Ana Maria Carraco Patrão dos Reis

Essays on prevention of diseases related to alcohol and tobacco use

A contribution to a financially sustainable NHS

Tese de doutoramento em Economia, orientada por Prof. Doutor Óscar Lourenço e Prof.ª Doutora Carlota Quintal e apresentada à Faculdade de Economia da Universidade de Coimbra

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Orientadores: Prof. Doutor Óscar Lourenço e Prof.ª Doutora Carlota Quintal

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Abstract

In the current economic context, the stabilisation of public health expenditures is a cause of concern. The prevention of avoidable diseases, and thus the expected reduction of the need and demand for medical services, can be an important tool to achieve the necessary cost saving to sustain health expenditures. Unhealthy lifestyles are the major causes of avoidable diseases worldwide and have become the central focus of the public health. Tobacco and alcohol are listed among the 10 leading risk factors of death and disability in the world. If effective prevention policies are implemented deaths and diseases could be avoided, and health expenditures can be reduced. In Portugal, empirical evidence concerning health risk behaviours is sparse. Therefore, national prevention policies will benefit from new economic analysis on this topic. Moreover, this dissertation gives a contribution to health policy in general and aims to provide important insights to discuss future responses to reduce unhealthy habits.

This study aims to contribute to empirical evidence, supporting prevention policies that focus on unhealthy and addictive behaviours, specifically on tobacco and harmful alcohol use. In more detail, this dissertation has the following main purposes: to identify smoking and drinking determinants; to discuss the more opportune moment to intervene to reduce tobacco consumption, considering the duration of the smoking habit; to analyse interactions between health risk behaviours; to study alcohol addiction's effect.

The data used was extracted from the Portuguese wave of the Survey of Health Ageing and Retirement in Europe (SHARE), in 2011. Econometric models were applied to address the above investigation questions. Parametric and non-parametric duration models were used to analyse smoking life cycle, based on the duration of the smoking habit. In parallel, a conceptual policy framework was developed to discuss the best moment to adopt prevention policies related to tobacco use. A bivariate probit model was used to simultaneously identify the variables that influence the decision to smoke and drink, identifying potential correlations between the error terms of alcohol and

tobacco equations. Addiction's effect on the current alcohol consumption was assessed by using an ordered probit model.

Framed in the conceptual policy framework developed to discuss the best moment to adopt prevention policies, the empirical results revealed policies implemented in the first 25 years of smoking habit are, possibly, more effective on quitting. From the parametric estimates, the results also suggest the need to explore synergies among different areas, such as between health policy and social and education policies, due to the positive impact of unemployment and higher education on smoking duration. Policies could further be differentiated based on gender and marital status. The results also showed the error terms of alcohol and tobacco equations are not correlated, which can reveal different addiction degrees associated with distinct risk behaviours. Age, gender, marital status, education, health status and health-related habits are characteristics that influence the decision to, simultaneously, consume alcohol and tobacco, as well as the decision to smoke among alcohol consumers. Finally, we have found that drinking problems in the past do not discourage current consumption. Past drinking problems have a positive effect on the probabilities of consuming alcohol less than once a month up to six days a week, but reduce the probability of reporting the highest category of consumption.

This dissertation stresses some difficulties in measuring health-related behaviours. There is a lack of clear concepts and of valid instruments to measure these behaviours. Further studies can benefit from health policy discussion on the appropriate measurement techniques and valid instruments.

Keywords: Prevention policies; Risk behaviours; Tobacco; Alcohol; Addiction.

Resumo

No contexto económico atual, a estabilização da despesa pública em saúde é uma das principais problemáticas. A prevenção de doenças evitáveis poderá ser uma ferramenta importante para a diminuição de custos e garantia da sustentabilidade das despesas em saúde. Os estilos de vida pouco saudáveis são a maior causa de doenças evitáveis no mundo, e tornaram-se o foco central da saúde pública, com o tabaco e o álcool a figurarem entre os 10 primeiros fatores de risco para a saúde. Nesse âmbito, políticas de prevenção efetivas contribuirão para a diminuição da prevalência de doenças, e para a redução da necessidade de cuidados de saúde associados, com impacto nas despesas em saúde. Em Portugal, a evidência empírica relacionada com comportamentos de risco para a saúde é escassa, pelo que as políticas de prevenção nacionais irão beneficiar de novas análises económicas neste tópico. Esta dissertação pretende contribuir para a política de saúde em geral, através da disponibilização de informação de apoio à discussão das respostas futuras para redução dos comportamentos de risco.

Esta dissertação tem como objetivo fornecer evidência empírica de suporte a políticas de prevenção, com foco no consumo de tabaco e de álcool, considerando que são ambos bens aditivos e de risco para a saúde. Em concreto, esta dissertação pretende: identificar as determinantes de fumar e beber excessivamente; discutir o momento mais oportuno da intervenção para promover a cessação tabágica, considerando a duração do hábito; analisar interações entre comportamentos de risco para a saúde; estudar o efeito da adição no consumo de álcool.

Os dados utilizados advêm do Survey of Health Ageing and Retirement in Europe (SHARE), recolhidos em Portugal em 2011. Foram aplicados modelos econométricos para responder às questões apresentadas. Para analisar o consumo de tabaco ao longo da vida, foram implementados métodos de duração paramétricos e não paramétricos. Em paralelo, foi desenvolvido um modelo conceptual de política, com o intuito de discutir o melhor momento para adotar políticas de prevenção do tabagismo. Para identificar as variáveis que influenciam simultaneamente o hábito de fumar e beber, e estudar as

potenciais correlações entre os termos de erro das equações do tabaco e do álcool, foi utilizado um modelo probit bivariado. O efeito da adição no consumo corrente de álcool foi analisado com recurso a um modelo probit ordenado.

Tendo por base o modelo conceptual de política, os resultados empíricos revelaram que políticas implementadas nos primeiros 25 anos de duração do hábito de fumar são, provavelmente, mais efetivas na promoção a cessação tabágica. As estimativas paramétricas sugerem o aproveitamento de sinergias entre diferentes áreas de política, designadamente entre a saúde, a educação e a área social, pelo impacto positivo do desemprego e do ensino superior na duração do hábito. Destaca-se ainda a necessidade de intervenções distintas com base no género e no estado civil. Os resultados também denotam existirem diferentes graus de adição associados a comportamentos de risco distintos, pois os termos de erros das equações do tabaco e do álcool não estão correlacionados. A idade, o género, o estado civil, a educação, o estado de saúde e os estilos de vida influenciam simultaneamente o hábito de fumar e beber, bem como a decisão de fumar na subamostra de consumidores de álcool. Por último, problemas relacionados com o consumo excessivo de álcool no passado, classificados neste estudo com adição, não dissuadem o indivíduo de consumir no presente. Com efeito, o consumo problemático no passado impacta positivamente nas probabilidades de consumir álcool menos do que uma vez por mês até seis dias por semana, embora reduzam a probabilidade do indivíduo reportar a categoria mais alta de consumo.

Esta dissertação enfatiza dificuldades em medir os comportamentos de risco para a saúde. Constatou-se existir uma lacuna de conceitos claros e de instrumentos válidos para medir estes comportamentos. Assim, estudos futuros poderão beneficiar da discussão, no contexto da política de saúde, das técnicas e instrumentos de medida apropriados.

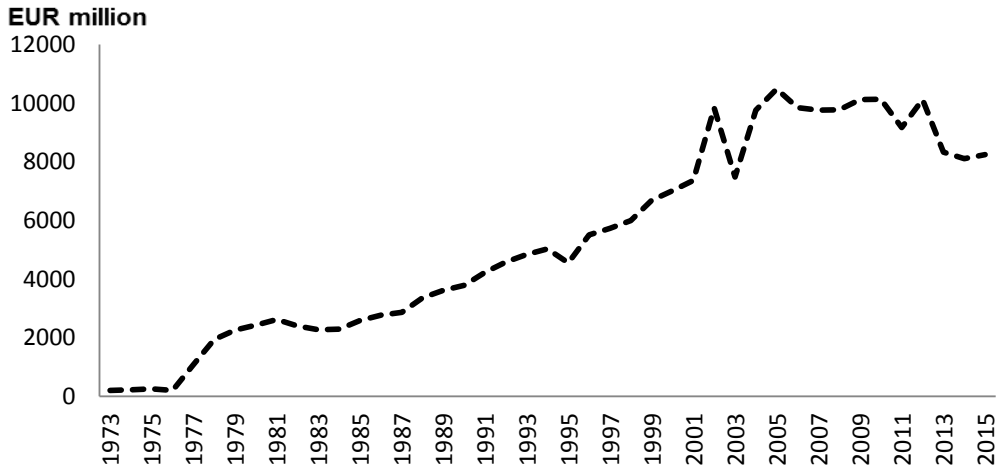
Palavras-chave: Políticas de prevenção; Comportamos de risco; Tabaco; Álcool; Adição.

Contents

1. Introduction

In a context of economic crisis, unsustainable trends in public spending were exposed in many European countries, and particularly in Portugal. The need to stabilise public health expenditures is a cause of concern, in a climate of growing pressure on national budgets. In Portugal, the need to reduce costs gained a major relevance in 2011, with the signature of the Memorandum of Understanding between the Portuguese authorities, the European Commission, the European Central Bank and the International Monetary Fund. Therefore, the Program of the 19th Constitutional Government (21st June 2011 – 30th October 2015) aimed to guarantee, inter alia, the economic and financial sustainability of the National Health Service (NHS) (Presidency of the Council of Ministers of Portugal 2011). This is reflected in the downward trend in public health expenditures, observed between 2012 and 2014, in Portugal (Figure 1). However, the public health expenditures increased slightly in 2015, compared with the previous year.

