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Alcohol, tobacco and health care costs: a population-wide cohort study (*n* = 606 947 patients) of current drinkers based on medical and administrative health records from Catalonia

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Background: Most cost of illness studies are based on models where information on exposure is combined with risk information from meta-analyses, and the resulting attributable fractions are applied to the number of cases. **Methods:** This study presents data on alcohol and tobacco use for 2011 and 2012 obtained from a routine medical practice in Catalonia of 606 947 patients, 18 years of age and older, as compared with health care costs for 2013 (all costs from the public health care system: primary health care visits, hospital admissions, laboratory and medical tests, outpatient visits to specialists, emergency department visits and pharmacy expenses). Quasi-Poisson regressions were used to assess the association between alcohol consumption and smoking status and health care costs (adjusted for age and socio-economic status). **Results:** Resulting health care costs per person per year amounted to 1290 Euros in 2013, and were 20.1% higher for men than for women. Sex, alcohol consumption, tobacco use and socio-economic status were all associated with health care costs. In particular, alcohol consumption had a positive dose–response association with health care costs. Similarly, both smokers and former smokers had higher health care costs than did people who never smoked. **Conclusions:** Alcohol and tobacco use had modest and large impacts respectively on health care costs, confirming the results of previous ecological modelling analyses. Reductions of alcohol consumption and smoking through public policies and via early identification and brief interventions would likely be associated with reductions in health care costs.

Introduction

Alcohol and tobacco use are major contributors to the burden of disease.[1] Indeed, the use of alcohol and tobacco is estimated to have caused more than 9 million deaths globally in 2015, and more than 250 million disability-adjusted life years lost (assuming no overlap).[1] Furthermore, the resulting social costs attributable to alcohol and tobacco are substantial: for the European Union, the social costs resulting from alcohol and tobacco use in 2010 exceeded 200 billion Euros (€).[2] Alcohol and tobacco health care costs represent between 9–24 and 15%, respectively of all social costs of these substances.[3,4]

Tobacco smoking was found to be the first cause of premature death in the United Kingdom, and a primary source of preventable health care costs to the National Health Service of the UK, estimated to be between £2.7 billion and £5.2 billion per year in the last decade and representing 5% of the total National Health Service budget.[4] In the case of alcohol,[5] 33 billion € were spent in Europe in 2010 to treat alcohol-attributable diseases.[6] This estimate does not take into account the costs of specialized care required for treating alcohol use disorders.

Cost-of-illness studies have been carried out to estimate the social costs of alcohol and tobacco to define the impact of their use on welfare. These type of studies are very valuable for establishing public health plans and evaluating cost-effective interventions to prevent alcohol and tobacco consumption and the resulting consequences. However, it would be preferable to base health decisions on studies using real data from large samples. A number of international modelling efforts using the cost-of-illness methodology have been performed within Europe;[2] for an explanation of the cost-of-illness methodology see.[7,8] These estimates are problematic for two reasons: first, they are based on ecological models, which are based, in turn, on general population prevalence and risk relations derived

from meta-analyses;[9] (for tobacco;[10] for alcohol[11]). Moreover, average case costs are used, assuming that each outcome will result in the same health service utilization, even though substance use impacts both on co-morbidities and on health care utilization patterns, albeit not always in the same direction. Thus, although in general most models concluded that smoking results in higher health care utilization, there are some conflicting findings in the literature.[10,12] For alcohol consumption, the health services utilization for people with problem drinking patterns or alcohol use disorders seems clear,[13,14] but there are questions which remain concerning the health care utilization of drinkers not qualifying for this diagnosis.[15,16]

In this study, we tried to overcome the limitations of the cost-of-illness studies by using real data from a large cohort of primary health care patients in Catalonia who are current drinkers, and whose use of alcohol and tobacco is systematically collected through an electronic medical record which can be linked to economic data (use of health services and costs incurred) gathered by the Catalan government.

Accordingly, the aim of this study was to assess if the amounts of alcohol consumed per day by a population of current drinkers who were primary health care patients and this population's smoking status were associated with health care services costs. Abstainers were not considered in the analysis as they might be a very heterogeneous group.

