BMJ Open

OPPOSITE TRENDS IN THE CONSUMPTION OF MANUFACTURED AND ROLL-YOUR-OWN CIGARETTES IN SPAIN (1991-2020)

Journal:	*BMJ Open*
Manuscript ID:	bmjopen-2014-006552
Article Type:	Research
Date Submitted by the Author:	05-Sep-2014
Complete List of Authors:	Fu, Marcela; Institut Català d'Oncologia, Tobacco Control Unit Martínez-Sánchez, Jose; Institut Català d'Oncologia, Tobacco Control Unit Cleries, Ramón; Institut Català d'Oncologia, Pla Director Villalbí, Joan; Agència de Salut Pública de Barcelona, Daynard, Richard; Northeastern University, Public Health Advocacy Institute Connolly, Gregory; Harvard School of Public Health, Department of Society, Human Development and Health Fernandez, Esteve; Institut català d'Oncologia, Tobacco Control Unit
Primary Subject Heading:	Smoking and tobacco
Secondary Subject Heading:	Public health
Keywords:	PUBLIC HEALTH, Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Epidemiology < ONCOLOGY

OPPOSITE TRENDS IN THE CONSUMPTION OF MANUFACTURED AND ROLL-YOUR-OWN CIGARETTES IN SPAIN (1991-2020)

Marcela Fu[1,2,3], Jose M Martínez-Sánchez[1,2,4,5], Ramon Clèries[2,3,6], Joan R Villalbí[7,8,9], Richard A Daynard[5], Gregory N Connolly[10], and Esteve Fernández[1,2,3]

1 Tobacco Control Unit, Cancer Prevention and Control Programme, Catalan Institute of Oncology-ICO, L'Hospitalet de Llobregat, Spain
2 Cancer Control and Prevention Group, Bellvitge Biomedical Research Institute-IDIBELL, L'Hospitalet de Llobregat, Spain
3 Department of Clinical Sciences, School of Medicine, Universitat de Barcelona, Barcelona, Spain
4 Biostatistics Unit, Department of Basic Sciences, Universitat Internacional de Catalunya, Sant Cugat del Vallès, Spain
5 Public Health Advocacy Institute, Northeastern University, Boston, MA, USA
6 Cancer Registry of Catalonia, Plan for Oncology of the Catalan Government, L'Hospitalet de Llobregat, Spain
7 Public Health Agency of Barcelona, Barcelona, Spain
8 Biomedical Research Networking Centre of Public Health and Epidemiology-CIBERESP, Spain
9 Biomedical Research Institute Sant Pau, Barcelona, Spain
10 Department of Social and Behavioral Sciences, Center for Global Tobacco Control, Harvard School of Public Health, Boston, MA, USA

Keywords: tobacco products; rolling tobacco; RYO cigarettes; legal sales; sales projections

Word count: 1790 words

Corresponding author
Jose M Martínez-Sánchez
Permanent address:
Tobacco Control Unit, Institut Català d'Oncologia
Av. Granvia de L'Hospitalet, 199-203
08908 L'Hospitalet de Llobregat, Barcelona, Spain
Tel.: +34-932607357; Fax: +34-932607956
E-mail: jmmartinez@iconcologia.net

ABSTRACT

Objective: To describe trends in the consumption per capita of manufactured and roll-your-own cigarettes in Spain and to project time trends up to 2020.

Methods: We estimated daily consumption per capita during 1991-2012 using data on sales of manufactured cigarettes (20-packs) and rolling tobacco (kg) from the Tobacco Market Commission, and using data of the Spanish adult population from the National Statistics Institute. We considered different weights (0.5, 0.8, 1g) to compute the number of rolled cigarettes per capita. We computed the annual percent of change and assessed possible changes in trends using joinpoint regression, and projected the consumption up to 2020 using Bayesian methods.

Results: Daily consumption per capita of manufactured cigarettes decreased on average 3.03% per year in 1991-2012, from 7.6 to 3.8 units, with 3 trend changes. However, daily consumption per capita of roll-your-own cigarettes increased on average 14.08% per year, from 0.07 to 0.92 units of 0.5g, with unchanged trends. Together, daily consumption per capita decreased between 2.90% and 2.54%, depending on the weight of the roll-your-own cigarettes. Projections up to 2020 indicate a decrease of manufactured cigarettes (1.75 units per capita) but an increase of roll-your-own cigarettes (1.25 units per capita).

Conclusions: Whilst the consumption per capita of manufactured cigarettes has decreased in the last years in Spain, the consumption of roll-your-own cigarettes has increased at an annual rate around 14% over the last years. Whereas a net decrease in cigarette consumption is expected in the future, use of roll-your-own cigarettes will continue to increase.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- Our study allowed providing an estimation of tobacco sales (and tobacco consumption) at a national level, and, more importantly, allowed us to compare the consumption of manufactured and roll-your-own cigarettes.
- We estimated the cigarette consumption per capita by means of the information available on product sales. This information provides a crude estimation of the population's consumption.
- The proportion of roll-your-own cigarettes from overall cigarettes per capita in creased from 0.9% in 1991 to 19.6% in 2012.
- Projections indicate 36% increasing trend of RYO cigarette consumption per capita by 2020, representing 41.6% of overall cigarettes per capita by that year. These projections put into evidence the need of developing urgent measures to better comprehend this phenomenon, in order to prevent and control the spread of use of roll-your-own cigarettes and other alternative forms of tobacco products, especially in vulnerable populations.

INTRODUCTION

Smoking is the leading cause of preventable morbidity and premature mortality worldwide.[1] As a consequence of the increasing awareness by the population of the harmful effects of smoking and the tobacco control policies promoted by the WHO Framework Convention on Tobacco Control,[2] a decrease in cigarette consumption has been observed in many developed countries in the last years. In Western Europe, cigarette consumption dropped by 26% between 1990 and 2009.[3] Nevertheless, the use of forms of tobacco other than conventional cigarettes is becoming widespread, because of their lower regulation and prices.[4]

Although a decreasing conventional manufactured cigarette smoking has been also described in adolescents,[5,6] concurrent use of multiple tobacco products is becoming prevalent among young populations.[7] In this sense, the use of rolling tobacco, or roll-your-own cigarettes, is increasing in many countries,[8] in part because of the widespread belief of minimal hazardous health effects.[9] Evidence does not support this belief; on the contrary, rolling tobacco yields higher nicotine, tar and carbon monoxide levels than manufactured cigarettes.[10–12]

As in other countries, the economic crisis during the last years in Spain seems to have lead to an increase in the consumption of other tobacco products subject to lower taxes and thus being cheaper for smokers.[13] The aim of this study is to describe trends in the consumption of manufactured and roll-your-own cigarettes between 1991 and 2012 in Spain, and to project these trends up to 2020.

METHODS

We used the official Spanish data on legal sales of tobacco products from the Tobacco Market Commission,[14] which monthly collects information on tobacco product sales to smokers from tobacconists'. We included data from the Iberian Peninsula & the Balearic Islands and excluded data from Ceuta & Melilla, reported only from 2009, because of the different taxation in these territories. We considered data on manufactured cigarettes and rolling tobacco from 1991, when this latter was first included in the registries, up to 2012. Information on manufactured cigarettes was first reported in million packs of cigarettes and then in packs of 20 cigarettes. For rolling tobacco, nevertheless, there has been some variability in the way the statement has been made. It was first expressed in millions of packages (from 1991 to 1998), then in millions of bags (from 1999 to 2000), then in millions of bags or cans (from 2001 to 2008), and finally in kg of product (from 2008 up to now). We assumed that one pack/bag/can of rolling tobacco weighs 50g, on the basis of the available data in 2008, when the information on sales was available in both bags/cans and in kilograms. We estimated this figure by dividing the total grams sold in 2008 by all the bags/cans sold that same year, resulting in 46.85g. Using the rounded figure of 50g per unit of pack/bag/can, we were able to estimate the sales of rolling tobacco in kg of product for all the studied period.

We also collected data from the National Statistics Institute of the Spanish population ≥16 years old for the period 1991-2012, using the population censuses and the official inter-censuses data (available up to 2012).[15] This information allowed us to estimate the average number of manufactured and roll-your-own cigarettes per year and person.[16,17] Since this

information is aggregated data and it does not contain data on individuals, ethical approval was not required.

Because the amount of tobacco included in a unit of roll-your-own cigarette is variable as it depends on the way the smoker makes the roll,[12] we considered three possible weights to estimate the number of cigarettes: 0.5g, 0.8g, and 1g of tobacco. For each option, we calculated the annual percent of change (APC) of the number of cigarettes per person and year for manufactured cigarettes, roll-your-own cigarettes, and both type of cigarettes taken together.

In order to assess changing trends during 1991-2012, we used joinpoint regression.[18] To predict trends, we fitted an autoregressive Bayesian log-linear model during the last time period, where the joinpoint analysis found a changing trend. In this model, the temporal trend was modeled through a random walk of order 2.[19] Once the model was fitted, we predicted the cigarette consumption for the period 2013-2020, based on the time trend estimated with this Bayesian model.

RESULTS

Daily consumption per capita of manufactured cigarettes decreased from 7.6 units in 1991 to 3.8 units in 2012, with an average APC of –3.03% (Figure 1). Daily consumption per capita of roll-your-own cigarettes in the same period increased according to the scenario considered, from 0.07 to 0.92 units of 0.5g, from 0.04 to 0.58 units of 0.8g, and from 0.03 to 0.46 units of 1g (average APC: 14.08%). This represents an increase in the proportion of roll-you-own cigarettes from 0.9% in 1991 to 19.6% in 2012 of overall cigarettes per capita, considering

rolled units of 0.5g (from 0.5% to 13.3% and from 0.4% to 10.8% considering roll-your-own cigarettes of 0.8g and 1g, respectively). Overall, daily consumption per capita (manufactured plus roll-your-own cigarettes) decreased from 7.6 to 4.7 units (average APC: –2.09%), from 7.6 to 4.4 units (average APC: –2.42%), and from 7.6 to 4.2 units (average APC: –2.54%), depending on the weight of the roll-your-own cigarettes considered.

Joinpoint analyses (Table 1) indicated a decrease in the consumption of manufactured cigarettes at the beginning of the period (1991-1996), then a period of non-significant rising during 1997-2001, and then a significant downward trend in 2002-2008, that accelerated afterwards in 2009-2012 (APC of –12.6). When we considered only roll-your-own cigarettes, we observed a continuous significant increasing trend of 14.1% for the whole study period (1991-2012).

Table 1 Joinpoint analyses of daily cigarette consumption per capita by adult population ≥16 years old in Spain (manufactured cigarettes, roll-your-own cigarettes and both type of cigarettes) over the period 1991-2012 and the corresponding annual percent of change (and their 95% confidence intervals).