Figure 1 Public health expenditures in Portugal in constant 2011 prices, using the Consumer Price Index



Source: PORDATA, 2016

The necessary cost saving to promote health expenditures stability can be supported by demand-side interventions, conducting disease prevention measures and thus reducing the need and demand for medical services. In this framework, the adoption

of efficient and effective prevention policies is of fundamental importance, considering both health gain and the reduction of health expenditures. One of the measures to achieve this objective is to intensify integrated programs of health promotion and disease prevention closer to the population (Portuguese Health Regulation Authority 2011).

Prevention can be classified into three categories: primary – implemented before the biological origin of disease –, secondary – applied after the disease can be recognized, but prior to causing suffering and disability – and tertiary – practiced after suffering or disability, preventing further health deterioration (Baumann and Karel 2013; Gordon 1983; Commission on Chronic Illness 1957). It is important to compare the costs and benefits of prevention measures, and carefully choose areas of intervention. The most generally applicable prevention measures – desirable for everybody and for which benefits outweigh costs and risks for everyone – relate to lifestyles, such as maintenance of an adequate diet and smoking cessation (Gordon 1983), and are embedded within primary prevention. Empirical evidence suggests that programs focused on lifestyles seem to reduce mortality (Maciosek et al. 2006) and generate savings in health care costs (U.S. Department of Health and Human Services 2003).

Nowadays, the new public health has been largely focused on diseases that can be linked to unhealthy lifestyles, rather than on controlling contagious diseases (Petersen and Lupton 1996). The predominance of noncommunicable diseases in 2010 highlights the global epidemiological transition that has occurred since 1990 (Lim et al. 2012). The factors contributing to the occurrence of noncommunicable chronic diseases must be identified as well as the instruments that could modify the pathways through which these diseases are generated (Sassi and Hurst 2008). Unhealthy behaviours influence individual and public health, given that they are linked with nearly all of the noncommunicable chronic diseases, as emphasised by the Portuguese Directorate-General of Health (DGS) (DGS 2015). Therefore, public health can be improved and related costs can be reduced if health risk behaviours are discouraged.

According to the World Health Organization (WHO), alcohol consumption and tobacco use are among the major risk factors for premature mortality and remain alarmingly high in the European Region (WHO Regional Office for Europe 2015a). The

Organisation for Economic Co-operation and Development (OECD) also highlights tobacco and alcohol as main non-medical determinants of health (OECD 2015a). Alcohol consumption has been identified as a component cause of more than 200 health conditions covered by ICD-10 disease and injury codes (WHO 2014a). It was estimated that, in 2012, it has contributed to 3.3 million deaths, or 5.9% of all deaths worldwide, (WHO 2014b). Likewise, smoking contributes to about 71% of lung cancer, 42% of chronic respiratory disease and nearly 10% of cardiovascular disease (WHO 2009) and claim more lives than HIV/AIDS, malaria and tuberculosis combined, with around 6 million lives lost (WHO 2015).

The great concern about unhealthy behaviours and related health problems is evidenced in several reports of international organisations, such as the OECD and the WHO (OECD 2015a; WHO 2014b, 2009). In 2014, the 'Global status report on prevention and control of noncommunicable disease' was framed around nine voluntary global targets, included in the global action plan for the prevention and control of non-communicable diseases (WHO 2014b). Tobacco and harmful use of alcohol are among this set of targets to be attained by 2025, to prevent and control noncommunicable diseases (WHO 2014b). In accordance, specific programmes focused on reducing tobacco and excessive alcohol consumption were defined. In what concerns tobacco consumption, the importance of this subject led to the creation in 2008 of the MPOWER, a WHO's project, that identified six evidence-based tobacco control measures that are the most effective in reducing tobacco use (WHO 2013b). One of them was monitoring tobacco use, reinforcing the importance on adopting the adjusted prevention policies (WHO 2013b). On the other hand, the 'Global strategy to reduce the harmful use of alcohol', which contained a set of guiding principles for the development and implementation of alcohol policies, defined priority areas for global action and recommended target areas for national action (WHO 2010a).

In Portugal, the awareness of the importance of prevention policies has remained on the Government agenda. The Program of the 21st Constitutional Government (26th November 2015 –) (Presidency of the Council of Ministers of Portugal 2015) stated the need to promote health through the development of prevention measures focused on

tobacco, alcohol, and other addictive behaviours. The Portuguese National Health Plan 2012-2016, the keystone of health policies in Portugal, advocates the development of an integrated health approach over the life cycle, which should take account of the need for early intervention in the risk factors, to induce health gains and sustainability (Portuguese Ministry of Health 2012).

The WHO Regional Office for Europe provided comments on the Portuguese National Health Plan 2012-2016 (WHO Regional Office for Europe 2015b). In this report, it is also mentioned that noncommunicable diseases are accountable for the majority of deaths and disease burden across the WHO European Region, including Portugal, and many of them are preventable through intervention in the risk factors (WHO Regional Office for Europe 2015b). Following the WHO Regional Office for Europe's suggestions, the Portuguese National Health Plan 2012-2016 was revised and extended to 2020 (Portuguese Ministry of Health 2015). The major health goals to 2020 are to reduce premature mortality, to increase healthy life expectancy at 65 years of age, and to minimise risk factors related to noncommunicable diseases. Therefore, the Portuguese National Health Plan proposes strengthening intersectoral strategies that promote health by minimising risk factors, and one of the guiding principles is focused on prevention and disease control of noncommunicable diseases (Portuguese Ministry of Health 2015). With investment in improved prevention and control of noncommunicable diseases, Portuguese authorities expect to reduce the disease burden, the premature deaths, the morbidity and disability, and to promote active and healthy aging, increasing the quality of life, well-being, social cohesion and productivity of people and communities (Portuguese Ministry of Health 2015).

In sum, the sustainability of health expenditures need to be obtained, and this could be achieved through the adoption of effective and efficient prevention policies. Tobacco and alcohol consumption are listed among the 10 leading risk factors of death and disability in the world and if discouraged deaths and diseases can be avoided, with economic and health gains. The adoption of health policies to reduce health risk behaviours should be assessed empirically *ex-ante*, supporting policymakers' decisions. It is of major relevance understanding the factors that influence the adoption of unhealthy

behaviours, to help in the definition of policy targets and to direct the policy resources more wisely. In Portugal, empirical evidence concerning health risk behaviours is sparse. Therefore, prevention policies will benefit from new economic analysis on this topic. Moreover, this dissertation gives a contribution to health policy in general and aims to provide important insights to discuss future responses to reduce unhealthy habits.

With this work we aim to contribute with empirical evidence to support prevention policies in what concerns tobacco and alcohol consumption, taking into account its nature of unhealthy and addictive behaviours. We used data extracted from the Survey of Health Ageing and Retirement in Europe (SHARE)[1], including Portuguese adults, in 2011. More specifically, this dissertation has the following main purposes: to identify the factors that influence the consumption of alcohol and tobacco; theoretically and empirically discuss the more opportune moment to intervene to reduce tobacco consumption, considering the duration of the smoking habit; to analyse the interaction between alcohol and tobacco use; to study addiction's effect in current alcohol consumption. A more detailed description on each of these objectives is given below.

We have structured this dissertation in five main parts. This chapter contains a brief introduction of the topics discussed. The second chapter covers empirical evidence related to the prevalence of smoking habit. A description of tobacco consumption's scenario, in Portugal, is provided using a logit model to identify the variables that influence smoking probability. Taking into account that negative health consequences also depends on habit's duration, we develop a theoretical policy framework to discuss the best moment to adopt prevention policies, arguing that the time of the intervention should combine individuals' motivations and the expected health gains. This framework is explored using nonparametric duration estimates, based on years of smoking habit. In more detail, the survival and hazard functions are obtained, to assist in the identification of moments when smokers are more and less likely to quit. Additionally, parametric methods are implemented in order to identify the variables that influence quitting decisions.

[1] http://www.share-project.org/

In Chapter 3, we empirically assess and discuss the potential interrelations between tobacco and excessive alcohol consumption, due to their common addictive nature. This chapter starts by describing and discussing the similarities between these two goods, namely as unhealthy behaviours and potential addictive goods. We specify, estimate and interpret parameters of an empirical model that includes alcohol and tobacco equations in the same framework: a bivariate probit model. This model makes it possible to test correlations between the error terms of the two equations. If these potential correlations are neglected we can obtain biased estimates (C. Cameron and Trivedi 2005). The bivariate probit model also allows the identification of variables that influence both decisions to consume alcohol and tobacco, as well as the determinants of tobacco consumption among alcohol consumers. Therefore, studying these two behaviours within a single model, we have the opportunity to recognise similarities between the decisions to consume alcohol and tobacco. In other words, we can explore the possibility of applying a concerted strategy to reduce both.

In Chapter 4, we analyse addition effect, focused on alcohol. Based on the rational addiction model, we discuss the measurement problems of alcohol addiction. This study differs from previous ones by acknowledging that not all individuals who consume alcohol throughout life are addicted and by adding the assumption that addiction occurs when alcohol consumption exceeds a threshold that causes harmful consequences. Using a variable that measures past excessive and harmful alcohol consumption, we analyse its effect on the current frequency of alcohol consumption. Given that our dependent variable is a categorical ordered variable, we apply an ordered probit model.