Methods

Study design

A cohort study was conducted based on medical and administrative health records (Clinicaltrials.gov: NCT02343874).

Setting and participants

Patients 18 years of age and older who attended at a primary health care centre provided by the Catalan Health Institute (CHI), and who had their alcohol and tobacco consumption registered in an electronic medical record in 2011 and/or 2012, were included in the study (n = 1 883 047).

Procedure

General practitioners (GPs) registered alcohol consumption using an application installed in the electronic medical record. This programme, which is based on the SIAC instrument (Systematic Interview of Alcohol Consumption),[17] recorded the information in two ways: quantitatively and categorically (Supplementary table S1). The total amount of alcohol consumed in a week was recorded in standard units per week; in Spain, a standard unit was equivalent to 10 g of pure alcohol. GPs also could determine a patient's pattern of alcohol consumption, namely, abstainer, low-risk drinker or risky drinker (Supplementary table S1). When inconsistencies were observed between the two principal variables, the most conservative scenario was considered. With respect to smoking, patients were classified by their GP as smoker, non-smoker or former smoker.

Socio-demographic, clinical and costs information was obtained from two different registries: the Information System for the Development of Research in Primary Care (SIDIAP) and the Central Register of Morbidity provided by the Catalan Health Service. SIDIAP is a database of anonymized patients that contains information respecting almost 80% of the Catalan population, which represents 10.2% of the Spanish population. This database, derived from data collected at the CHI, provided information on alcohol, tobacco, sick leave costs, laboratory test costs and medical test costs. The Catalonia Health Department database of morbidity, which gathers information from the Minimum Basic Dataset for Healthcare Units registry and pharmacy registry, provided the remainder of the information. After authorization has been obtained from external data custodians, CHI acts as a trusted third part to handle the linkage deterministically using the unique personal identification number in a controlled environment. Finally, linked data is anonymized to be incorporated into the research project database.

At baseline (December 31, 2012), information was obtained on sex, age, socio-economic level (the latter calculated as an ecological variable related to a basic health area and not at an individual level; see Supplementary table S2) and morbidity (patients' diagnoses following the International Statistical Classification of Diseases, 9th revision, clinical modification—ICD-9-CM)).[18]

Health costs for 2013 provided by the public health care system during 2013 were analysed (see Supplementary figure S1). Data on hospitalizations were calculated using three indicators: costs, number of admissions and number of hospitalization days. Three types of hospitals were included: general (acute) hospitals, skilled nursing facilities and psychiatric hospitals. Furthermore, information on medication expenses and sick-leave costs were included. Costs of visits to GPs, nurses or social workers, as well as costs of medical tests, can be found in Supplementary table S3. Admissions to nursing facilities and to psychiatric hospitals have a standard price per day (long-term 50.22 €/d and convalescence 86.91 €/d, acute admissions 183.31 €/d and sub-acute admissions 115.35 €/d, respectively). Acute hospital admissions costs are calculated taking into account the patient's diagnosis and the type of hospital where the patient was admitted (Supplementary table S3).[40]

The observational research studies using SIDIAP data were approved by a local ethics committee (Clinical Research Ethics Committee of the IDIAP Jordi Gol i Gurina), code number P14/004. The study protocol was also approved by the ethics committee of Hospital Clínic de Barcelona (register number 2013/873). Patients' consent was not required because all data used were anonymized. Finally, the confidentiality of medical records was respected in accordance with Spanish Law (LOPD 15/1999).