	Trend 1	Trend 2	Trend 3	Trend 4
Period	1991-1996	1997-2001	2002-2008	2009-2012
Manufactured cigarettes	–2.9 (–5.3, –0.6)*	3.3 (–0.2, 6.9)	–1.9 (–3.7, –0.1)*	–12.6 (–16.2, –8.9)*
Period	1991-1996	1997-2001	2002-2008	2009-2012
Combined cigarettes	–2.8 (–5.3, –0.3)*	3.6 (–0.1, 7.3)	–1.1 (–2.9, 0.8)	–9.8 (–13.4, –6.8)*
Period	1991-2012	-	-	-
Roll-your-own cigarettes	14.1 (13.1, 15.2)*	-	-	-

*Statistically significant (p<0.05).

Figure 1 shows the trends in daily consumption of units of manufactured and roll-your-own cigarettes, as well as the projections up to 2020. For that year, differences between the consumption of both types of cigarettes taking together (solid line) and the consumption of manufactured cigarettes only (dashed line) reach 36 percent increase comparing to that

observed at the end of the observed period in 2012. By 2020, projections indicate a daily consumption per capita of 1.75 units of manufactured cigarettes and 1.25 units of roll-your-own cigarettes, this latter representing 41.6% of overall cigarettes per capita projected by that year.

DISCUSSION

Besides a decrease in daily consumption per capita of manufactured cigarettes, we observed an increase in the consumption of roll-your-own cigarettes, thus indicating a shift from one to another. We found an increasing contribution of the roll-your-own cigarettes to the overall cigarette consumption per capita during 1991-2012. They represented 0.9% in 1991 and 19.6% in 2012 of overall cigarettes per capita, when considering roll-your-own units of 0.5g. This trend has also been observed in other developed countries,[20–22] including younger populations.[23] Although the global trend of daily use of cigarettes per capita is decreasing, the increasing trend of use of roll-your-own cigarettes is very concerning, and our projections indicate that it will continue in the future at higher rate, with an estimated proportion of 41.7% of overall cigarettes per capita by 2020.

Article 6 of the FCTC urges the parties to adopt price and tax measures to all tobacco products.[2] In Spain, several tax reforms have accompanied the implementation of more restrictive tobacco regulations, but they have been mainly applied to manufactured cigarettes. In recent years, the prices of these products have been remarkably different, with rolling tobacco costing about 50% less than manufactured cigarettes until 2009, when a small tax was introduced. This fact has contributed to an increase of the market share of rolling tobacco, from 1.6 to 5.1% of sales from 2005 to 2011.[13]

The decrease in sales of manufactured cigarettes is possibly in part a collateral effect of the Spanish smoke-free legislation of 2010, reflecting less smoking by adult smokers. The current economic crisis could also have contributed to make some smokers shift from manufactured to roll-your-own cigarettes, especially younger smokers. This shift should be explored in depth in order to develop prevention strategies, especially among young people. A New Zealand study found that the reasons referred by smokers for this shift are, in order of importance, that roll-your-own cigarettes are cheaper, taste better, are more satisfying, reduce the amount smoked, and have less harmful effects.[24] With more detailed knowledge of this shift by population strata, more appropriate strategies may be planned to tackle rolling tobacco consumption and encourage cessation; among them, awareness campaigns and better information to the population on the health effects of rolling tobacco, with an emphasis in youth and socio-economic deprived areas.

Some limitations of our investigation deserve consideration. First, we estimated the cigarette consumption per capita by means of the information available on product sales. This information provides a crude estimation of the population's consumption, as they do not distinguish between sales to the Spanish population and tourists, a common situation especially in the nation's border and coastal provinces. On the other hand, official sales do not include smuggling and therefore a variable portion of the consumption is not being considered. Second, information on tobacco sales is heterogeneous. In the case of manufactured cigarettes, sales were registered in "packs" the first years (until 2005, packs of 10 and 19 cigarettes existed, although they represented a very small portion of the volume share). The available information on rolling tobacco is more heterogeneous, because the registries on sales during the first years included units of product and no specification on their

weights were provided. Fortunately, information on units of product and the corresponding kilograms were available for the year 2008, allowing us to obtain some estimations. Third, the amount of tobacco in a roll-your-own cigarette is variable and this contributes to an imprecise estimation of the number of cigarettes. Some reports have used conversion factors between 0.6 and 0.9 g per cigarette,[5,13,20,22] and a revision of studies providing data on the weight of roll-your-own cigarettes indicated median estimates ranging between 0.48 and 1.1.[25] In our study, we used 3 different options (0.5, 0.8, and 1g). Fourth, pipe tobacco can be also used to make roll-your-own cigarettes, so their unitary estimations may be slightly underestimated. Despite this, our analysis allowed providing an estimation of tobacco sales (and tobacco consumption) at a national level, and, more importantly, allowed us to compare the consumption of manufactured and roll-your-own cigarettes.

In conclusion, although the sales of manufactured cigarettes are decreasing as observed in the last years in Spain, use of rolled-your-own cigarettes are progressively increasing. Rolling tobacco sales will continue increasing in the next years, partly due to a shift in the consumption from manufactured to roll-your-own cigarettes. More attention should be paid to this and other alternative tobacco products, in order to hinder its access especially to young people. More concrete strategies, such as higher taxation and information on their health effects, are key strategies to be developed, with emphasis in specific populations.

Competing interests: None.

Funding: This work was supported by the Instituto de Salud Carlos III, Government of Spain (RTICC RD12/0036/0053) and the Ministry of Universities and Research, Government of Catalonia (grant 2009SGR192).

Contributionship: JMMS and EF conceived the study. MF, RC, and JMMS prepared the database and conducted the analyses. All the authors contributed substantially to the interpretation of the data. MF drafted the first version of the manuscript; all the authors contributed to its subsequent versions and approved the final version. EF is the guarantor.

Data sharing statement: Since the data are provided by official institutions, the authors cannot offer any additional unpublished data.

Ethical approval: This study does not use data of individuals and thus an ethical approval is not required.

REFERENCES

1 World Health Organization. WHO Report on the Global Tobacco Epidemic, 2008: the MPOWER package. Geneva: WHO Press 2008. www.who.int/tobacco/mpower/en/ (accessed August 2014).

2 World Health Organization. WHO Framework Convention in Tobacco Control. Geneva: World Health Organization 2003. http://www.who.int/fctc/text_download/en/index.html (accessed August 2014).

3 Eriksen MP, Mackay JL, Ross H. The Tobacco Atlas. Atlanta, GA.: American Cancer Society, Inc. 2012. www.TobaccoAtlas.org (accessed August 2014).

4 Prignot JJ, Sasco AJ, Poulet E, *et al.* Alternative forms of tobacco use. *Int J Tuberc Lung Dis* 2008;12:718–27.

5 Centers for Disease Control and Prevention. Current tobacco use among middle and high school students—United States, 2011. *Morb Mortal Wkly Rep* 2012;61:581–5.

6 Villalbí JR, Suelves JM, García-Continente X, *et al.* [Changes in smoking prevalence among adolescents in Spain]. *Aten Primaria* 2012;44:36–42. doi:10.1016/j.aprim.2010.12.016

7 U.S. Department of Health and Human Services. Preventing tobacco use among youth and young Adults: A Report of the Surgeon General. Atlanta: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, Office on Smoking and Health; 2012.

8 Young D, Wilson N, Borland R, *et al.* Prevalence, correlates of, and reasons for using roll-your-own tobacco in a high RYO use country: Findings from the ITC New Zealand Survey. *Nicotine Tob Res* 2010;12:1089–98. doi:10.1093/ntr/ntq155

9 O'Connor RJ, McNeill A, Borland R, *et al.* Smokers' beliefs about the relative safety of other tobacco products: findings from the ITC collaboration. *Nicotine Tob Res* 2007;9:1033–42. doi:10.1080/14622200701591583

10 Shahab L, West R, McNeill A. A comparison of exposure to carcinogens among roll-your-own and factory-made cigarette smokers. *Addict Biol* 2009;14:315–20. doi:10.1111/j.1369-1600.2009.00157.x

11 Castaño Calduch T, Hebert Jiménez C, Campo San Segundo MT, *et al.* [Fine-cut tobacco: a priority for public health and consumer advocacy]. *Gac Sanit* 2012;26:267–9. doi:10.1016/j.gaceta.2011.09.010

12 Darrall KG, Figgins JA. Roll-your-own smoke yields: theoretical and practical aspects. *Tob Control* 1998;7:168–75. doi:10.1136/tc.7.2.168

13 López-Nicolás Á, Cobacho MB, Fernández E. The Spanish tobacco tax loopholes and their consequences. *Tob Control* 2013;22:e21–4. doi:10.1136/tobaccocontrol-2011-050344

14 Ministerio de Hacienda y Administraciones Públicas. Comisionado para el Mercado de Tabacos. Tobacco market statistics and indicators. http://www.cmtabacos.es/wwwcmt/paginas/EN/mercadoEstadisticas.tmpl (accessed August 2014).

15 Instituto Nacional de Estadística. Population figures and Demographic Censuses. http://www.ine.es/en/inebmenu/mnu_cifraspob_en.htm (accessed August 2014).

16 Gallus S, Tramacere I, Boffetta P, *et al.* Temporal changes of under-reporting of cigarette consumption in population-based studies. *Tob Control* 2011;20:34–9. doi:10.1136/tc.2009.034132

17 Martínez-Sánchez JM, Fu M, Gallus S, *et al.* [Variability in cigarette consumption according to the data source in Spain (1993-2009)]. *Gac Sanit* 2013;27:61–3. doi:10.1016/j.gaceta.2012.05.003

18 Kim HJ, Fay MP, Feuer EJ, *et al.* Permutation tests for joinpoint regression with applications to cancer rates. *Stat Med* 2000;19:335–51 (erratum in *Stat Med*. 2001;20:655). doi:10.1002/(SICI)1097-0258(20000215)19:3<335::AID-SIM336>3.0.CO;2-Z

19 Clèries R, Martínez JM, Moreno V, *et al.* Predicting the change in breast cancer deaths in Spain by 2019: a Bayesian approach. *Epidemiology* 2013;24:454–60. doi:10.1097/EDE.0b013e31828b0866

20 Connolly GN, Alpert HR. Trends in the use of cigarettes and other tobacco products, 2000-2007. *JAMA* 2008;299:2629–30. doi:10.1001/jama.299.22.2629

21 Young D, Yong H-H, Borland R, *et al.* Trends in roll-your-own smoking: findings from the ITC Four-Country Survey (2002-2008). *J Environ Public Health* 2012;2012:406283. doi:10.1155/2012/406283