Finally, in Chapter 5 we summarise the main findings and highlight policy implications, by identifying problems concerning the measurement of health-related behaviours and presenting information that can sustain the adoption of prevention measures.

The main contributions and novelties contained in this dissertation can be synthesised in the following points: the new policy intervention framework proposed for reducing tobacco use and the empirical analysis used to discuss it; the assumption that addiction requires problems related to past alcohol consumption, and that not all

individuals who consume alcohol throughout life are addicted; the analysis of the determinants of smoking and excessive alcohol use, filling the empirical gap observed in Portugal; the combined approach concerning tobacco and alcohol consumption, identifying variables that influence joint consumption.

2. Where and when to intervene to reduce tobacco consumption

2.1. Introduction

According to the WHO, tobacco kills approximately 6 million people and causes more than half a trillion dollars of economic damage every year, being the world´s major cause of preventable death (WHO 2013b). In Portugal, in 2005, 11.7% of the annual deaths were attributable to diseases related with tobacco consumption (Borges et al. 2009), and, in 2010, tobacco consumption was the fourth risk factor responsible for the major burden of disease (Campos and Simões 2014). Moreover, the banning policies adopted do not seem to have the expected impact reducing tobacco prevalence, in Portugal (DGS 2011; WHO 2013a, 2010b), despite a slight decline in 2012 (DGS 2015). In Portugal, it was estimated that tobacco was responsible for hospitalisation and ambulatory care costs of around 490 million euros, in 2005 (Gouveia et al. 2008). The same authors also concluded that, if the Portuguese smokers had quit, this could represent savings of 1% in total health expenditure, and 2% in NHS expenditure[2].

In addition to the direct health benefits to the population, effective prevention measures influence the reduction of two types of costs. On one hand, direct costs, related to illness, including exams, treatments and follow-up. On the other, indirect costs, which include loss of production due to illness or premature death, loss of leisure time of family and friends providing support to the sick person – also called productivity costs (Barros 2009) –, as well as externalities caused by second-hand smoke exposure (Hofmann and Nell 2012). The potential saving in health expenditure due to tobacco reduction is of special importance in the current economic context where public health expenditures need to be controlled, if not reduced. Following the signing of the Memorandum of Understanding between the Portuguese authorities, the European Commission, the European Central Bank and the International Monetary Fund, in 2011, the Action Program of the 19th Constitutional Portuguese Government established, as one of the measures to achieve NHS expenditures sustainability, to intensify integrated programs of health

[2] The calculation of these percentages consider the data of Gouveia et al. (2008) and the data made available by National Statistical Institute (INE), concerning the current health expenditure, in Portugal, in 2005.

promotion and disease prevention closer to the population (Portuguese Health Regulation Authority 2011).

In sum, there is a need to develop effective policies to reduce tobacco consumption. Given that tobacco consumption remains high and among the four leading causes of burden of disease, in Portugal (DGS 2015), we should consider different policy perspectives. Public policies could discourage tobacco initiation and/or help smokers to quit. The implementation of policies to stimulate tobacco cessation should take into account the duration of the smoking habit, in order to identify periods with higher quitting probabilities. Evidence has shown that price increases are the most cost-effective policy in reducing tobacco consumption (WHO 2015), however, it does not seem to have a significant influence in deterring the habit of Portuguese smokers (WHO 2013a). In the same direction, Labeaga (1999) refers that price rises could only be an effective tool in reducing the quantity of tobacco consumed for a limited number of households and that the individuals' response to prices is very small (Labeaga 1999).

This chapter aims to fill the empirical gap concerning smoking decisions in Portugal, given that the existing literature is sparse (Alves et al. 2012; Gouveia, Inês, and Joaquim 2015; Pereira et al. 2013; Precioso et al. 2009), as well as to introduce the discussion on the more effective moment to adopt policies to promote smoking cessation. We developed a policy intervention framework, arguing that timing to intervene should combine individuals' intention to quit and the expected gains. The main idea is that intervening early in the habit duration has advantages in terms of healthy life years gained. However, policies are more likely to fail if individuals are little prone to quit. We used data taken from SHARE, including Portuguese adults, in 2011. Considering the duration of the smoking habit, we adopted both non-parametric and parametric duration models to identify variables that affect quitting decision, as well as the more opportune moment to intervene. Our contribution relies on analysing how quitting probability evolves, based on years of smoking habit.

This chapter is organised into 7 sections. In Section 2.2. our theoretical policy intervention framework is presented and discussed. Section 2.3 describes the methods and the data and section 2.4. clarifies the determinants of smoking in Portugal, in 2011.

Estimated results are presented and discussed in Sections 2.5 and section 2.6, respectively. Finally, Section 2.7 contains the main conclusions.

2.2. The policy intervention framework

There are several forces that influence the duration of smoking habit and, consequently, the decision to quit: To name a few, the level of addiction, the individual's characteristics and time preference, health status, life expectancy, information regarding the hazards of smoking, and exogenous shocks. A smoker will decide to quit smoking 'when he finds a way to rise long-term benefits sufficiently above the short-term costs of adjustment' (Becker and Murphy 1988).

Addiction requires an effect of the good's past consumption on current and future consumption (Becker and Murphy 1988). The main feature of Becker and Murphy's (1988) rational addiction model is that greater past consumption of addictive goods, such as cigarettes, stimulates current consumption by increasing the marginal utility of current consumption more than the present value of the marginal harm from future consumption (Becker and Murphy 1988). Extensions to this model incorporate a withdrawal effect when smokers attempt to quit smoking, which reduces utility and diminishes the probability of quitting (Suranovic, Goldfarb, and Leonard 1999). This withdrawal effect imposes costs when smokers decide to stop smoking and include a wide range of symptoms, such as loss of concentration and extreme irritability (Suranovic, Goldfarb, and Leonard 1999).

Clinical evidence on this subject strengthens these theories of rational addiction. In fact, nicotine, a substance contained in tobacco products, leads to dependency. When smokers intend to quit the habit they need to deal with the 'abstinence syndrome', characterised by a strong desire to smoke again (Nunes 2006). However, according to the definition presented by Becker and Murphy (1988), 'a good may be addictive to some persons but not to others', and the consumption of an addictive good involves an interaction between persons and goods. Then, individual's degree of time preference is

an important determinant of the duration of the smoking habit. From the rational addiction model insights, we expect present-oriented individuals to smoke for a longer period than future-oriented individuals. More farsighted individuals will be more concerned about future health-related problems and will stop smoking earlier (Becker and Murphy 1988). Grossman (1972) developed a model in which utility depends on health status but also on the consumption of other commodities, which in turn may influence health. Although Grossman's model does not focus on health risk behaviours, it is suitable to frame our discussion. In Grossman's framework, the present value of health-related utility is higher the smaller is the rate of time preference for the present (Grossman 1972).

Previous evidence found a reduction in tobacco consumption when the information on the relationship between smoking and health began to become available, in the late 1950s. This evidence contradicted the view that the majority of smokers were myopic and would not respond to information about future consequences (R. Ippolito, Murphy, and Sant 1979). However, the individuals who have consumed non-optimally are expected to consume more upon hearing of the hazard of smoking than they would have if they had been consuming at a lower rate (P. Ippolito 1981). Smokers' perceptions of tobacco damages and related diseases could also be important to explain smoking decisions (Farrell and Fuchs 1982). Viscusi (1990) examined the effects of lung cancer risk perception on smoking and concluded risk perceptions significantly reduce the probability of smoking (Viscusi 1990).

It is also expected that health status is an important determinant of the duration of the smoking habit. Cigarette smoking is an input with an expected negative marginal effect on health (Grossman 1972). To achieve the same health status of a non-smoker, smokers need to invest more in health. Kenkel (1995) estimated the impacts of lifestyles in health, concluding tobacco consumption is a harmful input in the health production function and smoking 20 cigarettes a day was equivalent to being over 13 years older (Kenkel 1995). However, a similar study developed in Portugal reported that the smoking coefficient on health was negative, but the effect on the health status was not statistically significant (Barros 2003).

Health recovery after quitting smoking is gradual. Stopping smoking reduces the excess mortality rates, and most of the excess risk of vascular mortality due to smoking can be eliminated rapidly upon cessation, but the excess risk for lung diseases, where the damaging effects of smoking are greatest, is only eliminated after 20 years (Kenfield et al. 2008). Current acute health problems may be due to past smoking (Kenkel 1995), and some of the deaths in former smokers attributable to smoking still occur (Kenfield et al. 2008), which empirically support that health damages remain after quitting.

The expected age of death plays an important role in the decision to engage or to persist in the consumption of the hazardous goods. An individual who expects to die earlier than normal faces a lower cost for hazardous consumption and should, on average, consume more (P. Ippolito 1981). Accordingly, individuals with potential longer life expectancy have more to lose, in terms of years of life, by smoking (Adda and Lechene 2013). As such, older persons are less concerned about the future consequences of current consumption, and hence are more likely to become addicted (Becker and Murphy 1988), which can discourage quitting decisions.

Finally, temporary shocks, such as health shocks, could affect the duration of the smoking habit. For example, developing diseases related to tobacco consumption or obtaining further information about the related risks can prompt individuals to quit smoking. A recent study showed that health shocks increase quitting probability during the same year in which the individual experienced the health shock (Sundmacher 2012), thus decreasing the expected duration of the smoking habit.