Statistical analysis

Descriptive analyses of socio-demographic, clinical and economic data were presented in terms of means, percentages and 95% CIs. In order to analyse the relationship between the amount of alcohol consumed by the sample per week and the health care costs, we analysed data of those patients who reported drinking alcohol, as the number of abstainers reported in SIDIAP data (67.8%) was higher than that reported in general population surveys,[3,19] which may indicate an oversampling of abstainers or that the alcohol consumption of these patients was not measured. Individuals registered as abstainers may represent a very heterogeneos group (lifetime abstainers, former drinkers or poorly named drinkers), and for that reason were not included in the analysis. The associations between the dependent variables of interest (namely, total costs excluding sick leaves and total costs including sick leaves) and the independent variables of interest (namely, age, socio-economic status, alcohol consumption and tobacco smoking) were performed using a quasi-Poisson regression model. The analysis of costs which included sick leaves was restricted to the population under 65 years of age. The distribution of total costs excluding sick leaves and total costs including sick leaves (i.e. quasi-Poisson) was determined through visual inspection of histograms and through comparing histograms of the residuals for quasi-Poisson and negative binomial general linear regression models. Furthermore, the Anderson-Darling test of normality returned P-values below 0.0001, and, thus, the data were unlikely to be normally distributed. In the quasi-Poisson regression equations, smoking of tobacco was modelled using separate indicators for former smokers and smokers (compared with lifetime non-smokers). Alcohol consumption was modelled as a continuous untransformed variable (grams/day). Functional forms were determined via exploratory local area regressions (distance

weighted approaches).[20] Final regression models were adjusted for age (in years) and for socio-economic status (the latter using four dummy variables with one reference category as the measurement was not interval scaled). All models were stratified by sex, after interactions between sex and all other variables (for alcohol consumption) were found to be significant through a likelihood ratio test (using a Gaussian distribution as quasi-Poisson regressions do not produce likelihoods). The results of the quasi-Poisson regression models were also used to predict the health care costs given the age, sex, socio-economic status, alcohol consumption and smoking status characteristics of an individual. Data were analysed using the statistical software package R.

Results

A total of 1 883 047 adults who attended at primary health care centres provided by the CHI had their alcohol consumption and smoking status registered in the electronic medical record (54.3% were women, on average 55.8 years old, 41.4% had a moderate socio-economic level and 20.2% and 17.7% were current and former cigarette smokers, respectively). Due to the high percentage of abstainers (67.8%) we analysed adults who reported consuming alcohol: 606, 947. Of those who reported consuming alcohol, 32.1% were women while 67.9% were men, with an average age of 54.5 years. Furthemore, for those who reported consuming alcohol, 10.5% were risky drinkers (consuming at or above 170 and 280 g of alcohol per week for women and men, respectively), 29.5% were current smokers, and 23.0% were former smokers. Male drinkers consumed, on average, more than twice as much alcohol as did female drinkers (19.5 vs. 9.4 g of pure alcohol per day), and had higher rates of current and former smoking (22.4 and 127.1% higher, respectively). Detailed socio-demographic data are described in table 1.

Annual health care costs in 2013 amounted to 1283 € per person. Among people with health care utilization in 2013, men incurred 23.2% higher health care costs than did women. When the costs of sick leave (an average of 1529 € per person per year) were included in the cost estimates, the relative difference in costs incurred between men and women was slightly lower (about 15.5% higher in men) (table 1).

Health care costs were associated with age, socio-economic status, alcohol and tobacco use when payments for sick leave were both included and excluded. Costs were positively associated with age, and negatively associated with socio-economic levels (areas) in all regression models.

Alcohol and tobacco were significantly associated with health care costs. Alcohol consumption showed a dose–response relationship for both sexes in all four models: the higher the consumption, the higher the health care costs (table 2). Specifically, for men, for a 40 g/d increase in alcohol consumption, health care costs excluding sick leave increased by 2.3% (95% CI: 1.5–3.1%), while health care costs including sick leave increased by 4.3% (95% CI: 3.2–5.3%). For women, for a 40 g/d increase in alcohol consumption, health care costs excluding sick leave increased by 4.2% (95% CI: 1.9–6.5%), while health care costs including sick leave increased by 4.0% (95% CI: 1.1–6.9%). Furthermore, for men, being a current smoker or a former smoker (as compared with a lifetime abstainer) was associated with a 22.5% (95% CI: 20.6–24.4%) and 28.0% (95% IC: 26.3–29.8%) increase in health care costs excluding sick leave respectively; a similar relationship was found when including sick leave costs. Among women, being a current smoker or a former smoker (as compared with a lifetime abstainer) was associated with a 14.7% (95% CI: 12.1–17.3%) and 16.6% (95% CI: 13.7–19.7%) increase in health care costs excluding sick leave, respectively, while being a current smoker or a former smoker (as compared with a lifetime abstainer) was associated with a 23.5% (95% CI: 20.4–26.7%) and 20.2% (95% IC: 16.3–24.2%) increase in health care costs including sick leave, respectively.

