0.15)	9.30	(0.59, 147.56)
Spain	1.00		1.00		1.00	
Degree of urbanization						
Urban	0.88	(0.67, 1.15)	0.86	(0.46, 1.58)	1.56	(0.67, 3.66)
Intermediate	1.01	(0.78, 1.30)	1.26	(0.78, 2.03)	1.23	(0.54, 2.82)
Rural	1.00		1.00		1.00	
Sex						
Female	0.95	(0.82, 1.10)	1.06	(0.74, 1.53)	0.94	(0.59, 1.50)
Male	1.00		1.00		1.00	
Age group						
18–24	1.33	(0.91, 1.96)	1.90	(0.77, 4.67)	0.75	(0.26, 2.18)
25–39	1.38	(1.08, 1.74)	1.29	(0.75, 2.23)	0.73	(0.37, 1.42)
40–54	1.06	(0.85, 1.32)	0.91	(0.54, 1.54)	0.82	(0.42, 1.60)
55+	1.00		1.00		1.00	
Marital status						
Not married	0.96	(0.69, 1.35)	0.69	(0.34, 1.42)	1.82	(0.52, 6.39)
Married/common-law	0.80	(0.60, 1.06)	0.82	(0.43, 1.56)	1.76	(0.56, 5.58)
Widowed	0.55	(0.36, 0.86)	0.38	(0.12, 1.18)	0.99	(0.21, 4.65)
Divorced	1.00		1.00		1.00	
Income						
Income not reported	1.38	(1.06, 1.80)	0.71	(0.34, 1.49)	1.90	(0.77, 4.68)
Low income	2.08	(1.53, 2.84)	1.22	(0.62, 2.40)	1.99	(0.76, 5.24)
Moderate income	1.85	(1.47, 2.32)	0.83	(0.42, 1.61)	1.27	(0.48, 3.39)
High income	1.00		1.00		1.00	
Education						
Low education	1.59	(1.18, 2.13)	1.30	(0.66, 2.59)	0.83	(0.26, 2.69)
Moderate education	1.31	(0.97, 1.75)	1.66	(0.83, 3.32)	1.99	(0.66, 5.96)
High education	1.00		1.00		1.00	
Cigarettes smoked/day						
≤10	0.69	(0.44, 1.06)	1.08	(0.39, 2.96)	1.19	(0.34, 4.22)
11–20	1.12	(0.74, 1.71)	1.49	(0.56, 3.95)	1.02	(0.33, 3.20)
21–30	1.91	(1.18, 3.10)	2.43	(0.85, 6.92)	1.17	(0.32, 4.36)
31+	1.00		1.00		1.00	

FM, factory-made cigarettes; RYO, roll-your-own tobacco. Transition from FM to RYO (exclusive or with FM) from wave 1 to wave 2 is based only on those respondents who smoked FM exclusively in wave 1 (1 = yes vs. 0 = no transition). Transition from RYO to FM (exclusive or with RYO) from wave 1 to wave 2 is based only on those respondents who smoked RYO exclusively in wave 1 (1 = yes vs. 0 = no transition).

Perceptions and knowledge

Across all six countries, 81.7% of respondents who reported exclusive use of RYO in wave 2 and 91.2% of those who reported dual use agreed with the statement that RYO is cheaper than FM cigarettes ($P = 0.043$). Almost 22% of exclusive RYO users and 15.6% of dual users thought that RYO is not as bad for health as FM cigarettes and less than half in both groups reported that RYO may reduce tobacco consumption (table 3). Greece had the highest proportion of RYO users who thought that RYO tastes better and that it helps reduce consumption, whereas half of Romanian exclusive RYO users (51.2%) thought that it is not as bad for one's health as FM cigarettes. Controlling for sociodemographic factors and cigarette consumption, RYO users in Hungary, Poland and Germany were the most likely to say that RYO is cheaper (OR = 4.10, OR = 3.88 and OR = 2.62 compared with Spain, respectively) and those in Greece that it tastes better (OR = 3.32) and that it helps reduce consumption (OR = 6.26). With the exception of Romania, RYO users in all other countries were less likely to believe that RYO is not as bad for health as FM cigarettes compared with Spain (results not shown in tables). There was a positive association between exclusive RYO use and thinking that RYO tastes better (OR = 3.41; 2.36, 4.92) and is not as bad for health (OR = 1.68; 1.04, 2.74) compared with dual use (table 4).