The described forces are important to define policy interventions that seek to reduce avoidable diseases related to tobacco consumption and improve population's health. To incentivise smokers to quit the habit, governments invest large amounts of resources in related interventions. From a policy point of view, an intervention should be designed to maximise society's welfare. Therefore, the target population of such intervention must be carefully selected. Usually, the target population is chosen in function of the individuals' characteristics. However, our hypothesis is that the design of the intervention should account for the duration of the habit, in addition to the personal characteristics of the individuals whose activity the intervention is set out to change. The

frameworks analysed and discussed so far might help us to introduce the discussion on the right moment of intervening. The expected result of a particular campaign/intervention depends on the probability of quitting, and on the health gains due to smoking cessation. Therefore, the expected policy's results (EPR) for the individual i, at the time of intervention t can be written as (equation 1):

$$(1)\ EPR_t = P(Quit)_t * \sum_{t=1}^{n} (Health\ Gains_t)$$

Where P(Quit) is the probability of quitting as a result of the intervention, Health Gains is a measure of the individual health impact of quitting, for those who quit, and n represents the remaining years of life. Life expectancy is reduced with age as well as with duration of tobacco consumption, because tobacco is a hazardous good whose health risk increases significantly with the years of consumption, not being very dangerous initially (P. Ippolito 1981). Starting from the Grossman Framework, health stock at time t, for individual i can be represented as (equation 2):

$$(2)\ H_t = H_{t-1} + I_{t-1} - \rho H_{t-1}$$

Current health stock (H_t) depends upon the health stock in the previous year, rate of depreciation of health (ρ), and the flow of gross investment (I_{t-1}). Lifestyles, such as tobacco consumption and the individual stock of schooling capital determine gross investment. Education increases the individual's efficiency to produce health investments, while tobacco has a negative effect on investment (Kenkel 1995). Rate of depreciation of health (ρ) is an exogenous variable that may vary with personal characteristics, such as age, and with tobacco consumption, which increases the depreciation rate. Moreover, the rate of depreciation is subject to random shocks. For example, as a result from a stroke, the individual's health stock is reduced, and the individual needs to invest more to recover the past health level, namely by reducing unhealthy behaviours.

Health gains due to intervention, where H_t^{int} denotes health status with intervention and $H_t^{no\ int}$ health status without intervention can be represented by equation 3:

$$(3)\ Health\ gains_t\ =\ H_t^{int} - H_t^{no\ int} = I_{t-1}^{int} - I_{t-1}^{no\ int} + (\rho^{no\ int} - \rho^{int})H_{t-1}$$

Health gains are influenced by exogenous variables related to individual's characteristics (X_i), which influence the productivity of gross investment (such as education), the past health (chronical conditions) or the rate of depreciation (age, gender) (Kenkel 1995). Health gains also vary with the duration of the smoking habit. If the duration of smoking habit increases, the depreciation of health is higher due to age, and the disinvestment in health due to tobacco consumption is higher due to its increasing hazard effect. Older individuals have less to lose in terms of years of life, by smoking, and have a higher rate of depreciation of health. From the health system perspective, a heavy investment will be necessary to achieve the same level of health status of younger individuals. This need of investment can be increased due to the delayed health effects of tobacco consumption (P. Ippolito 1981), which is individuals who smoke for longer periods can develop health-related problems in the future, even if they quit.

On the other hand, equation (1) depends on the probability of quitting, as a result of the intervention. Policy's effectiveness is influenced by an individual predisposition to quit smoking. If the individual is more likely to quit, the expected policy results are reinforced. Then, we can further separate utility of quitting, for any individual, into two parts (equation 4), adapting Orphanides and Zervos (1995) model. The first part of this equation relates to the quitting benefits and the second the quitting costs:

$$(4)\ P(Quit)_t = \eta[e^{-\sigma}(\textstyle\sum_{t=1}^{n}\ (H_t^{quit} - H_t^{smoke})\ \ ) -\ \ (b(a_t) + v(a_t, s_t))]$$

Here ($H_t^{quit} - H_t^{smoke}$) are the expected health benefits, with H_t^{quit} health after quit and H_t^{smoke} health if the individual keeps smoking. σ is the rate of time preference for the present ($\sigma \in [0, 1]$), and η represents health or exogenous shocks, such as the availability of information about the hazards of tobacco use, that can prompt smokers to quit smoking. $b(a_t)$ are the benefits of consuming the addictive good (a), including 'smoking pleasure', $v(a_t, s_t)$ represents negative side effects of past consumption, such as 'abstinence syndrome'. s_t represents the long-lasting effect of past consumption of tobacco, which depreciates at rate $\delta \in [0\ , 1]$ (equation 5):

$$(5)\ s_{t+1} = \delta s_t + a_t$$

Even if the individual stopped smoking (which is $a_t = 0$) the negative consequences persist in future periods (recovery after quit smoking is gradual), and the depreciation rate (δ) captures the degree of persistence of these negative consequences over time. If the individual keeps smoking, we expect the level of consumption to rise with the duration of the smoking habit due to reinforcement – greater current consumption of a good raises its future consumption – and tolerance – given levels of consumption are less satisfying when past consumption has been greater (Becker and Murphy 1988).

Quitting decisions are influenced by the duration of smoking habit and individual's characteristics, namely, the rate of time preference. Quitting utility is smaller when the rate of time preference (σ) and the depreciation rate on past consumption (δ) are greater. Myopic individuals will be more concerned about the current benefits of smoking, rather than future health-related problems. Duration of smoking habit has not an obvious effect on quitting decision. We expect to observe growing level of consumption with the duration of the smoking habit over time, due to addiction effect (s_t), which increases the negative side effects of quit smoking. The duration of the smoking habit also increases the occurrence of future health problems even if the individual quit smoking (because negative health effect usually occurs with a delay), while

'smoking pleasure' yields positive utility directly (Grossman 2000), which can discourage quitting decisions. However, individuals who experienced health shocks can decide to quit smoking to improve health. We expect that for each individual, in some points of the duration of the smoking habit function, after several years of exposure to tobacco smoke, the benefits could be smaller than the costs of quit smoking, reducing quitting probability.

In sum, both terms of the equation (1) depend on the duration of smoking as well as on the individual's personal characteristics. Therefore, we may rewrite the EPR as a function of time, t, and X_i which is a vector of personal characteristics (equation 6):

$$(6) EPR(t) = P(t \leq Duration < t + dt | Duration \geq t, X) * Health\ Gains(t; X),$$

Where $P(t \leq Duration < t + dt | Duration \geq t, X)$ is the probability of quit smoking in time $t + dt$, given that the individual was a smoker until t. Based on the framework described, considering that quitting costs increase over time, due to addiction, while health and life expectancy are reduced with duration of smoking habit, policy gains will be reduced with duration of smoking habit. Latter interventions will need more investment to achieve the same stock of health than early interventions. Early interventions will also diminish the future need of treatment due to delayed effects of tobacco consumption, because they reduce exposure time.

In sum, policy interventions need to consider the individual intention to quit smoking, as well as the expected health gains. If a policy is implemented in a moment when the quitting probability is lower, the expected policy gains will also be lower, because it will concentrate resources in an individual that is not amenable to quit. Given that we have information on habit's duration, we can implement survival models to analyse how the probability of quitting evolves in our sample. Therefore, we can include one element of the equation 6 on the discussion, the quitting probability, although the health gains and the specific factors that encourage each individual to quit smoking are unknown. The discussion on the optimal timing to promote tobacco cessation has not

been explicitly addressed by previous studies; we thus aim to shed some lights on this topic based on our results and using the methods described in the next section.

2.3. Data and Methods

The data for this work was extracted from SHARE Wave 4, a panel database of micro data on health, socio-economic status and family networks (Börsch-Supan 2013, 2016, Börsch-Supan et al. 2013a, 2013b; Malter and Börsch-Supan (eds.) 2013). Regarding Portugal, there is only one period of observations, 2011. The complete dataset has information about 2080 Portuguese individuals. In this sample, the great majority of the population is aged 50 and over. We considered that it fits better the purposes of this study because it captures the history of tobacco consumption, and it is expected that these individuals already had thought about smoking and quitting decisions.

The next section describes the determinants of smoking behaviour in Portugal, in 2011, based on a logit model, where 1 designates the current smoker status, zero otherwise. As is well-known, an ordinary least squares (OLS) regression ignores the discreteness and binary nature of the dependent variable and does not constrain predicted probabilities to be between zero and one (C. Cameron and Trivedi 2005). Consequently, models tailored to analyse binary outcome variables are more appropriate. Some alternative binary outcome models like probit, logit or complementary log-log regression could be implemented, and after balance these options, we decided to implement the logit model.

The main objective of this chapter is to analyse the duration of the habit of smoking in order to estimate the hazard rate function, which is the probability of quitting smoking presented in the equation of the EPR (equation 6), also as a function of a set of covariates. Given that the variable of interest is the duration of smoking habit, a censored transition variable, survival/duration models are the more appropriate to analyse the length of time spent in a given state (smoker) before the transition to another state (non-smoker).

When we analyse the number of years elapsed until the cessation of smoking, at a given moment in time, we deal with right censoring. That is, we observe spells from time 0 until a censoring time c, which is in this study 2011. Some spells have ended by 2011 (completed spells, covering individuals who stopped smoking), but others were incomplete and all we know is that they will end after 2011 (those who are current smokers in 2011). The censoring mechanism is assumed to be independent censoring.