Table 1 Socio-demographic, smoking, alcohol consumption and health care cost characteristics for adult drinkers in Catalonia in 2011 and 2012 who had at least one routine medical practice visit[a]

Socio-demographic characteristics	Men (n = 412 382) Point estimate	Women (n = 194 565) Point estimate	Total (n = 606 947) Point estimate
Gender			
Men			67.9%
Women			32.1%
Age (years)			
Average	55.4	52.8	54.5
18–24	4.0%	6.6%	4.9%
25–34	9.7%	12.2%	10.5%
35–44	14.1%	14.1%	14.1%
45–54	17.7%	18.8%	18.1%
55–64	21.0%	20.2%	20.7%
65–74	19.5%	16.1%	18.4%
75–84	11.7%	9.7%	11.1%
85 and older	2.3%	2.3%	2.3%
Socio-economic level (by area)			
1 (Very high)	5.9%	8.1%	6.6%
2 (High)	19.9%	23.2%	21.0%
3 (Moderate)	42.4%	42.1%	42.3%
4 (Low)	20.3%	17.7%	19.4%
5 (Very low)	11.5%	8.9%	10.7%
Health care costs (€/year)			
Average (€/year)	1356	1129	1283
Prevalence of people with no costs	8.7%	6.3%	7.9%
Average (no costs excluded) (€/year)	1485	1206	1394
Health care costs including costs of sick leave (€/year)			
Average (€/year)	1598	1384	1529
Prevalence of people with no costs	8.7%	6.3%	7.9%
Average (no costs excluded) (€/year)	1749	1477	1661
Alcohol use			
Grams of pure alcohol per day among drinkers	19.5	9.4	16.2
Risky drinking[b]	12.8%	5.5%	10.5%
Tobacco use[a]			
Lifetime abstainer	40.6%	62.0%	47.5%
Current smoker	31.4%	25.6%	29.5%
Former smoker	28.0%	12.3%	23.0%

Purchasing power parity (Spain 2013): 0.675 €/USD (OECD 217).
a: Presented data are only for drinkers (alcohol use > 0) and non-missing tobacco use status.
b: Consuming at or above 170 and 280 g of alcohol per week for women and men respectively.

In order to illustrate the impact of smoking and alcohol on health care costs, some illustrative cases are shown in figures 1 and 2: the dose–response relationship for alcohol use is shown for non-smoking and smoking by men and women, respectively, for health care costs excluding (figure 1) and including sick-leave payments (figure 2).

Discussion

In a large, population-based cohort study of n = 606 947 patients in Catalonia, we found that both alcohol use and tobacco use were associated with increased health care costs. For alcohol, there was a dose–response relationship: every increase of consumption increased the health care costs incurred by the public health care system for each patient.

Table 2 Factors associated with health care costs among men and women (determined through a quasi-Poisson regression)