Knowledge of the health effects of smoking was generally high in wave 2, although approximately 20% of smokers did not know that smoking causes lung cancer or heart diseases. The percentages of smokers who knew about the association between smoking and blindness, tuberculosis and impotence were below 50% in several countries and subgroups (table 3). Controlling for sociodemographic factors and country, there was no statistically significant difference in the odds of knowing about any of the health effects of smoking by product use (RYO only, FM only or dual use) (table 4).

Discussion

Our analysis confirmed that use of RYO is quite popular among smokers in European countries, albeit less so than FM cigarettes, although there were variations among the six countries assessed. Overall, those of low income and education were more likely to be RYO users, but no such associations were significant in switching from and to RYO between 2016 and 2018. We also found that overall knowledge of the health effects of smoking was not associated with RYO use, but perceptions that RYO is less harmful than FM were widespread among RYO smokers. The majority of RYO users also reported that RYO is cheaper than FM.

Table 3 Perceptions and health beliefs by type of product used and by country in wave 2

Perceptions	Germany ^a %	Greece ^a %	Hungary ^a %	Poland ^a %	Romania ^a %	Spain ^a %	Overall ^b %	CMH Test ^c <i>P</i>
RYO are cheaper ^d								
RYO only	90.7	68.5*	91.0	89.5	84.7	74.3	81.7***	0.043
Dual use	91.1	89.6	93.9	94.6	87.9	83.2	91.2	
RYO taste better ^d								
RYO only	70.2***	84.6	49.8	45.9***	55.4	60.5***	62.4***	<.001
Dual use	37.8***	72.2	37.5	17.3	21.0	20.4	28.9	
RYO are not as bad for health ^d								
RYO only	12.7	15.5	15.9	30.0	51.2	40.1	21.7*	0.027
Dual use	5.9	12.1	22.0	14.4	34.3	25.3	15.6	
RYO help reduce amount smoked ^d								
RYO only	30.4	83.4	25.4	25.4	71.2	45.7	45.9	0.161
Dual use	39.9	76.4	36.5	23.0	69.1	55.3	39.2	
Smoking causes heart disease								
FM only	79.7	95.3	70.3	78.8	87.0	88.2	83.8	0.852
RYO only	86.1	93.9	68.8	79.4	82.5	83.0	80.6	
Dual use	82.6	95.0	59.9	81.3	92.6	88.5	80.9	
Smoking causes heart attacks								
FM only	45.0	60.6*	49.5	59.4	73.0	75.6*	61.3**	0.098
RYO only	51.8	55.5	48.7	51.9	74.7	58.5	53.3	
Dual use	45.3	84.2	38.6	67.2	74.6	65.3	57.6	
Smoking causes stroke								
FM only	77.4	80.2	68.4*	63.3	75.0	76.9	73.7*	0.096
RYO only	81.4	75.0	59.4	65.7	79.1	70.3	68.2	
Dual use	76.7	68.8	56.9	62.3	85.7	71.5	68.7	
Smoking causes impotence								
FM only	58.9	55.1	57.9	56.9	68.0	64.2	60.6*	0.312
RYO only	64.6	55.2	51.5	48.9	57.1	55.1	54.1	
Dual use	67.4	53.6	45.2	52.0	70.5	52.0	56.6	
Smoking causes blindness								
FM only	35.7	40.9	42.7	42.8	66.0	56.7	48.3*	0.496
RYO only	39.6	41.5	38.2	34.8	79.3	48.2	41.5	
Dual use	31.4	42.3	33.6	41.7	83.9	48.4	40.9	
Smoking causes mouth cancer								
FM only	90.0	94.7*	84.0	83.5	86.4	93.6*	88.7	0.077
RYO only	94.3	97.4	78.9	84.6	88.5	90.6	87.8	
Dual use	93.1	95.0	81.1	91.2	88.6	98.7	91.5	
Smoking causes lung cancer								
FM only	78.9	88.1	74.8	80.2	79.9	84.9	81.2	0.297
RYO only	86.4	82.4	72.5	83.1	82.5	78.0	78.3	
Dual use	83.8	89.9	76.4	81.8	93.9	78.9	82.2	
Smoking causes throat cancer								
FM only	83.7	91.3	80.7	82.8	85.6	85.4	85.1	0.342
RYO only	89.4	86.8	76.1	85.4	88.5	81.7	82.0	
Dual use	85.5	79.6	79.3	86.3	93.9	84.7	85.0	
Smoking causes COPD								
FM only	69.9	87.5	68.4	75.2	71.1	84.0	75.9	0.197
RYO only	77.4	91.3	69.9	80.8	85.1	83.4	79.9	
Dual use	63.0	79.6	74.3	85.6	90.7	85.0	77.4	
Smoking causes bronchitis								
FM only	74.8	88.4	76.7	70.6	78.3	94.6	80.3	0.769
RYO only	81.9	91.8	75.4	74.7	82.5	89.0	82.9	
Dual use	66.4	84.6	76.5	70.9	83.9	96.7	75.5	
Smoking causes tuberculosis								
FM only	44.4	47.6	54.8	64.7	77.4	61.7	59.5**	0.177
RYO only	48.6	44.4	51.2	68.7	88.3	53.3	51.8	
Dual use	36.6	25.2	42.2	65.5	86.4	44.3	50.1	

a: χ^2 test within country.