Survival models are more efficient and direct than binary regression methods, and also have the additional advantage of being able to handle censored durations (C. Cameron and Trivedi 2005). In these models, both parametric and non-parametric approaches can be used. Non-parametric models, with no regressors included, were implemented to shed light on the discussion of the right(s) moment(s) to intervene to potentiate smoking cessation. We will try to identify the periods of the duration of the smoking habit when the effectiveness of policies is potentially low, or when is even undesirable to intervene, discussing the expected gains on health, based on the most relevant theoretical models.

In survival analysis (C. Cameron and Trivedi 2005), duration in the state 'smoker' is a nonnegative random variable, denoted T. The cumulative distribution function of T is denoted F(t) and the density function is $f(t) = dF(t)/dt$ (equation 7). Then the probability that the duration or spell length is less than t years of smoking duration is:

$$(7)\mathrm{F(t)} = \Pr[\mathrm{T} \leq \mathrm{t}] = \int_0^s f(s)d(s)$$

A complementary concept, the survivor function, is the probability that duration equals or exceeds t, which is the length of time survived in a particular state (equation 8):

$$(8)\ \mathrm{S(t)} = \Pr[\mathrm{T} > \mathrm{t}] = 1 - \mathrm{F(t)}$$

An alternative nonparametric approach is to model the hazard function, which shows the instantaneous probability to be a former smoker in year $t+1$, conditional on survival (keep smoking) to time t, and spells are at risk of failure if they have not yet failed or been censored (C. Cameron and Trivedi 2005). The hazard function is defined as equation 9:

$$(9)\ \lambda(t) = \lim_{\Delta t \to 0} \frac{\Pr[t \le T < t + \Delta t \mid T \ge t]}{\Delta t} = \frac{f(t)}{S(t)}$$

Given that we are interested in understanding the right moment to apply policies that reduce tobacco consumption, which depends on the probability of quitting smoking, the more intuitive estimator to address this question is the hazard function. Hazard function's estimates enable us to analyse how the probability of quitting smoking evolves with habit's duration, providing information on the equation of the expected policy gains described in the previous section, being an important tool in the conceptual framework presented. The hazard function's shape enables us to identify if the spell is more likely to end the longer it lasts – if the hazard function is increasing (Winkelmann 2008) – or if the quitting hazard is equal or smaller than in the period before – in the points were the hazard function stabilizes or reduces, respectively.

Parametric models were also implemented to model the duration of the habit as a function of a set of covariates, in order to identify the variables that influence the duration of the smoking habit. We adopted a duration model instead of mean duration, as weaker distributional assumptions are needed to consistently develop duration analysis, due to the censored nature of the data (C. Cameron and Trivedi 2005). The parametric duration models consider the influence of the variables on the hazard rate, which is in our case the probability of quitting. Parametric models are based on continuous distributions, the regressors are assumed to be time-invariant, and the data are augmented by a variable indicating the presence of censoring, assumed to be independent or noninformative (C. Cameron and Trivedi 2005). The exponential duration

distribution, the basis of parametric models, has a constant hazard rate $\lambda(\mathrm{t}) = \gamma$ that does not vary with t.

An alternative parametric model is a log-normal distribution, which has an inverted bathtub hazard that first increases with t and then decreases with t. The log-logistic has a similar behaviour for α > 1 (C. Cameron and Trivedi 2005). Given that we expect the hazard function to increase with duration, the previous parametric models do not seem to fit the data.

The Weibull distribution is a generalisation of the exponential commonly used in econometrics, because and exponential is a one-parameter distribution that is too restrictive in practice (C. Cameron and Trivedi 2005). The Weibull has hazard $\lambda(\mathrm{t}) = \gamma\alpha\mathrm{t}^{\alpha-1}$, which is monotonically increasing if $\alpha > 1$ and monotonically decreasing if $\propto < 1$. and it allows the hazard function to have a more flexible shape (C. Cameron and Trivedi 2005).

The Gompertz distribution is a similar to Weibull, with hazard $\lambda(\mathrm{t}) = \gamma \exp(\alpha t)$, which is monotonically increasing if $\alpha > 0$ and monotonically decreasing if $\propto < 0$, with the exponential as a special case (α = 0) (C. Cameron and Trivedi 2005).

Fully parametric models with independent, or non-informative, censoring are estimated by Maximum Likelihood Estimation. The information criteria test was applied to choose between parametric models. The information criteria are log-likelihood criteria with degrees of freedom adjustment, and the model with the smallest information criterion is preferred (C. Cameron and Trivedi 2005).

Table 1 contains variables' definition. As explanatory variables to our models, we used respondent characteristics such as age, gender, level of education, marital status, occupation, income, physical activity, drinking, and eating habits. In addition, as a proxy for chronical conditions and worse long-term health status, we included the variable that reveals a diagnosis of diabetes. It was also used a measure of financial risk aversion as a proxy for health risk aversion, which takes the value 1 if the individual is not willing to take any financial risks. Stata Statistical Software (Release 13. College Station, TX: StataCorp LP) was used for all analyses.

Table 1 Variables description

Variables	Description
Age	Number of life years
Male	Binary variable. 1 if male
Secondary education	Binary variable. 1 if the individual has completed secondary education.
Higher education	Binary variable. 1 if individuals holds a degree
Divorced	Binary variable. 1 if divorced
Married	Binary variable. 1 if married
Widowed	Binary variable. 1 if widowed
Unemployed	Binary variable. 1 if unemployed
Retirement	Binary variable. 1 if retired
Drinks	Number of drinks on the days respondent drank, in three months before the questionnaire
Risk aversion	Financial risk aversion as a proxy for health risk aversion. 1 if the individual is not willing to take any financial risks.
Physical Activity	Binary variable. 1 if the individual does physical exercise more than once a month
Diet	In a regular week, how often the respondent consumes fruits or vegetables. Categorical variable 1) Every day; 2) 3-6 times a week; 3) Twice a week; 4) Once a week; 5) Less than once a week
Income	The value of annual income in the previous year, after taxes, in euros. It includes wages, salaries or other earnings from dependent employment, approximate annual income from self-employment, after any taxes and contributions and after paying for any materials, equipment or goods used in his/her work, income from different public pensions and benefits, and additional, or extra or lump sum payment from public pensions and benefit
Diabetes	Binary variable used as a proxy for chronical conditions and worse health status, which takes the value 1 if individual has diabetes

2.4. Determinants of smoking behaviour in Portugal

We considered important, due to the limited empirical evidence in Portugal concerning this topic, to first clarify the scenario of smoking behaviour in Portugal, based on our dataset. In addition to the duration of the analysis that will be presented below, we adopted a logit specification to model the dependent variable 'smoke', which equals 1 if the individual is a current smoker and zero otherwise, to better understand which characteristics distinguish individuals that are more likely to smoke.

Table 2 presents the odds ratio of the estimation. The odds ratios are the proportionate change implied in the relative risk of being a smoker by one unit increase in each covariate. For example, the odds ratio of age takes the value of 0.913, meaning that when the individual age increases by one year the relative risk of smoking decreases approximately by 8.7%.

Table 2 Smoking probability (Odds ratios)

Variables	Odds ratio
Male	3.663
	(0.877)***
Age	0.913
	(0.016)***
Unemployed	2.011
	(0.715)**
Retirement	1.779
	(0.496)**
Secondary education	2.066
	(0.596)**
Higher education	2.416
	(0.733)***
Married	0.345
	(0.105)***
Widower	0.317
	(0.178)**
Divorced	0.605
	(0.251)
Risk aversion	0.814
	(0.240)
Physical activity	0.696
	(0.141)*
Drinks	1.098
	(0.048)**
Income	1.000
	(0.000)
Diabetes	0.687
	(0.201)
Diet	1.282
	(0.207)
Constant	21.491
	(22.377)**

N= 1360. Standard errors in parentheses *Significant at the 10% level, ** significant at the 5% level,*** significant at the 1% level. χ^2 (15)= (154.81)***

In what concerns to individual characteristics, gender had a statistically significant effect concerning smoking probability. The odds of men being smokers were 3.7 times larger than the odds for women. Regarding the marital status, despite we found no significant effect of divorce, being widower and being married had a negative effect on the probability of smoking, compared to single people. Retired and unemployed people had larger odds of smoking. This last effect can be related to stress, as suggested by Becker and Murphy (1988). However, Chaloupka (1991) concluded that cigarette consumption was basically unrelated to unemployment rates.

Concerning the potential effect of unhealthy behaviours on tobacco smoking, alcohol consumption (number of drinks) increased the relative risk of smoking by 9.8 %. On the other hand, those who were physical active had their relative risk of smoking decreased approximately by 30.4%. Our proxy for worse health status had not a statistically significant effect on the probability of smoking.

The different levels of schooling (secondary and higher school) had a significant effect on smoking probability, but not in the expected direction that higher education levels are associated with a lower probability of ever smoking (Douglas 1998; Forster and Jones 2001; Nicolás 2002; Malhotra and Boudarbat 2008; Jones 1997). In this study, higher levels of schooling had a positive effect on smoking probability. The odds of smoking were 2.1 times larger in individuals with secondary education and 2.4 in individuals with higher education. Alves et al. (2012), using a sample of 1704 Portuguese individuals aged 40 years or older, studied between 1999 and 2003, have reached similar conclusions. That study concluded that 'the least educated women smoked less frequently', while among men smoking prevalence did not vary with education or occupation. In Spain, the prevalence of current smoking in individuals aged 35–74 years was also found greater in the highest educational level group in 1995 (Redondo et al. 2011).