Health care costs						
	Men			**Women**		
Variable	**β estimates[a]**	**Standard error**	***P*-value**	**β estimates[a]**	**SE**	***P*-value**
(Intercept)	5.87	0.03	<0.001	6.03	0.03	<0.001
Alcohol (per 40 g of alcohol per day increase)	0.02	<0.01	<0.001	0.04	0.01	<0.001
Age (years)						
18–24	REF	–	–	REF	–	–
25–34	0.05	0.03	0.123	0.16	0.03	<0.001
35–44	0.33	0.03	<0.001	0.32	0.03	<0.001
45–54	0.70	0.03	<0.001	0.53	0.03	<0.001
55–64	1.11	0.03	<0.001	0.76	0.03	<0.001
65–74	1.47	0.03	<0.001	1.10	0.03	<0.001
75–84	1.79	0.03	<0.001	1.43	0.03	<0.001
85 and older	1.89	0.03	<0.001	1.49	0.03	<0.001
Socio-economic level (by area)						
1 (Very high)	REF	–	–	REF	–	–
2 (High)	0.05	0.01	<0.001	0.12	0.02	<0.001
3 (Moderate)	0.08	0.01	<0.001	0.19	0.02	<0.001
4 (Low)	0.12	0.01	<0.001	0.24	0.02	<0.001
5 (Very low)	0.15	0.02	<0.001	0.31	0.02	<0.001
Tobacco use						
Never smokers	REF	–	–	REF	–	–
Current smokers	0.20	0.01	<0.001	0.14	0.01	<0.001
Former smokers	0.25	0.01	<0.001	0.15	0.01	<0.001
Health care costs including costs of sick leave						
Variables	**Men**			**Women**		
	β estimates[a]	**SE**	***P*-value**	**β estimates[a]**	**SE**	***P*-value**
(Intercept)	6.13	0.03	<0.001	6.27	0.03	<0.001
Alcohol (per 40 g of alcohol per day increase)	0.04	<0.01	<0.001	0.04	0.01	<0.001
Age (years)						
18–24	REF	–	–	REF	–	–
25–34	0.20	0.03	<0.001	0.38	0.03	<0.001
35–44	0.46	0.03	<0.001	0.51	0.03	<0.001
45–54	0.78	0.03	<0.001	0.67	0.03	<0.001
55–64	1.11	0.03	<0.001	0.82	0.03	<0.001
65–74	–	–	–	–	–	–
75–84	–	–	–	–	–	–
85 and older	–	–	–	–	–	–
Socio-economic level (by area)						
1 (Very high)	REF	–	–	REF	–	–
2 (High)	0.01	0.02	<0.001	0.08	0.03	<0.001
3 (Moderate)	0.07	0.02	<0.001	0.13	0.02	<0.001
4 (Low)	0.08	0.02	<0.001	0.17	0.03	<0.001
5 (Very low)	0.08	0.02	<0.001	0.22	0.03	<0.001
Tobacco use						
Never smokers	REF	–	–	REF	–	–
Current smokers	0.26	0.01	<0.001	0.21	0.01	<0.001
Former smokers	0.28	0.01	<0.001	0.18	0.02	<0.001

a: β estimates are on a logarithmic scale.

The current analysis of a large cohort in which alcohol and tobacco consumption data were obtained from medical records and at an individual level confirms the results of previous ecological studies which found that health care costs are associated with alcohol consumption and tobacco use. Although age and socio-economic level highly influence health costs, smoking and drinking also have an impact. Our findings based on real data describe in a very large sample how health care costs are related to age, socio-economic status and tobacco and alcohol use when studied at an individual level. Smoking had a strong effect on health care costs, while alcohol use had a moderate effect. This difference could be due to the fact that only 10.5% of drinking patients were risky drinkers. For alcohol, a linear increase of health care costs was found for both sexes. When excluding sick leave costs, the increase in health care costs due to alcohol consumption is slightly lower in men than in women. Some of the gender differences observed in the relationship between alcohol consumption and health care costs could be due to previously described gender differences in the use of health care services, namely that women are more likely to attend primary health care services.[21]

The limitations of this study are linked to the measurement of alcohol and the population coverage of the sample. First, the sample does not include abstainers as the high proportion of abstainers in the full database may suggest a sample bias, since reimbursement for primary health care services is linked to fulfilling a certain quota of alcohol inquiries. Furthermore, the application used to record this information was recently added to the electronic medical record system, and some health professionals may be reluctant to use it. Additionally, the assessment of both alcohol consumption and smoking are based on self-reporting, and, especially in the case of alcohol, patients tend to underreport their consumption (in national surveys, 25–70% of all alcohol consumed as measured by sales is usually covered by the answers in representative samples—partially due to the sampling frame and non-response,[22,23] and partially due to underreporting.[24,25] Clearly, comparing the average consumption of our sample with *per capita* consumption listed earlier, our sample