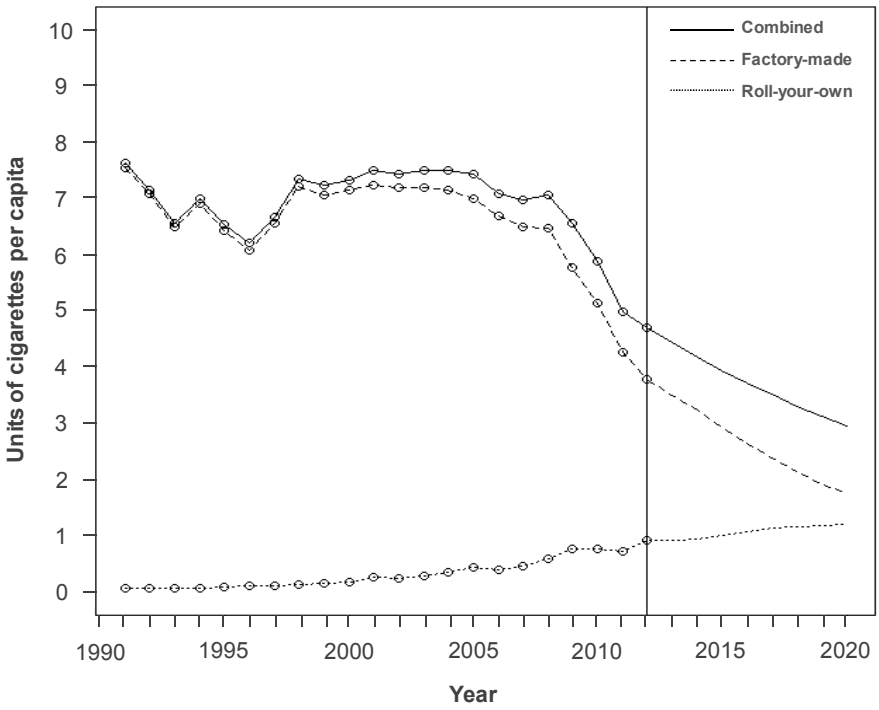
22 Gallus S, Lugo A, Colombo P, *et al.* Smoking prevalence in Italy 2011 and 2012, with a focus on hand-rolled cigarettes. *Prev Med* 2013;56:314–8. doi:10.1016/j.ypmed.2013.02.009

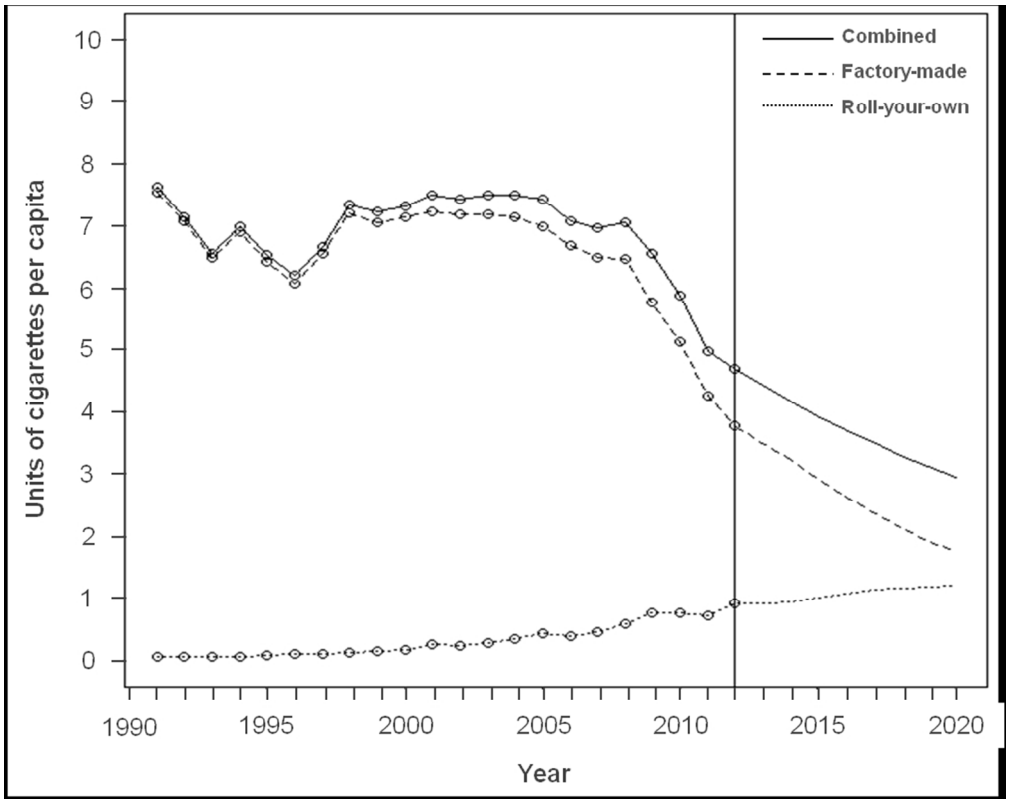
23 Raisamo SU. Trends in roll-your-own tobacco use among adolescents in Finland, 1981-2009. *Prev Med* 2011;53:431–2. doi:10.1016/j.ypmed.2011.09.004

24 Wilson N, Young D, Weerasekera D, *et al.* The importance of tobacco prices to roll-your-own (RYO) smokers (national survey data): higher tax needed on RYO. *New Zeal Med J* 2009;122:92–6.

25 Gallus S, Lugo A, Ghislandi S, *et al.* Roll-your-own cigarettes in Europe: use, weight and implications for fiscal policies. *Eur J Cancer Prev* 2014;23:186–92. doi:10.1097/CEJ.0000000000000010

Figure 1 Daily cigarette consumption per capita (units of factory-made and roll-your-own cigarettes) in Spain during 1991-2012 and predictions for the years 2013-2020.





169x134mm (150 x 150 DPI)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of observational *studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	#2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	#2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	#4
Objectives	3	State specific objectives, including any prespecified hypotheses	#4
Methods			
Study design	4	Present key elements of study design early in the paper	#5-6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	#5-6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	#5-6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	#5-6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	#5-6
Bias	9	Describe any efforts to address potential sources of bias	#5-6
Study size	10	Explain how the study size was arrived at	#5-6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	#6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Not applicable
		(*b*) Describe any methods used to examine subgroups and interactions	Not applicable
		(*c*) Explain how missing data were addressed	Not applicable
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	Not applicable
		(*e*) Describe any sensitivity analyses	Not applicable
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Not applicable
		(b) Give reasons for non-participation at each stage	Not applicable
		(c) Consider use of a flow diagram	No diagram included
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	#6-7
		(b) Indicate number of participants with missing data for each variable of interest	Not applicable
Outcome data	15*	Report numbers of outcome events or summary measures	#6-7
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	#6-7
		(*b*) Report category boundaries when continuous variables were categorized	Not applicable
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Not applicable
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Not applicable
Discussion			
Key results	18	Summarise key results with reference to study objectives	#8
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	#9-10
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	#8-10
Generalisability	21	Discuss the generalisability (external validity) of the study results	#9-10
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	#11

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

OPPOSITE TRENDS IN THE CONSUMPTION OF MANUFACTURED AND ROLL-YOUR-OWN CIGARETTES IN SPAIN (1991-2020)

Journal:	*BMJ Open*
Manuscript ID:	bmjopen-2014-006552.R1
Article Type:	Research
Date Submitted by the Author:	09-Oct-2014
Complete List of Authors:	Fu, Marcela; Institut Català d'Oncologia, Tobacco Control Unit Martínez-Sánchez, Jose; Institut Català d'Oncologia, Tobacco Control Unit Cleries, Ramón; Institut Català d'Oncologia, Pla Director Villalbí, Joan; Agència de Salut Pública de Barcelona, Daynard, Richard; Northeastern University, Public Health Advocacy Institute Connolly, Gregory; Harvard School of Public Health, Department of Society, Human Development and Health Fernandez, Esteve; Institut català d'Oncologia, Tobacco Control Unit
Primary Subject Heading:	Smoking and tobacco
Secondary Subject Heading:	Public health
Keywords:	PUBLIC HEALTH, Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Epidemiology < ONCOLOGY

OPPOSITE TRENDS IN THE CONSUMPTION OF MANUFACTURED AND ROLL-YOUR-OWN CIGARETTES IN SPAIN (1991-2020)

Marcela Fu[1,2,3], Jose M Martínez-Sánchez[1,2,4,5], Ramon Clèries[2,3,6], Joan R Villalbí[7,8,9], Richard A Daynard[5], Gregory N Connolly[10], and Esteve Fernández[1,2,3]

1 Tobacco Control Unit, Cancer Prevention and Control Programme, Catalan Institute of Oncology-ICO, L'Hospitalet de Llobregat, Spain
2 Cancer Control and Prevention Group, Bellvitge Biomedical Research Institute-IDIBELL, L'Hospitalet de Llobregat, Spain
3 Department of Clinical Sciences, School of Medicine, Universitat de Barcelona, Barcelona, Spain
4 Biostatistics Unit, Department of Basic Sciences, Universitat Internacional de Catalunya, Sant Cugat del Vallès, Spain
5 Public Health Advocacy Institute, Northeastern University, Boston, MA, USA
6 Cancer Registry of Catalonia, Plan for Oncology of the Catalan Government, L'Hospitalet de Llobregat, Spain
7 Public Health Agency of Barcelona, Barcelona, Spain
8 Biomedical Research Networking Centre of Public Health and Epidemiology-CIBERESP, Spain
9 Biomedical Research Institute Sant Pau, Barcelona, Spain
10 Department of Social and Behavioral Sciences, Center for Global Tobacco Control, Harvard School of Public Health, Boston, MA, USA

Keywords: tobacco products; rolling tobacco; RYO cigarettes; legal sales; sales projections

Word count: 2041 words

Corresponding author
Jose M Martínez-Sánchez
Permanent address:
Tobacco Control Unit, Institut Català d'Oncologia
Av. Granvia de L'Hospitalet, 199-203
08908 L'Hospitalet de Llobregat, Barcelona, Spain
Tel.: (+34) 932607357; Fax: (+34) 932607956
E-mail: jmmartinez@iconcologia.net

ABSTRACT

Objective: The aim of this study is to describe trends in the consumption of manufactured and roll-your-own cigarettes between 1991 and 2012 in Spain, and to project these trends up to 2020.

Methods: We estimated daily consumption per capita during 1991-2012 using data on sales of manufactured cigarettes (20-packs) and rolling tobacco (kg) from the Tobacco Market Commission, and using data of the Spanish adult population from the National Statistics Institute. We considered different weights (0.5, 0.8, 1g) to compute the number of rolled cigarettes per capita. We computed the annual percent of change and assessed possible changes in trends using joinpoint regression, and projected the consumption up to 2020 using Bayesian methods.

Results: Daily consumption per capita of manufactured cigarettes decreased on average 3.03% per year in 1991-2012, from 7.6 to 3.8 units, with 3 trend changes. However, daily consumption per capita of roll-your-own cigarettes increased on average 14.08% per year, from 0.07 to 0.92 units of 0.5g, with unchanged trends. Together, daily consumption per capita decreased between 2.90% and 2.54%, depending on the weight of the roll-your-own cigarettes. Projections up to 2020 indicate a decrease of manufactured cigarettes (1.75 units per capita) but an increase of roll-your-own cigarettes (1.25 units per capita).