One possible explanation of education effect could be a selection effect on life expectancy, prior that on smoking. Given that the sample in this study includes mainly people aged 50 and over, people that are more educated could be healthier, could have a longer life expectancy, and reach the age of 50 more frequently than less educated

people reach. Another possible explanation could relate to smokers' perception of the health risks of tobacco use. Individuals with more years of schooling could understand better that, after several years of tobacco consumption, they had been exposed long enough to health-related risks, being aware of the chance of developing related diseases even after they stop smoking.

2.5. Results

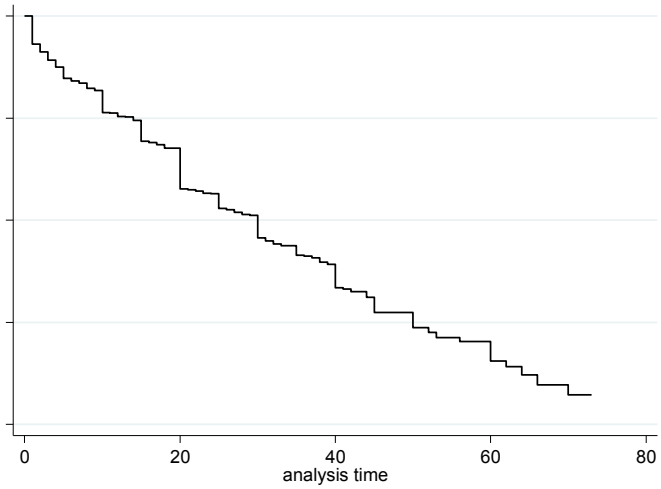
In this section, we used as dependent variable the duration of the smoking habit and considered all individuals who were current smokers or former smokers (640 individuals). In Table 3, we describe the sample under analysis. The sample was mainly constituted by men (75.6%), married (75.0%) with a median age of 63.2. Regarding health-related behaviours, 57.0% were sedentary, they consumed an average of nearly two drinks a day and consumed fruit and vegetables daily. The respondents' mean income was approximately 10,950 euros, 17.2% had higher education and the majority was risk aversive (85.2%). Considering health status, 17.8% had diabetes.

Table 3 Variables descriptive statistics

Variables	Mean	Std. Dev.
Male	0.756	0.430
Age	63.231	9.137
Unemployed	0.084	0.278
Retirement	0.581	0.494
Secondary education	0.150	0.357
Higher education	0.172	0.378
Married	0.750	0.433
Divorced	0.088	0.283
Widower	0.047	0.212
Risk aversion	0.852	0.356
Physical activity	0.430	0.495
Drinks	1.752	2.153
Income	10950.28	22520.99
Diabetes	0.178	0.383
Diet	1.256	0.652

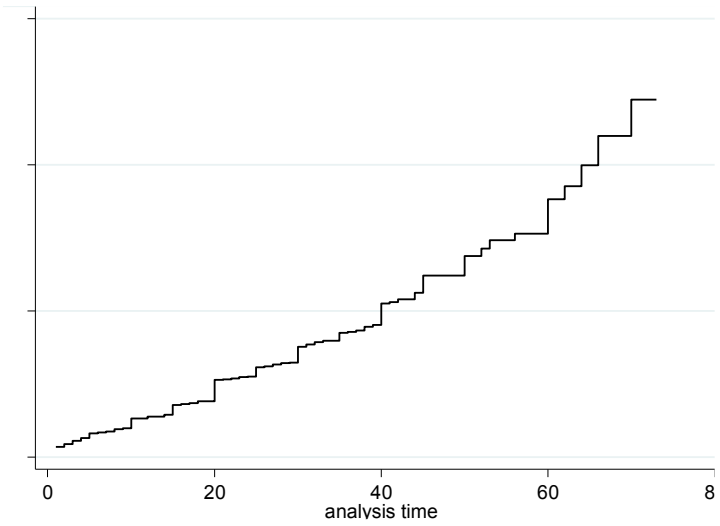
We first developed a Kaplan-Meier non-parametric approach, with no restrictions on the data, which produces empirical estimates of the survival and hazard functions to duration until quitting smoking (Figure 2). The survival function diminishes sharply in the first 25 years, approaching 0.5. However, after 50 years of the duration of the smoking habit, 0.25 of smokers kept smoking.

Figure 2 Survival Function of the duration of the smoking habit



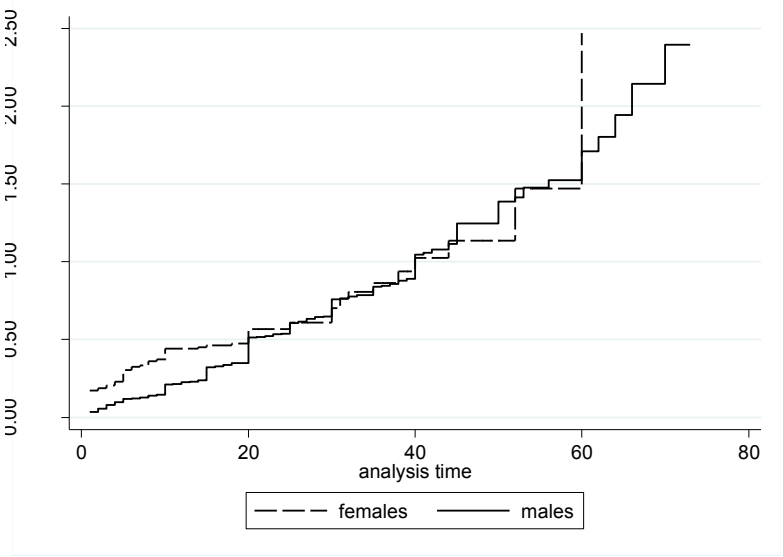
The Nelson-Aalen estimator is a non-parametric estimator of the cumulative hazard function based on a right censored sample. In Figure 3, the concave up pattern indicates a decreasing time between failures over time. The cumulative hazard function is steeper after 60 years of smoking habit, denoting the higher probability of stopping smoking, maybe related to health problems.

Figure 3 Nelson-Aalen Cumulative Hazard



When comparing men to women, by analysing the slopes of Nelson-Aalen (Figure 4), we can see that between 20 and 40 years men were more likely to stop smoking than women.

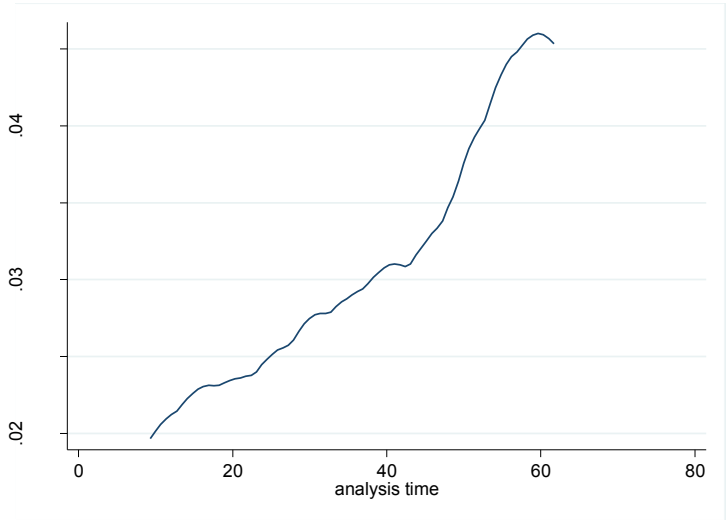
Figure 4 Nelson-Aalen Cumulative Hazard, by gender



The determined hazard function (Figure 5) rises with the duration of the smoking habit. However, the function admits some points contrasting with the tendency, where

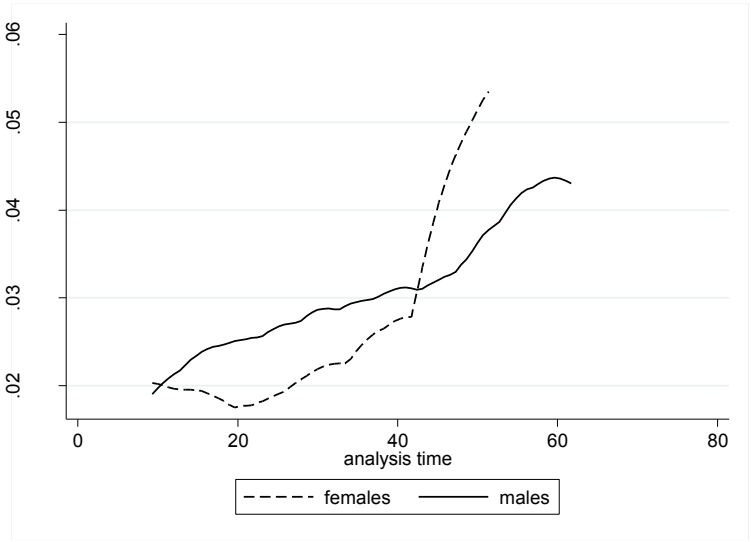
the probability of quitting does not increase between years. After about 45 years of smoking habits, the function has a more pronounced increase and shows a peak nearly 60 years.

Figure 5 Hazard function of the duration of the smoking habit



In the hazard function shown below (Figure 6), we can observe the presence of gender differences concerning quitting decisions. The hazard function of women decreases between 10 and 20 years of the smoking habit. This means that the quitting probability decreased, approaching the beginning point after around 25 years of the smoking habit. Therefore, policies implemented in this range could be less effective. The non-parametric function of men denotes a positive relationship between quitting decision and the number of years of consumption, with an inflexion after 60 years of the smoking habit.