b: Overall χ^2 test between RYO status and perceptions ignoring country.

c: CMH, Cochran–Mantel–Haenszel test controlling for country (tests association between RYO status and perception controlling for country).

d: Perceptions of RYO cigarettes were only asked of RYO smokers, not those who smoke FM exclusively.

*** $P < 0.001$, ** $P < 0.01$, * $P < 0.05$.

A significant proportion of smokers in our sample used RYO either exclusively or in combination with FM cigarettes, especially in some of the countries assessed. This confirms the penetration of RYO in European markets which has been observed in previous, country-specific studies.^{5,25,26} In the longitudinal sample, only 7.4% of exclusive FM smokers in 2016 switched—partly or exclusively—to RYO by 2018, whereas 29.5% of exclusive RYO smokers switched to FM during the same period. However, there were many

more exclusive FM smokers in the sample; therefore overall, more smokers switched from FM to RYO (5.6%) than from RYO to FM (3.2%), which is consistent with the increasing prevalence and sales of RYO in Europe in recent years.¹⁰

RYO use was more likely among those with low education and income. The majority of RYO users also reported that RYO is cheaper than FM, which is true in the majority of EU Member States, as it still is subject to lower taxation,²⁷ although direct

Table 4 Factors associated with perceptions about RYO tobacco among RYO users and with health beliefs about smoking among FM and RYO tobacco users in wave 2

Covariate	RYO cheaper (n = 1407)		RYO tastes better (n = 1405)		RYO not as bad for health (n = 1405)		RYO to reduce amount smoked (n = 1407)					
	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)				
Smokes FM/RYO												
RYO only	0.65	(0.37, 1.13)	3.41	(2.36, 4.92)	1.68	(1.04, 2.74)	0.73	(0.50, 1.07)				
Dual use	1.00		1.00		1.00		1.00					
Covariate	Heart disease (n = 5545)		Heart attacks (n = 5533)		Stroke (n = 5531)		Impotence (n = 5534)		Blindness (n = 5531)			
	OR	(95%CI)	OR	(95%CI)	OR	(95%CI)	OR	(95%CI)	OR	(95%CI)		
Smokes FM/RYO												
FM only	0.91	(0.66, 1.25)	0.94	(0.71, 1.24)	1.06	(0.78, 1.44)	1.05	(0.81, 1.38)	1.11	(0.81, 1.53)		
RYO only	0.92	(0.63, 1.35)	0.77	(0.58, 1.03)	0.89	(0.64, 1.23)	0.93	(0.70, 1.24)	0.99	(0.71, 1.37)		
Dual use	1.00		1.00		1.00		1.00		1.00			
Covariate	Lung cancer (n = 5537)		Mouth cancer (n = 5532)		Throat cancer (n = 5533)		COPD (n = 5527)		Bronchitis (n = 5539)		Tuberculosis (n = 5523)	
	OR	(95%CI)	OR	(95%CI)	OR	(95%CI)	OR	(95%CI)	OR	(95%CI)	OR	(95%CI)
Smokes FM/RYO												
FM only	0.61	(0.38, 0.97)	0.83	(0.57, 1.22)	0.85	(0.59, 1.23)	0.80	(0.58, 1.10)	1.04	(0.74, 1.48)	1.34	(0.98, 1.82)
RYO only	0.61	(0.37, 1.00)	0.75	(0.52, 1.09)	0.76	(0.52, 1.11)	0.99	(0.68, 1.45)	1.14	(0.77, 1.68)	1.20	(0.88, 1.64)
Dual use	1.00		1.00		1.00		1.00		1.00		1.00	

ORs further adjusted for country, age, sex, degree of urbanization, marital status, wave of recruitment, income, education and number of cigarettes smoked per day.

comparisons of cost are undermined by the variable quantity of tobacco used in each RYO cigarette.²⁵ These findings highlight the fact that RYO may be attractive to those with limited financial capacity to buy cigarettes.^{2,6,7,10,28} Therefore, it could serve as an alternative to FM cigarette when taxation and prices increase. When we looked at switching between RYO and FM cigarettes, no sociodemographic factors were associated with transitions from one to another so we were unable to resolve the debate regarding the importance of financial capacity and price differences in this context.^{16,17} A potential reason for this is that we did not have data on the balance between FM and RYO in dual users. For instance, dual users with lower income may indeed consume more RYO than FM as a strategy to avoid increasing costs. Overall, dual users were the most likely to change smoking behaviors and had the lowest proportion of quitting between the two waves, so they likely play a key role in transitions and switching which should be investigated in future research.