Conclusions: Whilst the consumption per capita of manufactured cigarettes has decreased in the last years in Spain, the consumption of roll-your-own cigarettes has increased at an annual rate around 14% over the last years. Whereas a net decrease in cigarette consumption is expected in the future, use of roll-your-own cigarettes will continue to increase.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- Our study allowed providing an estimation of tobacco sales (and tobacco consumption) at a national level, and, more importantly, allowed us to compare the consumption of manufactured and roll-your-own cigarettes.
- We estimated the cigarette consumption per capita by means of the information available on product sales. This information provides a crude estimation of the population's consumption.
- The proportion of roll-your-own cigarettes from overall cigarettes per capita increased from 0.9% in 1991 to 19.6% in 2012.
- Projections indicate 36% increasing trend of roll-your-own cigarette consumption per capita by 2020, representing 41.6% of overall cigarettes per capita by that year. These projections put into evidence the need of developing urgent measures in order to prevent and control the spread of roll-your-own cigarettes and other alternative forms of tobacco products, especially in vulnerable populations.

INTRODUCTION

Smoking is the leading cause of preventable morbidity and premature mortality worldwide.[1] As a consequence of the increasing awareness by the population of the harmful effects of smoking and the tobacco control policies promoted by the WHO Framework Convention on Tobacco Control,[2] a decrease in cigarette consumption has been observed in many developed countries in the last years. In Western Europe, cigarette consumption dropped by 26% between 1990 and 2009.[3] Nevertheless, the use of forms of tobacco other than conventional cigarettes is becoming widespread, because of their lower regulation and prices.[4]

Although a decreasing conventional manufactured cigarette smoking has been also described in adolescents,[5,6] concurrent use of multiple tobacco products is becoming prevalent among young populations.[7] In this sense, the use of rolling tobacco, or roll-your-own cigarettes, is increasing in many countries,[8] in part because of the widespread belief of minimal hazardous health effects.[9] Evidence does not support this belief; on the contrary, rolling tobacco yields higher nicotine, tar and carbon monoxide levels than manufactured cigarettes.[10–12]

As in other countries, the economic crisis during the last years in Spain seems to have lead to an increase in the consumption of other tobacco products subject to lower taxes and thus being cheaper for smokers.[13] The aim of this study is to describe trends in the consumption of manufactured and roll-your-own cigarettes between 1991 and 2012 in Spain, and to project these trends up to 2020.

METHODS

We used the official Spanish data on annual legal sales of tobacco products from the Tobacco Market Commission.[14] The Commission collects information on tobacco product sales to smokers from tobacconists'. We included data from the Iberian Peninsula & the Balearic Islands and excluded data from Ceuta & Melilla, reported only from 2009, because of the different taxation in these territories. We considered annual data on manufactured cigarettes and rolling tobacco from 1991, when this latter was first included in the registries, up to 2012. Information on manufactured cigarettes was first reported in million packs of cigarettes and then in packs of 20 cigarettes. For rolling tobacco, nevertheless, there has been some variability in the way the statement has been made. It was first expressed in millions of packages (from 1991 to 1998), then in millions of bags (from 1999 to 2000), then in millions of bags or cans (from 2001 to 2008), and finally in kg of product (from 2008 up to now). We assumed that one pack/bag/can of rolling tobacco weighs 50g, on the basis of the available data in 2008, when the information on sales was available in both bags/cans and in kilograms.[15,16] We estimated this figure by dividing the total grams sold in 2008 by all the bags/cans sold that same year, resulting in 46.85g. Using the rounded figure of 50g per unit of pack/bag/can, we were able to estimate the sales of rolling tobacco in kg of product for all the studied period.

We also collected data from the National Statistics Institute of the Spanish population ≥16 years old for the period 1991-2012, using the population censuses and the official inter-censuses data (available up to 2012).[17] This information allowed us to estimate the average number of manufactured and roll-your-own cigarettes per year and person.[18,19] Since this

information is aggregated data and it does not contain data on individuals, ethical approval was not required.

Because the amount of tobacco included in a unit of roll-your-own cigarette is variable as it depends on the way the smoker makes the roll,[12] we considered three possible weights to estimate the number of cigarettes: 0.5g, 0.8g, and 1g of tobacco. For each option, we calculated the annual percent of change (APC) of the number of cigarettes per person and year for manufactured cigarettes, roll-your-own cigarettes, and both type of cigarettes taken together.

In order to assess changing trends during 1991-2012, we used joinpoint regression. According to the procedure developed by Kim el al.,[20] and based on the shape of the time trend of the daily cigarette consumption per capita, we assumed a maximum number of 4 joinpoints. To predict trends, we fitted an autoregressive Bayesian log-linear Poisson model to the observed data in 1991-2012. This model allows better predictions in situations where other models may fail[20] and gives more weight to data from recent periods, especially when changing trends arise through the study period.[21] In this line, the temporal trend was modelled through a random walk (RW). We assessed the performance of the model comparing a RW of order 1, which assumes constant rate of changes, with a RW of order 2, which is a moving average that changes in time and allows for smoothing of the trend.[21] We found that model with RW of order 2 showed less variability in the within sample prediction of the observed cigarettes per capita in 1991-2012, and then the RW of order 2 assumption was used (see Supplementary Figure S1). Once the model was fitted, we predicted the cigarette consumption for the period 2013-2020, based on the time trend estimated with this Bayesian model.

RESULTS

Daily consumption per capita of manufactured cigarettes decreased from 7.6 units in 1991 to 3.8 units in 2012, with an average APC of –3.03% (Figure 1). Daily consumption per capita of roll-your-own cigarettes in the same period increased according to the scenario considered, from 0.07 to 0.92 units of 0.5g, from 0.04 to 0.58 units of 0.8g, and from 0.03 to 0.46 units of 1g (average APC: 14.08%). This represents an increase in the proportion of roll-you-own cigarettes from 0.9% in 1991 to 19.6% in 2012 of overall cigarettes per capita, considering rolled units of 0.5g (from 0.5% to 13.3% and from 0.4% to 10.8% considering roll-your-own cigarettes of 0.8g and 1g, respectively). Overall, daily consumption per capita (manufactured plus roll-your-own cigarettes) decreased from 7.6 to 4.7 units (average APC: –2.09%), from 7.6 to 4.4 units (average APC: –2.42%), and from 7.6 to 4.2 units (average APC: –2.54%), depending on the weight of the roll-your-own cigarettes considered.

Joinpoint analyses (Table 1) indicated a decrease in the consumption of manufactured cigarettes at the beginning of the period (1991-1996), then a period of non-significant rising during 1997-2001, and then a significant downward trend in 2002-2008, that accelerated afterwards in 2009-2012 (APC of –12.6). When we considered only roll-your-own cigarettes, we observed a continuous significant increasing trend of 14.1% for the whole study period (1991-2012).

Table 1 Joinpoint analyses of daily cigarette consumption per capita by adult population ≥16 years old in Spain (manufactured cigarettes, roll-your-own cigarettes and both type of cigarettes) over the period 1991-2012 and the corresponding annual percent of change (and their 95% confidence intervals).

	Trend 1	Trend 2	Trend 3	Trend 4
Period	1991-1996	1997-2001	2002-2008	2009-2012
Manufactured cigarettes	–2.9 (–5.3, –0.6)*	3.3 (–0.2, 6.9)	–1.9 (–3.7, –0.1)*	–12.6 (–16.2, –8.9)*
Period	1991-1996	1997-2001	2002-2008	2009-2012
Combined cigarettes	–2.8 (–5.3, –0.3)*	3.6 (–0.1, 7.3)	–1.1 (–2.9, 0.8)	–9.8 (–13.4, –6.8)*
Period	1991-2012	-	-	-
Roll-your-own cigarettes	14.1 (13.1, 15.2)*	-	-	-

*Statistically significant (p<0.05).

Figure 1 shows the trends in daily consumption of units of manufactured and roll-your-own cigarettes, as well as the projections up to 2020. For that year, differences between the consumption of both types of cigarettes taking together (solid line) and the consumption of manufactured cigarettes only (dashed line) reach 36 percent increase comparing to that observed at the end of the observed period in 2012. By 2020, projections indicate a daily consumption per capita of 1.75 units of manufactured cigarettes and 1.25 units of roll-your-own cigarettes, this latter representing 41.6% of overall cigarettes per capita projected by that year.

DISCUSSION

Besides a decrease in daily consumption per capita of manufactured cigarettes, we observed an increase in the consumption of roll-your-own cigarettes, thus indicating a shift from one to another. We found an increasing contribution of the roll-your-own cigarettes to the overall cigarette consumption per capita during 1991-2012. These changes have to be taken into account in future tobacco control policies. They represented 0.9% in 1991 and 19.6% in 2012 of overall cigarettes per capita, when considering roll-your-own units of 0.5g. This trend has

also been observed in other developed countries,[22–24] including younger populations.[25] Although the global trend of daily use of cigarettes per capita is decreasing, the increasing trend of use of roll-your-own cigarettes is very concerning, and our projections indicate that it will continue in the future at higher rate, with an estimated proportion of 41.7% of overall cigarettes per capita by 2020.

Article 6 of the FCTC urges the parties to adopt price and tax measures to all tobacco products.[2] In Spain, several tax reforms have accompanied the implementation of more restrictive tobacco regulations, but they have been mainly applied to manufactured cigarettes. In recent years, the prices of these products have been remarkably different, with rolling tobacco costing about 50% less than manufactured cigarettes until 2009, when a small tax was introduced. This fact has contributed to an increase of the market share of rolling tobacco, from 1.6 to 5.1% of sales from 2005 to 2011.[13]

The decrease in sales of manufactured cigarettes is possibly in part a collateral effect of the Spanish smoke-free legislation of 2010, reflecting less smoking by adult smokers. The current economic crisis could also have contributed to make some smokers shift from manufactured to roll-your-own cigarettes, especially younger smokers. This shift should be explored in depth in order to develop prevention strategies, especially among young people. A New Zealand study found that the reasons referred by smokers for this shift are, in order of importance, that roll-your-own cigarettes are cheaper, taste better, are more satisfying, reduce the amount smoked, and have less harmful effects.[26] With more detailed knowledge of this shift by population strata, more appropriate strategies may be planned to tackle rolling tobacco consumption and encourage cessation; among them, awareness campaigns and better

information to the population on the health effects of rolling tobacco, with an emphasis in youth and socio-economic deprived areas.