Figure 6 Hazard function, by gender



We applied a Log-rank test, which is the exponential scores test (Mantel 1963, 1966; Mantel and Haenszel 1959; Savage 1956), to test the null hypothesis of no difference between the survival curves of men and women, versus the alternative hypothesis that the survival curves are statistically different. This nonparametric test, based in Mantel and Haenszel (1959) and extended by Mantel (1963, 1966), is constructed by giving equal weights to the contribution of each failure time to the overall test statistic and is a commonly used two-sample test statistic for censored data (Fleming and Harrington 2005).

The basic assumption of this test is that the random variables $X_1 \dots X_m$, $Y_1 \dots Y_n$ are mutually independent, but the common continuous cumulative distribution functions of X's (represented by F(x)) and common continuous cumulative distribution functions of Y's (represented by (G(x)) are identical (Savage 1956). Therefore, the null hypothesis is:

$$(10)\ H_0: F(x) \equiv G(x)$$

The Log-rank test is a chi-square test, with one degree of freedom, commonly used to study the association between disease incidence and any particular factor, when the other factors are held constant (Mantel and Haenszel 1959). For one specified factor,

such as gender, there is a 2x2 table, and individuals are classified as with or without disease (Mantel 1963).

In this study, there were two groups that were not equal, men and women, and we wanted to test if the survival functions are proportional across them. We did not reject the null hypothesis for survival curves identical in the two groups (Table 4). As a result, we opted not to present the duration model divided by gender.

Table 4 Log-rank test, by gender

Gender	Events observed	Events expected
0 (female)	91	82.42
1 (male)	340	348.58
Total	431	431.00

$\chi^2(1) = 1.20;\ \Pr > \chi^2 = 0.273$

Moreover, we modelled the duration until smoking cessation, using the parametric distribution that best fits the data. Given that the hazard function presented a growing tendency in time, parametric models with increasing hazard functions are more appropriate. To choose between the parametric distributions, we applied the information criteria test; accordingly, the Gompertz model was used. The results of Gompertz model applied to the hazard function of the duration of smoking habit are presented in Table 5.

The hazard ratios represent the probability of transition from initial state – smoker – to another – non-smoker. If the hazard rate is smaller than 100, the quitting probability is lower and expected duration increases. For categorical variables, the hazard ratio measures the impact relative to the baseline hazard, which is a change from 0 to 1 (C. Cameron and Trivedi 2005).

According to our estimates, unemployed individuals had hazard rate equal to 0.65, which means that at each time, the hazard rate of unemployed was nearly 35.0% less than the hazard rate of those who were not unemployed, and duration of smoking habit was longer. However, being retired had not a statistically significant effect. Higher education reduced quitting probability, increasing duration, compared with lower levels

of education. In spite of a statistically significant effect of income has been observed, the marginal effect is very low. Regarding the marital status, being married, widower or divorced reduced the duration of the smoking habit, compared to single. In our model, age did not explain the duration, but gender had a statistically significant effect on the duration of the smoking habit. Being a man had a positive impact in the years of smoking, given that the hazard rate was 29.8% less than the hazard rate of being a woman.

Table 5 Gompertz model results

Variables	Hazard ratio
Male	0.702
	(0.098)**
Age	1.007
	(0.008)
Unemployed	0.650
	(0.151)*
Retirement	0.814
	(0.115)
Secondary education	0.875
	(0.132)
Higher education	0.729
	(0.109)**
Married	1.832
	(0.365)***
Widower	1.685
	(0.492)*
Divorced	1.905
	(0.491)**
Risk aversion	1.210
	(0.181)
Physical activity	1.178
	(0.123)
Drinks	0.994
	(0.024)
Income	1.000
	(-1.71e 06)*
Diabetes	1.239
	(0.156)*
Diet	0.807
	(0.068)**
Constant	0.013
	(0.006)***

N= 612. Standard errors in parentheses. *Significant at the 10% level, ** significant at the 5% level,*** significant at the 1% level.

Individuals who ate fruit and vegetables less frequently were less likely to quit smoking earlier. We did not identify a connection between drinking or physical activities and duration of the smoking habit. Considering health status, diabetes increased the hazard of quit smoking of around 23.9%.

2.6. Discussion

As we were concerned about the right moment to intervene, based on the duration of the smoking habit, we applied non-parametric models, and took into account the clinical evidence on the cessation health benefits, to analyse the potential effectiveness of an intervention that aims to reduce tobacco consumption. The positive effects of smoking cessation are greater the shorter the duration of consumption. Also, the excess risk for all mortality related to tobacco consumption decreases to the level of a never smoker 20 years after quitting (Kenfield et al. 2008), being greater if individuals stops before 30 years old, when the additional risk is practically eliminated (U.S. Department of Health and Human Services 1990).

In this study we have found that, considering both survival and hazard function results, policies implemented in the first 25 years of the duration of the smoking habit are, possibly, more effective on quitting. The survival function diminishes sharply in that period, approaching 0.5, and the aggregate intervention effect will be higher, given that it could influence more individuals. Moreover, in that period, the probability of quitting shows an upwards trend. This result is consistent with the economic model of rational addiction, which means that the spell is more likely to end the longer it lasts. There is not an obvious optimal point to intervene. However, the function admits some points contrasting with the tendency, which suggests that perceived benefits of keeping smoking are greater than the perceived benefits of quitting. Then, in the points of the hazard function where the hazard is equal to the previous period, there is no advantage in delaying the intervention. For the same quitting probability, the sooner the intervention,

preferably before the age of 30, the greater the health gains, thus increasing the policy expected results.

After 45 years of smoking, although the hazard function has a more pronounced increase, the individuals' health status and life expectancy gains might not justify an intervention or, at least, bearing in mind that resources are scarce, interventions in these situations should not be given priority. In addition, if smokers are highly likely to quit on their own, possible due to health-related problems, gains brought by policy interventions are low, compared to the alternative of doing nothing. To test this hypothesis, we considered two subsamples of individuals, with less than 45 years of tobacco consumption and with 45 years or more, and found that self-assessed health status (classified between excellent (1) and poor (5)) was worse in individuals who stopped smoking after 45 years of consumption. This finding supports the hypothesis that after 45 years of smoking habit, individuals eventually decide to quit smoking due to a worse level of health status, as suggested by other authors (Shmueli 1996; Hsieh 1998).

In this study, the hazard functions by gender showed differences between men and women probabilities to quit. Considering policy intervention, to optimise the efficacy based on quitting probability, gender differences may justify separate policies. In addition, from the parametric estimates, which allowed us to identify determinants of the duration of the smoking habit, we observed being married, divorced or widower reduced the duration. In other words, the quitting probability was higher in these groups than that of single respondents. Previous authors also found married individuals were more likely to quit (Aristei and Pieroni 2009).

We also found that unemployed individuals were less likely to quit smoking. This could be an opportunity to develop a joint policy intervention on health and social areas, paying special attention to unemployment individuals, providing, for example, occupational alternatives. However, other authors concluded that cigarette consumption was basically unrelated to unemployment rates (Chaloupka 1991; Becker, Grossman, and Murphy 1994). On the other hand, given that, in this study, the duration of the smoking habit was affected only slightly to changes in income it would not be surprising to observe a limited impact of price increases on tobacco consumption.

This study has shown that higher education reduced the quitting probability, compared with lower levels of education. A previous study, based on the observation of elderly population in Taiwan, found a positive effect of schooling in the probability of quitting smoking (Hsieh 1998) and other authors showed that higher education levels reduced the duration of the smoking habit (Forster and Jones 2001; Kidd and Hopkins 2004; Nicolás 2002). One possible explanation may be that more educated individuals are more informed about tobacco-related diseases than less educated ones, or they are more efficient at learning new risk information received from the observed health effects of smoking (Hsieh 1998). When individuals become more concerned with their health status, those who have smoked during a longer period know that there is a higher probability of developing cancer, even if they quit smoking, given that smoking has a delayed effect. This perception could be higher in individuals with higher levels of scholarly, and they might prefer the benefit of continuing smoking rather than the benefit of stop smoking.

In our parametric model, the age of the individuals did not explain the duration of the smoking habit. On the other hand, men had lower hazard rates than women, which might increase men's duration of smoking. Studies have shown that men were more likely to start smoking earlier (Adda and Lechene 2013; Douglas 1998; Kidd and Hopkins 2004; Malhotra and Boudarbat 2008), and that the duration of the smoking habit was greater than for females (Kidd and Hopkins 2004). However, other authors found that men were more likely to quit (Aristei and Pieroni 2009).

In this study, we have also found that healthy eating habits reduced the duration of the smoking habit. However, attention should also be paid when controlling obesity problems, given that individuals could start smoking as a method of appetite control (Cawley, Markowitz, and Tauras 2004; Cawley, Dragone, and Von Hinke Kessler Scholder 2016). Nevertheless, we did not observe a relation between drinking or physical activity and the duration of the smoking habit. According to Adda and Lechene (2013), individuals who consume alcohol have a higher probability of being smokers. However, Cutler and Glaeser (2005) found low correlations between different health risk behaviours. Our results also have shown that the decision to quit smoking can be motivated by chronical health problems, increasing the quitting probability, in line with Aristei and Pieroni (2009)

findings. In these cases, the quitting decision could be associated with the prohibition of smoking as a part of treatment, as suggested by Jones (1997). Shmueli (1996), analysing elderly people in Israel showed that recent quitters did so because of poor health (Shmueli 1996), and the same was found by Hsieh (1998). However, different results were obtained by Jones (1994), which concluded that good health creates an incentive to stop smoking (Jones 1994).