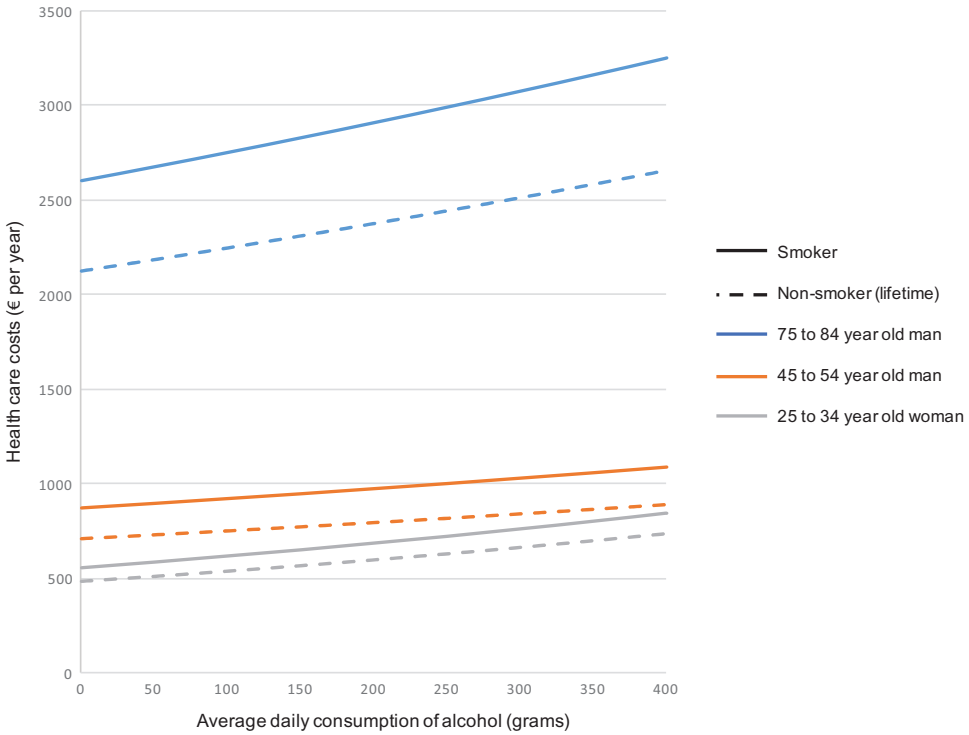

Figure 1 The effects of age, smoking and alcohol consumption on health care costs (excluding costs of sick leave)