Some limitations of our investigation deserve consideration. First, we estimated the cigarette consumption per capita by means of the information available on product sales. This information provides a crude estimation of the population's consumption, as they do not distinguish between sales to the Spanish population and tourists, a common situation especially in the nation's border and coastal provinces. On the other hand, official sales do not include smuggling and therefore a variable portion of the consumption is not being considered. However, smuggling had hugely decreased in the last decades[27] and in a European survey conducted in 2010 only 3.4% of Spanish smokers self-reported purchase from illicit source.[28] Second, information on tobacco sales is heterogeneous. In the case of manufactured cigarettes, sales were registered in "packs" the first years (until 2005, packs of 10 and 19 cigarettes existed, although they represented a very small portion of the volume share). The available information on rolling tobacco is more heterogeneous, because the registries on sales during the first years included units of product and no specification on their weights were provided. Fortunately, information on units of product and the corresponding kilograms were available for the year 2008, allowing us to obtain some estimations. Third, the amount of tobacco in a roll-your-own cigarette is variable and this contributes to an imprecise estimation of the number of cigarettes. Some reports have used conversion factors between 0.6 and 0.9 g per cigarette,[5,13,22,24] and according to the Pricing Policy And Control of Tobacco in Europe (PPACTE) project in 2010, median weight of roll-your-own cigarettes ranged between 0.48 and 1.15.[29] In our study, we used 3 different options (0.5, 0.8, and 1g). Fourth, pipe tobacco can be also used to make roll-your-own cigarettes, so their unitary estimations may be slightly underestimated, although less than 1% of the Spanish population

smoked pipes.[30] Despite this, our analysis allowed providing an estimation of tobacco sales (and tobacco consumption) at a national level, and, more importantly, allowed us to compare the consumption of manufactured and roll-your-own cigarettes. We have used a well-established time-series methodology to assess cigarette consumption over time. The statistical modelling through Bayesian autoregressive assumption appears a useful method to assess the long-run relationship between manufactured and RYO cigarettes. Moreover, the net estimations of manufactured and RYO cigarettes according to the constraints of the Bayesian model were similar to the data observed per each year (see Supplementary Table S1).

In conclusion, although the sales of manufactured cigarettes are decreasing as observed in the last years in Spain, use of rolled-your-own cigarettes are progressively increasing. Rolling tobacco sales will continue increasing in the next years, partly due to a shift in the consumption from manufactured to roll-your-own cigarettes. More attention should be paid to this and other alternative tobacco products, in order to hinder its access especially to young people. More concrete strategies, such as higher taxation and information on their health effects, are key strategies to be developed, with emphasis in specific populations.

Competing interests: None.

Funding: This work was supported by the Instituto de Salud Carlos III, Government of Spain (RTICC RD12/0036/0053) and the Ministry of Universities and Research, Government of Catalonia (grant 2009SGR192).

Contributionship: JMMS and EF conceived the study. MF, RC, and JMMS prepared the database and conducted the analyses. All the authors contributed substantially to the interpretation of the data. MF drafted the first version of the manuscript; all the authors contributed to its subsequent versions and approved the final version. EF is the guarantor.

Data sharing statement: Since the data are provided by official institutions, the authors cannot offer any additional unpublished data.

Ethical approval: This study does not use data of individuals and thus an ethical approval is not required.

Figure legend

Figure 1 Daily cigarette consumption per capita (units of factory-made and roll-your-own cigarettes) in Spain during 1991-2012 and predictions for the years 2013-2020.

REFERENCES

1 World Health Organization. WHO Report on the Global Tobacco Epidemic, 2008: the MPOWER package. Geneva: WHO Press 2008. www.who.int/tobacco/mpower/en/ (accessed August 2014).

2 World Health Organization. WHO Framework Convention in Tobacco Control. Geneva: World Health Organization 2003. http://www.who.int/fctc/text_download/en/index.html (accessed August 2014).

3 Eriksen MP, Mackay JL, Ross H. The Tobacco Atlas. Atlanta, GA.: American Cancer Society, Inc. 2012. www.TobaccoAtlas.org (accessed August 2014).

4 Prignot JJ, Sasco AJ, Poulet E, *et al.* Alternative forms of tobacco use. *Int J Tuberc Lung Dis* 2008;12:718–27.

5 Centers for Disease Control and Prevention. Current tobacco use among middle and high school students—United States, 2011. *Morb Mortal Wkly Rep* 2012;61:581–5.

6 Villalbí JR, Suelves JM, García-Continente X, *et al.* [Changes in smoking prevalence among adolescents in Spain]. *Aten Primaria* 2012;44:36–42. doi:10.1016/j.aprim.2010.12.016

7 U.S. Department of Health and Human Services. Preventing tobacco use among youth and young Adults: A Report of the Surgeon General. Atlanta: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, Office on Smoking and Health; 2012.

8 Young D, Wilson N, Borland R, *et al.* Prevalence, correlates of, and reasons for using roll-your-own tobacco in a high RYO use country: Findings from the ITC New Zealand Survey. *Nicotine Tob Res* 2010;12:1089–98. doi:10.1093/ntr/ntq155

9 O'Connor RJ, McNeill A, Borland R, *et al.* Smokers' beliefs about the relative safety of other tobacco products: findings from the ITC collaboration. *Nicotine Tob Res* 2007;9:1033–42. doi:10.1080/14622200701591583

10 Shahab L, West R, McNeill A. A comparison of exposure to carcinogens among roll-your-own and factory-made cigarette smokers. *Addict Biol* 2009;14:315–20. doi:10.1111/j.1369-1600.2009.00157.x

11 Castaño Calduch T, Hebert Jiménez C, Campo San Segundo MT, *et al.* [Fine-cut tobacco: a priority for public health and consumer advocacy]. *Gac Sanit* 2012;26:267–9. doi:10.1016/j.gaceta.2011.09.010

12 Darrall KG, Figgins JA. Roll-your-own smoke yields: theoretical and practical aspects. *Tob Control* 1998;7:168–75. doi:10.1136/tc.7.2.168

13 López-Nicolás Á, Cobacho MB, Fernández E. The Spanish tobacco tax loopholes and their consequences. *Tob Control* 2013;22:e21–4. doi:10.1136/tobaccocontrol-2011-050344

14 Ministerio de Hacienda y Administraciones Públicas. Comisionado para el Mercado de Tabacos. Tobacco market statistics and indicators. http://www.cmtabacos.es/wwwcmt/paginas/EN/mercadoEstadisticas.tmpl (accessed August 2014).

15 Ministerio de Hacienda y Administraciones Públicas. Comisionado para el Mercado de Tabacos. Tobacco market statistics and indicators. Data on sales of packs of 20 cigarettes and bags/cans of rolling tobacco for 2007-2008. http://www.cmtabacos.es/wwwcmt/verEstadistica.php?a=2008&f=2008_comun-u (accessed August 2014).

16 Ministerio de Hacienda y Administraciones Públicas. Comisionado para el Mercado de Tabacos. Tobacco market statistics and indicators. Data on sales of packs of 20 cigarettes and kilos of rolling tobacco for 2008-2009. http://www.cmtabacos.es/wwwcmt/verEstadistica.php?a=2009&f=2009_comun-u (accessed August 2014).

17 Instituto Nacional de Estadística. Population figures and Demographic Censuses. http://www.ine.es/en/inebmenu/mnu_cifraspob_en.htm (accessed August 2014).

18 Gallus S, Tramacere I, Boffetta P, *et al.* Temporal changes of under-reporting of cigarette consumption in population-based studies. *Tob Control* 2011;20:34–9. doi:10.1136/tc.2009.034132

19 Martínez-Sánchez JM, Fu M, Gallus S, *et al.* [Variability in cigarette consumption according to the data source in Spain (1993-2009)]. *Gac Sanit* 2013;27:61–3. doi:10.1016/j.gaceta.2012.05.003

20 Kim HJ, Fay MP, Feuer EJ, *et al.* Permutation tests for joinpoint regression with applications to cancer rates. *Stat Med* 2000;19:335–51 (erratum in *Stat Med*. 2001;20:655). doi:10.1002/(SICI)1097-0258(20000215)19:3<335::AID-SIM336>3.0.CO;2-Z

21 Clèries R, Martínez JM, Moreno V, *et al.* Predicting the change in breast cancer deaths in Spain by 2019: a Bayesian approach. *Epidemiology* 2013;24:454–60. doi:10.1097/EDE.0b013e31828b0866

22 Connolly GN, Alpert HR. Trends in the use of cigarettes and other tobacco products, 2000-2007. *JAMA* 2008;299:2629–30. doi:10.1001/jama.299.22.2629

23 Young D, Yong H-H, Borland R, *et al.* Trends in roll-your-own smoking: findings from the ITC Four-Country Survey (2002-2008). *J Environ Public Health* 2012;2012:406283. doi:10.1155/2012/406283

24 Gallus S, Lugo A, Colombo P, *et al.* Smoking prevalence in Italy 2011 and 2012, with a focus on hand-rolled cigarettes. *Prev Med* 2013;56:314–8. doi:10.1016/j.ypmed.2013.02.009

25 Raisamo SU. Trends in roll-your-own tobacco use among adolescents in Finland, 1981-2009. *Prev Med* 2011;53:431–2. doi:10.1016/j.ypmed.2011.09.004

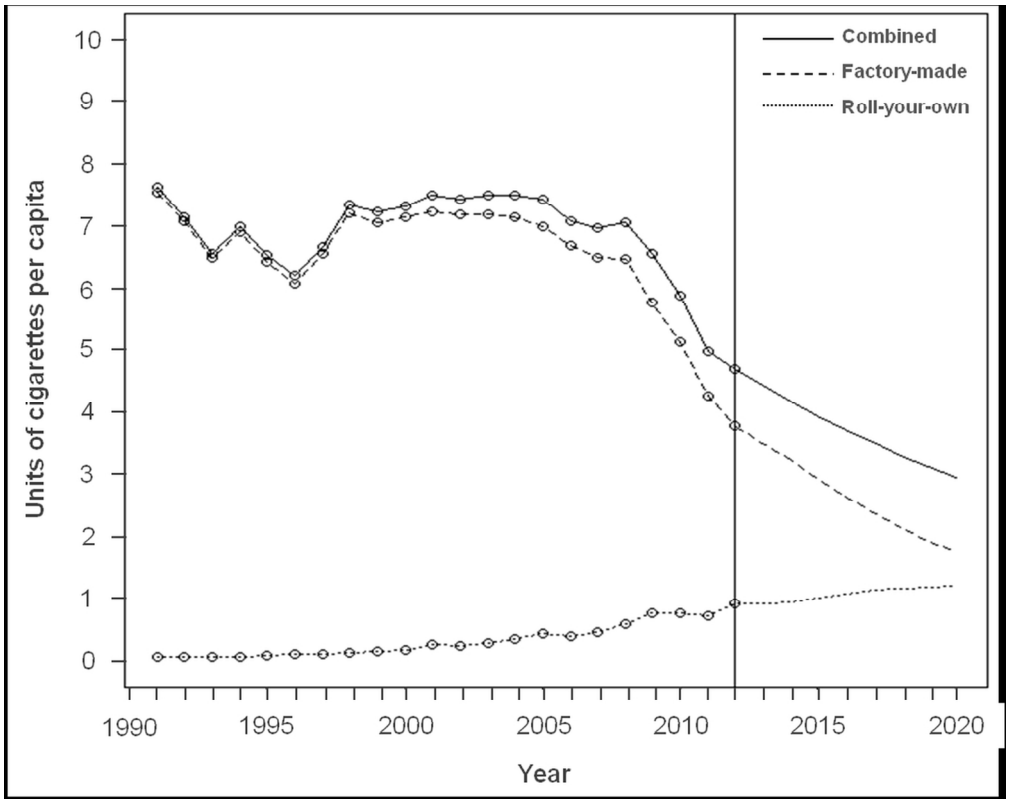
26 Wilson N, Young D, Weerasekera D, *et al.* The importance of tobacco prices to roll-your-own (RYO) smokers (national survey data): higher tax needed on RYO. *New Zeal Med J* 2009;122:92–6.