Overall, there were major differences between countries. Some of these may be linked to taxation and price differentials.²⁷ A recent study on pricing and taxation of FM and RYO in European countries found that, among the countries we studied, price differences between the cheaper brands of FM and RYO were highest in Germany and Hungary, while RYO was almost as costly as cheap cigarettes in Greece.¹⁵ However, these differences are not necessarily reflected in the findings of our study regarding perceptions that RYO is cheaper or/and transitions from one product to the other. Other factors, such as cultural, other tobacco control policies and market characteristics may better explain the variation. For instance, in Germany, where RYO is much cheaper than FM,¹⁵ tobacco control measures are rather weak,²⁹ so the strong financial incentive to switch to RYO may be attenuated by the lack of strict tobacco control measures which usually target FM. Similarly, the availability, promotion and pricing of electronic cigarettes and heated tobacco products also differ among the six countries; some smokers who may wish to switch away from FM and/or RYO could have opted for these novel products.

Although Romania had a high percentage of RYO users who thought it is less harmful than FM cigarettes, this does not seem to be a major reason for using RYO in most countries. Other than price, taste seems to be an important factor and, in Greece and Romania, the perception that it helps reduce consumption. This is

not necessarily true. Those smoking 21–30 cigarettes per day were more likely to smoke RYO compared with those smoking 30+ per day, so it might be partly true for heavy smokers, but there was no difference among those smoking less than 20 cigarettes per day.

We found no link between product used and knowledge of the health effects of smoking. However, exclusive RYO users were more likely to think that RYO is less harmful than dual users. This may imply that, although RYO users are not less likely to recognize the health consequences of smoking in general, they might think that these are relevant to FM smoking and not so much to RYO. Unfortunately, these questions were asked in general and not for specific types of tobacco. Years of different approaches in health warnings on packs of RYO compared with FM could partly explain this. Current TPD provisions¹⁴ are likely to narrow this gap in coming years. Some health effects were known to more smokers than others and there were stark differences between countries. Local information campaigns and varying efforts to raise awareness about specific diseases may explain this.²⁹ Following decades of campaigns and programs to educate the public, a substantial proportion of smokers still did not know that smoking causes cancer, respiratory and cardiovascular diseases, which highlights the need for continued effort to communicate the negative health effects of smoking.

Strengths and limitations

Our analysis is the first to investigate transitions between RYO and FM in multiple European countries before and after the implementation of the TPD. Sampling methods and questionnaires were consistent across survey waves and countries, allowing us to make direct comparisons between countries and over time. The longitudinal design of the study lends itself to adequately examining changes of smoking behaviors within individuals. However, the attrition rate varied among countries and was high, which may have introduced selection bias. We attempted to account for this by using longitudinal sampling weights in the analysis that account for attrition at a high level. Sources of RYO may vary, with some users obtaining tobacco directly from tobacco producers or other informal sources; however, we did not make such a distinction in our study. Another limitation was the relatively small number of smokers who switched

products during the study period, which reduced the power of our statistical analyses. In some countries in particular RYO use was rare; these small sample sizes preclude any firm conclusion in those countries where the prevalence of RYO use was low. The assessment of perceptions and knowledge was based on binary yes/no responses, which may fail to fully capture the extent of someone's knowledge and perceptions; however, this applied to both FM and RYO users, hence comparisons can still highlight differences between these groups of smokers. Finally, perceptions about RYO were assessed among RYO users only, which precluded more insightful investigation of the role of such perceptions in the transition between FM and RYO.

Conclusions

This study revealed a complex picture in the relationship between RYO and FM among smokers in six European countries. Switching between RYO and FM, as well as dual use was frequent despite the short follow-up period. We also found gaps in the knowledge of the health effects of smoking and concerning perceptions about RYO among its users. These findings highlight the increasing role of RYO in the tobacco market in Europe and underline the need for stricter regulatory approaches, some of which have already been legislated through the revised TPD. Future tobacco-related studies in Europe should routinely include RYO, with particular attention to dual use.

Supplementary data

Supplementary data are available at *EURPUB* online.

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