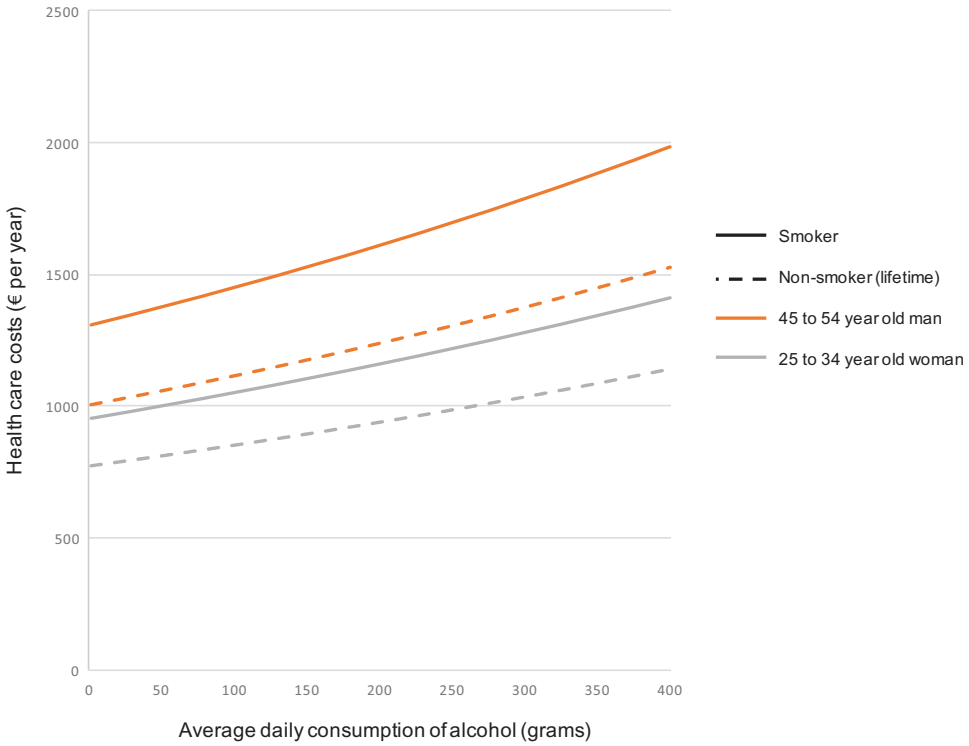

Figure 2 The effects of age, smoking and alcohol consumption on health care costs (including costs of sick leave)

consumed less alcohol, and this difference cannot be fully explained by age alone (primary health care patients are on average older than the population average).[26] The observed bias highlights the barriers that are encountered in the screening of alcohol consumption. Finally, our analysis was restricted to the public health care system, which is universal in Catalonia and financed via taxation. Some of the patients may have additionally sought private treatment (around 25%), which costs were missed in the analysis. Other factors, such as physical activity or dietary habits, that influence health care costs were not included in the study as this information was not gathered systematically in the electronic medical records. Furthermore, as the effect sizes for the increases in costs associated with increased alcohol consumption are relatively small, caution should be used in interpreting the findings of the study due to the

potential biases in the measurement of alcohol consumption and as potential confounding variables were not controlled for in the analyses.

The implications of the findings of this study are clear: increased prevention and treatment efforts will increase the smoking quit rates and reduce the average volume of alcohol consumption, as the lower the consumption levels, the better for health (and the lower the health care costs). Thus, despite some beneficial effects of light drinking, for example for ischaemic diseases and diabetes,[27,28] the effects of increased volumes of alcohol consumption on health care costs were observed even at lower volumes of alcohol use, at drinking levels which are applicable to most of the population.

As there are effective and cost-effective measures to increase quit rates for smoking[10] and to reduce alcohol consumption,[29–31] the challenge is to improve implementation of these interventions. Taxation, and/or a ban on advertisement, of both tobacco and alcohol (as part of the World Health Organization's best buys—see Appendix 3 of)[32,33] are measures implemented at a national level. Depending upon the jurisdiction, other measures, such as tobacco laws, can be implemented at the community or regional levels. Furthermore, health care costs might decrease by increasing early identification and brief interventions and treatment in primary health care facilities;[34,35] Catalonia has initiated steps in this direction, by introducing incentives, changes in medical records, and improved training and support to primary health care professionals to deal with both alcohol and tobacco use by their patients.[36] Improvements in screening and treatment for alcohol abuse and dependence may be slow to achieve as alcohol disorders are screened for in only 10–70% of patients in primary health care settings,[37,38] and screening tools are rarely used.[39]

The increased health care costs associated with both tobacco and alcohol are confirmed by this study that used real data on alcohol, tobacco and the resulting costs at an individual level. The results seem to justify increased preventive efforts via alcohol and tobacco policies (where price, availability and marketing restrictions are well documented and effective options) and the improvement of access to treatment in the form of both brief interventions and specialized therapies.

Supplementary data

Supplementary data are available at *EURPUB* online.

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Key points

- Most studies of the costs of alcohol and tobacco are based on population-level ecological modelling using meta-analytically derived risk relations.
- This study is based on a large representative cohort, and uses individual-level exposures and outcomes and the resulting costs incurred.
- Tackling tobacco smoking and alcohol consumption could markedly reduce health care costs in Catalonia.

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