27 Joossens L, Raw M. Progress in combating cigarette smuggling: controlling the supply chain. *Tob Control* 2008;17:399-404. doi: 10.1136/tc.2008.026567

28 Joossens L, Lugo A, La Vecchia C, *et al*. Illicit cigarettes and hand-rolled tobacco in 18 European countries: a cross-sectional survey. *Tob Control* 2014;23:e17-23. doi:10.1136/tobaccocontrol-2012-050644.

29 Gallus S, Lugo A, Ghislandi S, *et al.* Roll-your-own cigarettes in Europe: use, weight and implications for fiscal policies. *Eur J Cancer Prev* 2014;23:186–92. doi:10.1097/CEJ.0000000000000010

30. Bilal U, Fernández E, Beltran P, *et al*. Validation of a method for reconstructing historical rates of smoking prevalence. *Am J Epidemiol* 2014;179:15-9. doi: 10.1093/aje/kwt224



113x90mm (300 x 300 DPI)

OPPOSITE TRENDS IN THE CONSUMPTION OF MANUFACTURED AND ROLL-YOUR-OWN CIGARETTES IN SPAIN (1991-2020)

Marcela Fu[1,2,3], Jose M Martínez-Sánchez[1,2,4,5], Ramon Clèries[2,3,6], Joan R Villalbí[7,8,9], Richard A Daynard[5], Gregory N Connolly[10], and Esteve Fernández[1,2,3]

1 Tobacco Control Unit, Cancer Prevention and Control Programme, Catalan Institute of Oncology-ICO, L'Hospitalet de Llobregat, Spain
2 Cancer Control and Prevention Group, Bellvitge Biomedical Research Institute-IDIBELL, L'Hospitalet de Llobregat, Spain
3 Department of Clinical Sciences, School of Medicine, Universitat de Barcelona, Barcelona, Spain
4 Biostatistics Unit, Department of Basic Sciences, Universitat Internacional de Catalunya, Sant Cugat del Vallès, Spain
5 Public Health Advocacy Institute, Northeastern University, Boston, MA, USA
6 Cancer Registry of Catalonia, Plan for Oncology of the Catalan Government, L'Hospitalet de Llobregat, Spain
7 Public Health Agency of Barcelona, Barcelona, Spain
8 Biomedical Research Networking Centre of Public Health and Epidemiology-CIBERESP, Spain
9 Biomedical Research Institute Sant Pau, Barcelona, Spain
10 Department of Social and Behavioral Sciences, Center for Global Tobacco Control, Harvard School of Public Health, Boston, MA, USA

Keywords: tobacco products; rolling tobacco; RYO cigarettes; legal sales; sales projections

Word count: 2041 words

Corresponding author
Jose M Martínez-Sánchez
Permanent address:
Tobacco Control Unit, Institut Català d'Oncologia
Av. Granvia de L'Hospitalet, 199-203
08908 L'Hospitalet de Llobregat, Barcelona, Spain
Tel.: (+34) 932607357; Fax: (+34) 932607956
E-mail: jmmartinez@iconcologia.net

ABSTRACT

Objective: The aim of this study is to describe trends in the consumption of manufactured and roll-your-own cigarettes between 1991 and 2012 in Spain, and to project these trends up to 2020.

Methods: We estimated daily consumption per capita during 1991-2012 using data on sales of manufactured cigarettes (20-packs) and rolling tobacco (kg) from the Tobacco Market Commission, and using data of the Spanish adult population from the National Statistics Institute. We considered different weights (0.5, 0.8, 1g) to compute the number of rolled cigarettes per capita. We computed the annual percent of change and assessed possible changes in trends using joinpoint regression, and projected the consumption up to 2020 using Bayesian methods.

Results: Daily consumption per capita of manufactured cigarettes decreased on average 3.03% per year in 1991-2012, from 7.6 to 3.8 units, with 3 trend changes. However, daily consumption per capita of roll-your-own cigarettes increased on average 14.08% per year, from 0.07 to 0.92 units of 0.5g, with unchanged trends. Together, daily consumption per capita decreased between 2.90% and 2.54%, depending on the weight of the roll-your-own cigarettes. Projections up to 2020 indicate a decrease of manufactured cigarettes (1.75 units per capita) but an increase of roll-your-own cigarettes (1.25 units per capita).

Conclusions: Whilst the consumption per capita of manufactured cigarettes has decreased in the last years in Spain, the consumption of roll-your-own cigarettes has increased at an annual rate around 14% over the last years. Whereas a net decrease in cigarette consumption is expected in the future, use of roll-your-own cigarettes will continue to increase.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- Our study allowed providing an estimation of tobacco sales (and tobacco consumption) at a national level, and, more importantly, allowed us to compare the consumption of manufactured and roll-your-own cigarettes.
- We estimated the cigarette consumption per capita by means of the information available on product sales. This information provides a crude estimation of the population's consumption.
- The proportion of roll-your-own cigarettes from overall cigarettes per capita increased from 0.9% in 1991 to 19.6% in 2012.
- Projections indicate 36% increasing trend of roll-your-own cigarette consumption per capita by 2020, representing 41.6% of overall cigarettes per capita by that year. These projections put into evidence the need of developing urgent measures in order to prevent and control the spread of roll-your-own cigarettes and other alternative forms of tobacco products, especially in vulnerable populations.

INTRODUCTION

Smoking is the leading cause of preventable morbidity and premature mortality worldwide.[1] As a consequence of the increasing awareness by the population of the harmful effects of smoking and the tobacco control policies promoted by the WHO Framework Convention on Tobacco Control,[2] a decrease in cigarette consumption has been observed in many developed countries in the last years. In Western Europe, cigarette consumption dropped by 26% between 1990 and 2009.[3] Nevertheless, the use of forms of tobacco other than conventional cigarettes is becoming widespread, because of their lower regulation and prices.[4]

Although a decreasing conventional manufactured cigarette smoking has been also described in adolescents,[5,6] concurrent use of multiple tobacco products is becoming prevalent among young populations.[7] In this sense, the use of rolling tobacco, or roll-your-own cigarettes, is increasing in many countries,[8] in part because of the widespread belief of minimal hazardous health effects.[9] Evidence does not support this belief; on the contrary, rolling tobacco yields higher nicotine, tar and carbon monoxide levels than manufactured cigarettes.[10–12]

As in other countries, the economic crisis during the last years in Spain seems to have lead to an increase in the consumption of other tobacco products subject to lower taxes and thus being cheaper for smokers.[13] The aim of this study is to describe trends in the consumption of manufactured and roll-your-own cigarettes between 1991 and 2012 in Spain, and to project these trends up to 2020.

METHODS

We used the official Spanish data on annual legal sales of tobacco products from the Tobacco Market Commission.[14] The Commission collects information on tobacco product sales to smokers from tobacconists'. We included data from the Iberian Peninsula & the Balearic Islands and excluded data from Ceuta & Melilla, reported only from 2009, because of the different taxation in these territories. We considered annual data on manufactured cigarettes and rolling tobacco from 1991, when this latter was first included in the registries, up to 2012. Information on manufactured cigarettes was first reported in million packs of cigarettes and then in packs of 20 cigarettes. For rolling tobacco, nevertheless, there has been some variability in the way the statement has been made. It was first expressed in millions of packages (from 1991 to 1998), then in millions of bags (from 1999 to 2000), then in millions of bags or cans (from 2001 to 2008), and finally in kg of product (from 2008 up to now). We assumed that one pack/bag/can of rolling tobacco weighs 50g, on the basis of the available data in 2008, when the information on sales was available in both bags/cans and in kilograms.[15,16] We estimated this figure by dividing the total grams sold in 2008 by all the bags/cans sold that same year, resulting in 46.85g. Using the rounded figure of 50g per unit of pack/bag/can, we were able to estimate the sales of rolling tobacco in kg of product for all the studied period.

We also collected data from the National Statistics Institute of the Spanish population ≥16 years old for the period 1991-2012, using the population censuses and the official inter-censuses data (available up to 2012).[17] This information allowed us to estimate the average number of manufactured and roll-your-own cigarettes per year and person.[18,19] Since this

information is aggregated data and it does not contain data on individuals, ethical approval was not required.

Because the amount of tobacco included in a unit of roll-your-own cigarette is variable as it depends on the way the smoker makes the roll,[12] we considered three possible weights to estimate the number of cigarettes: 0.5g, 0.8g, and 1g of tobacco. For each option, we calculated the annual percent of change (APC) of the number of cigarettes per person and year for manufactured cigarettes, roll-your-own cigarettes, and both type of cigarettes taken together.

In order to assess changing trends during 1991-2012, we used joinpoint regression. According to the procedure developed by Kim el al.,[20] and based on the shape of the time trend of the daily cigarette consumption per capita, we assumed a maximum number of 4 joinpoints. To predict trends, we fitted an autoregressive Bayesian log-linear Poisson model to the observed data in 1991-2012. This model allows better predictions in situations where other models may fail[20] and gives more weight to data from recent periods, especially when changing trends arise through the study period.[21] In this line, the temporal trend was modelled through a random walk (RW). We assessed the performance of the model comparing a RW of order 1, which assumes constant rate of changes, with a RW of order 2, which is a moving average that changes in time and allows for smoothing of the trend.[21] We found that model with RW of order 2 showed less variability in the within sample prediction of the observed cigarettes per capita in 1991-2012, and then the RW of order 2 assumption was used. Once the model was fitted, we predicted the cigarette consumption for the period 2013-2020, based on the time trend estimated with this Bayesian model.

RESULTS

Daily consumption per capita of manufactured cigarettes decreased from 7.6 units in 1991 to 3.8 units in 2012, with an average APC of –3.03% (Figure 1). Daily consumption per capita of roll-your-own cigarettes in the same period increased according to the scenario considered, from 0.07 to 0.92 units of 0.5g, from 0.04 to 0.58 units of 0.8g, and from 0.03 to 0.46 units of 1g (average APC: 14.08%). This represents an increase in the proportion of roll-you-own cigarettes from 0.9% in 1991 to 19.6% in 2012 of overall cigarettes per capita, considering rolled units of 0.5g (from 0.5% to 13.3% and from 0.4% to 10.8% considering roll-your-own cigarettes of 0.8g and 1g, respectively). Overall, daily consumption per capita (manufactured plus roll-your-own cigarettes) decreased from 7.6 to 4.7 units (average APC: –2.09%), from 7.6 to 4.4 units (average APC: –2.42%), and from 7.6 to 4.2 units (average APC: –2.54%), depending on the weight of the roll-your-own cigarettes considered.

Joinpoint analyses (Table 1) indicated a decrease in the consumption of manufactured cigarettes at the beginning of the period (1991-1996), then a period of non-significant rising during 1997-2001, and then a significant downward trend in 2002-2008, that accelerated afterwards in 2009-2012 (APC of –12.6). When we considered only roll-your-own cigarettes, we observed a continuous significant increasing trend of 14.1% for the whole study period (1991-2012).

Table 1 Joinpoint analyses of daily cigarette consumption per capita by adult population ≥16 years old in Spain (manufactured cigarettes, roll-your-own cigarettes and both type of cigarettes) over the period 1991-2012 and the corresponding annual percent of change (and their 95% confidence intervals).

	Trend 1	Trend 2	Trend 3	Trend 4
Period	1991-1996	1997-2001	2002-2008	2009-2012
Manufactured cigarettes	–2.9 (–5.3, –0.6)*	3.3 (–0.2, 6.9)	–1.9 (–3.7, –0.1)*	–12.6 (–16.2, –8.9)*
Period	1991-1996	1997-2001	2002-2008	2009-2012
Combined cigarettes	–2.8 (–5.3, –0.3)*	3.6 (–0.1, 7.3)	–1.1 (–2.9, 0.8)	–9.8 (–13.4, –6.8)*
Period	1991-2012	-	-	-
Roll-your-own cigarettes	14.1 (13.1, 15.2)*	-	-	-

*Statistically significant (p<0.05).

Figure 1 shows the trends in daily consumption of units of manufactured and roll-your-own cigarettes, as well as the projections up to 2020. For that year, differences between the consumption of both types of cigarettes taking together (solid line) and the consumption of manufactured cigarettes only (dashed line) reach 36 percent increase comparing to that observed at the end of the observed period in 2012. By 2020, projections indicate a daily consumption per capita of 1.75 units of manufactured cigarettes and 1.25 units of roll-your-own cigarettes, this latter representing 41.6% of overall cigarettes per capita projected by that year.

DISCUSSION

Besides a decrease in daily consumption per capita of manufactured cigarettes, we observed an increase in the consumption of roll-your-own cigarettes, thus indicating a shift from one to another. We found an increasing contribution of the roll-your-own cigarettes to the overall cigarette consumption per capita during 1991-2012. These changes have to be taken into account in future tobacco control policies. They represented 0.9% in 1991 and 19.6% in 2012 of overall cigarettes per capita, when considering roll-your-own units of 0.5g. This trend has

also been observed in other developed countries,[22–24] including younger populations.[25] Although the global trend of daily use of cigarettes per capita is decreasing, the increasing trend of use of roll-your-own cigarettes is very concerning, and our projections indicate that it will continue in the future at higher rate, with an estimated proportion of 41.7% of overall cigarettes per capita by 2020.

Article 6 of the FCTC urges the parties to adopt price and tax measures to all tobacco products.[2] In Spain, several tax reforms have accompanied the implementation of more restrictive tobacco regulations, but they have been mainly applied to manufactured cigarettes. In recent years, the prices of these products have been remarkably different, with rolling tobacco costing about 50% less than manufactured cigarettes until 2009, when a small tax was introduced. This fact has contributed to an increase of the market share of rolling tobacco, from 1.6 to 5.1% of sales from 2005 to 2011.[13]

The decrease in sales of manufactured cigarettes is possibly in part a collateral effect of the Spanish smoke-free legislation of 2010, reflecting less smoking by adult smokers. The current economic crisis could also have contributed to make some smokers shift from manufactured to roll-your-own cigarettes, especially younger smokers. This shift should be explored in depth in order to develop prevention strategies, especially among young people. A New Zealand study found that the reasons referred by smokers for this shift are, in order of importance, that roll-your-own cigarettes are cheaper, taste better, are more satisfying, reduce the amount smoked, and have less harmful effects.[26] With more detailed knowledge of this shift by population strata, more appropriate strategies may be planned to tackle rolling tobacco consumption and encourage cessation; among them, awareness campaigns and better

information to the population on the health effects of rolling tobacco, with an emphasis in youth and socio-economic deprived areas.

Some limitations of our investigation deserve consideration. First, we estimated the cigarette consumption per capita by means of the information available on product sales. This information provides a crude estimation of the population's consumption, as they do not distinguish between sales to the Spanish population and tourists, a common situation especially in the nation's border and coastal provinces. On the other hand, official sales do not include smuggling and therefore a variable portion of the consumption is not being considered. However, smuggling had hugely decreased in the last decades[27] and in a European survey conducted in 2010 only 3.4% of Spanish smokers self-reported purchase from illicit source.[28] Second, information on tobacco sales is heterogeneous. In the case of manufactured cigarettes, sales were registered in "packs" the first years (until 2005, packs of 10 and 19 cigarettes existed, although they represented a very small portion of the volume share). The available information on rolling tobacco is more heterogeneous, because the registries on sales during the first years included units of product and no specification on their weights were provided. Fortunately, information on units of product and the corresponding kilograms were available for the year 2008, allowing us to obtain some estimations. Third, the amount of tobacco in a roll-your-own cigarette is variable and this contributes to an imprecise estimation of the number of cigarettes. Some reports have used conversion factors between 0.6 and 0.9 g per cigarette,[5,13,22,24] and according to the Pricing Policy And Control of Tobacco in Europe (PPACTE) project in 2010, median weight of roll-your-own cigarettes ranged between 0.48 and 1.15.[29] In our study, we used 3 different options (0.5, 0.8, and 1g). Fourth, pipe tobacco can be also used to make roll-your-own cigarettes, so their unitary estimations may be slightly underestimated, although less than 1% of the Spanish population

smoked pipes.[30] Despite this, our analysis allowed providing an estimation of tobacco sales (and tobacco consumption) at a national level, and, more importantly, allowed us to compare the consumption of manufactured and roll-your-own cigarettes. We have used a well-established time-series methodology to assess cigarette consumption over time. The statistical modelling through Bayesian autoregressive assumption appears a useful method to assess the long-run relationship between manufactured and RYO cigarettes. Moreover, the net estimations of manufactured and RYO cigarettes according to the constraints of the Bayesian model were similar to the data observed per each year (data not shown).

In conclusion, although the sales of manufactured cigarettes are decreasing as observed in the last years in Spain, use of rolled-your-own cigarettes are progressively increasing. Rolling tobacco sales will continue increasing in the next years, partly due to a shift in the consumption from manufactured to roll-your-own cigarettes. More attention should be paid to this and other alternative tobacco products, in order to hinder its access especially to young people. More concrete strategies, such as higher taxation and information on their health effects, are key strategies to be developed, with emphasis in specific populations.

Competing interests: None.

Funding: This work was supported by the Instituto de Salud Carlos III, Government of Spain (RTICC RD12/0036/0053) and the Ministry of Universities and Research, Government of Catalonia (grant 2009SGR192).

Contributionship: JMMS and EF conceived the study. MF, RC, and JMMS prepared the database and conducted the analyses. All the authors contributed substantially to the interpretation of the data. MF drafted the first version of the manuscript; all the authors contributed to its subsequent versions and approved the final version. EF is the guarantor.

Data sharing statement: Since the data are provided by official institutions, the authors cannot offer any additional unpublished data.

Ethical approval: This study does not use data of individuals and thus an ethical approval is not required.

REFERENCES

1 World Health Organization. WHO Report on the Global Tobacco Epidemic, 2008: the MPOWER package. Geneva: WHO Press 2008. www.who.int/tobacco/mpower/en/ (accessed August 2014).

2 World Health Organization. WHO Framework Convention in Tobacco Control. Geneva: World Health Organization 2003. http://www.who.int/fctc/text_download/en/index.html (accessed August 2014).

3 Eriksen MP, Mackay JL, Ross H. The Tobacco Atlas. Atlanta, GA.: American Cancer Society, Inc. 2012. www.TobaccoAtlas.org (accessed August 2014).

4 Prignot JJ, Sasco AJ, Poulet E, *et al.* Alternative forms of tobacco use. *Int J Tuberc Lung Dis* 2008;12:718–27.

5 Centers for Disease Control and Prevention. Current tobacco use among middle and high school students—United States, 2011. *Morb Mortal Wkly Rep* 2012;61:581–5.

6 Villalbí JR, Suelves JM, García-Continente X, *et al.* [Changes in smoking prevalence among adolescents in Spain]. *Aten Primaria* 2012;44:36–42. doi:10.1016/j.aprim.2010.12.016

7 U.S. Department of Health and Human Services. Preventing tobacco use among youth and young Adults: A Report of the Surgeon General. Atlanta: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, Office on Smoking and Health; 2012.

8 Young D, Wilson N, Borland R, *et al.* Prevalence, correlates of, and reasons for using roll-your-own tobacco in a high RYO use country: Findings from the ITC New Zealand Survey. *Nicotine Tob Res* 2010;12:1089–98. doi:10.1093/ntr/ntq155

9 O'Connor RJ, McNeill A, Borland R, *et al.* Smokers' beliefs about the relative safety of other tobacco products: findings from the ITC collaboration. *Nicotine Tob Res* 2007;9:1033–42. doi:10.1080/14622200701591583

10 Shahab L, West R, McNeill A. A comparison of exposure to carcinogens among roll-your-own and factory-made cigarette smokers. *Addict Biol* 2009;14:315–20. doi:10.1111/j.1369-1600.2009.00157.x

11 Castaño Calduch T, Hebert Jiménez C, Campo San Segundo MT, *et al.* [Fine-cut tobacco: a priority for public health and consumer advocacy]. *Gac Sanit* 2012;26:267–9. doi:10.1016/j.gaceta.2011.09.010

12 Darrall KG, Figgins JA. Roll-your-own smoke yields: theoretical and practical aspects. *Tob Control* 1998;7:168–75. doi:10.1136/tc.7.2.168

13 López-Nicolás Á, Cobacho MB, Fernández E. The Spanish tobacco tax loopholes and their consequences. *Tob Control* 2013;22:e21–4. doi:10.1136/tobaccocontrol-2011-050344

14 Ministerio de Hacienda y Administraciones Públicas. Comisionado para el Mercado de Tabacos. Tobacco market statistics and indicators. http://www.cmtabacos.es/wwwcmt/paginas/EN/mercadoEstadisticas.tmpl (accessed August 2014).

15 Ministerio de Hacienda y Administraciones Públicas. Comisionado para el Mercado de Tabacos. Tobacco market statistics and indicators. Data on sales of packs of 20 cigarettes and bags/cans of rolling tobacco for 2007-2008. http://www.cmtabacos.es/wwwcmt/verEstadistica.php?a=2008&f=2008_comun-u (accessed August 2014).

16 Ministerio de Hacienda y Administraciones Públicas. Comisionado para el Mercado de Tabacos. Tobacco market statistics and indicators. Data on sales of packs of 20 cigarettes and kilos of rolling tobacco for 2008-2009. http://www.cmtabacos.es/wwwcmt/verEstadistica.php?a=2009&f=2009_comun-u (accessed August 2014).

17 Instituto Nacional de Estadística. Population figures and Demographic Censuses. http://www.ine.es/en/inebmenu/mnu_cifraspob_en.htm (accessed August 2014).

18 Gallus S, Tramacere I, Boffetta P, *et al.* Temporal changes of under-reporting of cigarette consumption in population-based studies. *Tob Control* 2011;20:34–9. doi:10.1136/tc.2009.034132

19 Martínez-Sánchez JM, Fu M, Gallus S, *et al.* [Variability in cigarette consumption according to the data source in Spain (1993-2009)]. *Gac Sanit* 2013;27:61–3. doi:10.1016/j.gaceta.2012.05.003

20 Kim HJ, Fay MP, Feuer EJ, *et al.* Permutation tests for joinpoint regression with applications to cancer rates. *Stat Med* 2000;19:335–51 (erratum in *Stat Med*. 2001;20:655). doi:10.1002/(SICI)1097-0258(20000215)19:3<335::AID-SIM336>3.0.CO;2-Z

21 Clèries R, Martínez JM, Moreno V, *et al.* Predicting the change in breast cancer deaths in Spain by 2019: a Bayesian approach. *Epidemiology* 2013;24:454–60. doi:10.1097/EDE.0b013e31828b0866

22 Connolly GN, Alpert HR. Trends in the use of cigarettes and other tobacco products, 2000-2007. *JAMA* 2008;299:2629–30. doi:10.1001/jama.299.22.2629

23 Young D, Yong H-H, Borland R, *et al.* Trends in roll-your-own smoking: findings from the ITC Four-Country Survey (2002-2008). *J Environ Public Health* 2012;2012:406283. doi:10.1155/2012/406283

24 Gallus S, Lugo A, Colombo P, *et al.* Smoking prevalence in Italy 2011 and 2012, with a focus on hand-rolled cigarettes. *Prev Med* 2013;56:314–8. doi:10.1016/j.ypmed.2013.02.009

25 Raisamo SU. Trends in roll-your-own tobacco use among adolescents in Finland, 1981-2009. *Prev Med* 2011;53:431–2. doi:10.1016/j.ypmed.2011.09.004

26 Wilson N, Young D, Weerasekera D, *et al.* The importance of tobacco prices to roll-your-own (RYO) smokers (national survey data): higher tax needed on RYO. *New Zeal Med J* 2009;122:92–6.

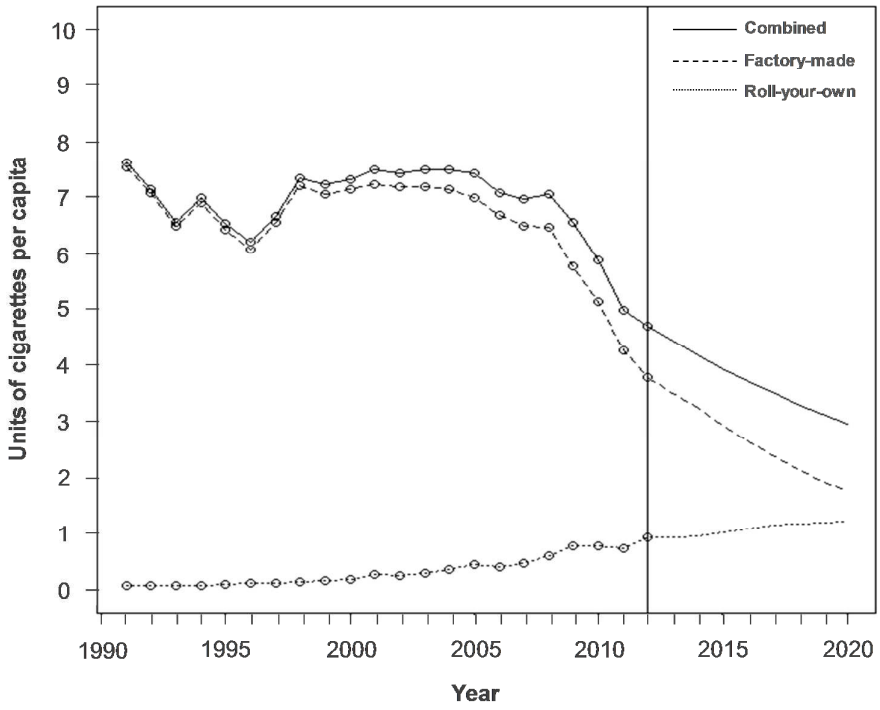
27 Joossens L, Raw M. Progress in combating cigarette smuggling: controlling the supply chain. *Tob Control* 2008;17:399-404. doi: 10.1136/tc.2008.026567

28 Joossens L, Lugo A, La Vecchia C, *et al*. Illicit cigarettes and hand-rolled tobacco in 18 European countries: a cross-sectional survey. *Tob Control* 2014;23:e17-23. doi:10.1136/tobaccocontrol-2012-050644.

29 Gallus S, Lugo A, Ghislandi S, *et al.* Roll-your-own cigarettes in Europe: use, weight and implications for fiscal policies. *Eur J Cancer Prev* 2014;23:186–92. doi:10.1097/CEJ.0000000000000010

30. Bilal U, Fernández E, Beltran P, *et al*. Validation of a method for reconstructing historical rates of smoking prevalence. *Am J Epidemiol* 2014;179:15-9. doi: 10.1093/aje/kwt224

Figure 1 Daily cigarette consumption per capita (units of factory-made and roll-your-own cigarettes) in Spain during 1991-2012 and predictions for the years 2013-2020.



STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of observational *studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	#2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	#2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	#4
Objectives	3	State specific objectives, including any prespecified hypotheses	#4
Methods			
Study design	4	Present key elements of study design early in the paper	#5-6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	#5-6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	#5-6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	#5-6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	#5-6
Bias	9	Describe any efforts to address potential sources of bias	#5-6
Study size	10	Explain how the study size was arrived at	#5-6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	#6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Not applicable
		(*b*) Describe any methods used to examine subgroups and interactions	Not applicable
		(*c*) Explain how missing data were addressed	Not applicable
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	Not applicable
		(*e*) Describe any sensitivity analyses	Not applicable
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Not applicable
		(b) Give reasons for non-participation at each stage	Not applicable
		(c) Consider use of a flow diagram	No diagram included
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	#6-7
		(b) Indicate number of participants with missing data for each variable of interest	Not applicable
Outcome data	15*	Report numbers of outcome events or summary measures	#6-7
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	#6-7
		(*b*) Report category boundaries when continuous variables were categorized	Not applicable
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Not applicable
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Not applicable
Discussion			
Key results	18	Summarise key results with reference to study objectives	#8
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	#9-10
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	#8-10
Generalisability	21	Discuss the generalisability (external validity) of the study results	#9-10
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	#11

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

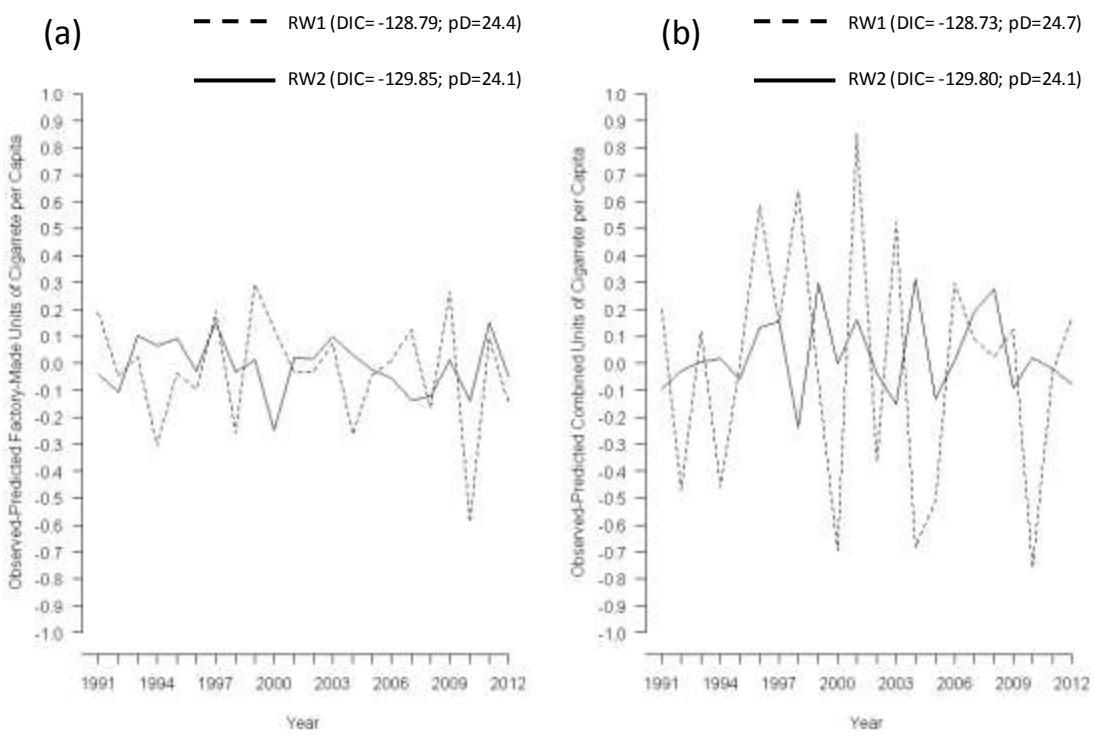
Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

Table S1 Manufactured cigarettes and RYO cigarettes observed and estimated according to the constraints of the Bayesian model.

Year	Observed data			Estimated data*		
	Manufactured cigarettes	RYO cigarettes	% of RYO from overall	Manufactured cigarettes	RYO cigarettes	% of RYO from overall
1991	7.55	0.07	0.88	7.55	0.07	0.88
1992	7.09	0.07	0.95	7.09	0.07	0.95
1993	6.49	0.07	1.09	6.45	0.11	1.68
1994	6.92	0.09	1.27	6.89	0.12	1.71
1995	6.43	0.10	1.54	6.41	0.12	1.84
1996	6.09	0.10	1.64	6.02	0.17	2.75
1997	6.55	0.12	1.81	6.51	0.16	2.40
1998	7.22	0.13	1.76	7.21	0.14	1.90
1999	7.07	0.16	2.15	7.01	0.22	3.04
2000	7.14	0.18	2.47	7.09	0.23	3.14
2001	7.23	0.26	3.46	7.15	0.34	4.54
2002	7.19	0.25	3.30	7.12	0.32	4.30
2003	7.19	0.29	3.94	7.12	0.36	4.81
2004	7.15	0.36	4.85	7.12	0.31	4.17
2005	6.99	0.44	5.92	6.91	0.52	7.00
2006	6.68	0.41	5.80	6.61	0.48	6.77
2007	6.50	0.47	6.80	6.45	0.52	7.46
2008	6.47	0.59	8.38	6.51	0.55	7.79
2009	5.77	0.78	11.87	5.68	0.87	13.28
2010	5.13	0.76	12.98	5.14	0.75	12.73
2011	4.26	0.71	14.35	4.27	0.70	14.08
2012	3.78	0.92	19.62	3.71	0.99	21.06

*Expected figures estimated through simulation from RW2 model fit.

Figure S1 Differences between observed and model predicted units of cigarettes per capita: (a) Factory Made; (b) Combined.



RW1: Random Walk 1 prior assumption; **RW2:** Random Walk 2 prior assumption;
DIC: Deviance Information Criterion; **pD:** effective number of parameters estimated through the model.