One of the limitations of this study is the unavailability of information about spending on tobacco, *per capita*. Moreover, our dataset does not allow us to capture regressors' variation during tobacco consumption period, and the level of consumption is unknown. We also did not observe the failed attempts to quit smoking, which could discourage new attempts. In addition, caution must be taken interpreting the results about the right moment to intervene because smoking cessation can increase the quality of life and potential lifespan lost due to smoking, even if it is not efficient from a policy perspective. Moreover, in our discussion, we have implicitly assumed that quitting decision is an exogenous factor that is not affected by the intervention. However, it could not be a total waste of resources if the policy is implemented at an 'undesirable' moment if the intervention affects the future quitting probability.

2.7. Chapter concluding remarks

In an economic context where public health expenditures need to be controlled, health and economic preventable losses related to tobacco consumption, justify the need to adopt effective and efficient policies to reduce the smoking prevalence. With this study, we aimed to fill the gap of empirical evidence to sustain these policy interventions. This study is also relevant because it identified the determinants of the quitting decisions, based on the duration of smoking habit, in Portugal. Its main novelty is the contribution to the discussion of the moment when the policies to promote smoking cessation could be more effective, based on the duration of the smoking habit.

The timing to intervene should combine individuals' motivations and the expected effectiveness of the policy. Considering that the hazard function revealed an increasing trend, which suggests that quitting probability increases with the duration of the smoking habit, there is not an optimal point to intervene. However, our results suggest that prevention policies could be more effective before 25 years of the duration of the smoking habit, considering both health gains and individual predisposition to quit smoking.

Our results also suggest that health policy to reduce smoking prevalence should be linked with social and education policies, due to the positive impact of unemployment situation and higher education on the duration of the smoking habit. Policies could further be differentiated based on gender and marital status. It could be relevant for policy purposes the conclusion that smoking duration is slightly influenced by income, which could diminish the effectiveness of policies based on tobacco's price increases. This result may help us understand the reason why the policies adopted to reduce tobacco consumption, including price increases, do not seem to have the expected impact in Portugal. For policy purposes, it will be also interesting to understand the determinants for initiating tobacco use and to apply both *ex-ante* and *ex-post* policies. It also could be useful to better explore the links between tobacco and other unhealthy behaviours. These questions may merit further investigation.

3. Killing two birds with one stone?

Association between tobacco and alcohol consumption

3.1. Introduction

Tobacco and alcohol are both health risk behaviours, related to negative health outcomes (Kenkel 1995), listed among the top 10 leading causes of death and disability-adjusted life year (DALYs), in 2004 (WHO 2009). Tobacco causes approximately 6 million deaths each year (WHO 2013b), which are projected to increase to 8.3 million in 2030 (Mathers et al. 2008), and deaths related to alcohol were estimated to achieve 3.3 million, in 2012 (WHO 2014a). Moreover, alcohol and tobacco when used together increase the risk of some types of cancer and cardiovascular diseases, more than the use of either drug alone (Castellsagué et al. 1999; Lee et al. 2005; Pelucchi et al. 2008; U.S. Department of Health and Human Services 1989). Therefore, if a combined policy is adopted, the expected health gains will exceed the sum of two separate interventions, focused on each good, which justify a study on the interdependence between goods. Although this is a worldwide problem, Portugal was, in 2012, the 10th country with the highest level of alcohol consumption (Sassi 2015), and the 22nd in percentage of daily smokers (OECD 2014).

While smoking is associated with negative health effects (P. Ippolito 1981), and a large proportion of smokers become addicted to nicotine (Chaloupka, Grossman, and Saffer 2002), alcohol use is socially acceptable if consumed moderately, and the negative health effects arise from overuse or misuse (Grossman et al. 1993). The social unacceptability of smoking has increased (Stuber, Galea, and Link 2008), combined with smoker-related stigmatization and self-stigma (Bell et al. 2010; Evans-Polce et al. 2015; Stuber, Galea, and Link 2008), but alcohol discrimination arise solely from alcohol misuse, which is from heavy drinking (Gilbert and Zemore 2016).

Tobacco use is responsible for more than half a trillion dollars of economic losses every year (WHO 2013b). The economic burden of alcohol was estimated to equate between 853.64 million dollars and 234,854 million dollars, considering total costs on 12 selected countries, including Portugal (Thavorncharoensap et al. 2009). These behaviours also include social losses, such as health risks of second-hand tobacco smoke and harm

done to their foetuses by pregnant women who smoke and drink excessively (Grossman et al. 1993).

Manning et al. (1989) estimated the negative externalities that smokers and drinkers impose on others. Considering that non-smokers subsidise smokers' medical care but smokers subsidise non-smokers' pensions and nursing home payments, these authors concluded that, on balance, smokers pay their own way at the current level of excise taxes on cigarettes, but the same is not true for drinkers, whose taxes cover only about half the costs imposed on others (Manning et al. 1989).

These two goods also share a potential addictive nature. The theoretical models focusing on addictive substances' demand – the myopic addiction model and the rational addiction model (Chaloupka and Warner 2000) – do not account for the possibility of consuming tobacco and alcohol together. However the rational addiction model 'implies the common view that present-oriented individuals are potentially more addicted to harmful goods than future-oriented individuals' (Becker and Murphy 1988), and more farsighted individuals will be more responsive to perceived future consequences of consuming hazardous goods (Chaloupka, Tauras, and Grossman 1999). Considering the myopic individuals, if the individual consumes one harmful good, because he prefers the present benefits rather than avoiding future negative consequences, he is likely to adopt other unhealthy behaviours that will give him a present reward. Therefore, it is important to analyse the potential connection between health-related behaviours.

The literature that considers the inter-relationship between alcohol and tobacco consumption is mainly focused on the price as the central variable and tests the complementarity between them based on cross-price elasticities. Various authors concluded that tobacco and alcohol are complements (L. Cameron and Williams 2001; Dee 1999; Decker and Schwartz 2000; Zhao and Harris 2004; Bask and Melkersson 2004; Pierani and Tiezzi 2009; Tauchmann et al. 2013). This complementarity between goods involves that greater utility is achieved when used together, associated with a combined 'reward effect' that is qualitatively different from the effects of either good consumed alone (Drobes 2002; Tizabi et al. 2007).

On the other hand, there is an extensive body of literature analysing the consumption of tobacco and alcohol separately. In a case study that was previously developed, the prevalence of smoking among alcohol dependents was 88% (Batel et al. 1995). The importance of analysing the interdependence between goods was also discussed concerning smoking and obesity, leading to the conclusion that a single policy tool can reduce both (Dragone, Manaresi, and Savorelli 2015).

The existing evidence supports the role of socioeconomic variables explaining alcohol consumption (Decker and Schwartz 2000; Su and Yen 2000), and also joint consumption of alcohol and tobacco (Chang, Just, and Lin 2010; Manrique and Jensen 2004). Manrique and Jensen (2004) applied a bivariate probit to estimate the joint use of alcohol and tobacco, in Spain, and concluded that there is a correlation between smoking and drinking (Manrique and Jensen 2004). Zhao and Harris (2004) results indicate a strong correlation between consumption of tobacco, alcohol and marijuana. Finally, Bussu and Detotto (2014), considering a sample of gamblers with a mean age of 35 years, in Sardinia, estimated a multivariate probit model that revealed a bidirectional effect between gambling, alcohol and drugs, and a unidirectional effect between gambling and smoking (Bussu and Detotto 2014). Although these authors have analysed the variables that influence alcohol and tobacco consumption, they estimate neither the determinants of joint consumption nor the probabilities of consuming tobacco conditional on being a drinker.

In sum, few studies control for potential correlation between the disturbance terms of the tobacco and alcohol equations, which can bias the obtained results. Additionally, as far as we know, the effects of socioeconomic factors that influence the decision to use both alcohol and tobacco, and that encourage drinkers to smoke were not the focus of previous studies. In Portugal, there is no empirical evidence on this topic, besides some descriptive statistics applied to tobacco and alcohol consumption (Ferreira and Torgal 2010), and we wanted also to fill this gap. Following this line, the objectives of this study are identifying the variables that influence the joint decision to consume alcohol and tobacco, and that encourage drinkers to smoke, accounting for potential correlation between the decisions of smoking and hazardous drinking. We propose a

bivariate probit model to analyse the variables that influence alcohol and tobacco consumption. This model was adopted in this context and presents advantages over other specifications because it allows detecting correlations between the error terms of two equations – in this study between tobacco and alcohol equations – and controls for potential reverse causality problems, given that alcohol can affect tobacco consumption, but alcohol consumption can also influence tobacco consumption. In addition to the estimates of the model, we also estimated the joint probabilities and conditional probabilities for identifying the variables that stimulated the consumption of both goods, and the variables that motivated alcohol consumers to smoke.

Considering that alcohol and tobacco consumption are both health risk behaviours that share also an addictive nature, and that health consequences may be greater if their consumption is combined, it is of major relevance to analyse the links between alcohol and tobacco consumption. From the health policy perspective, if these links are neglected, and not studied from a methodological and conceptual point of view, as we propose in our analysis, the policy could be less efficient.

The remainder of the chapter is structured as follows. Section 3.2. includes the methodology, dataset and variables; the estimation's results are described and discussed in Section 3.3.; in section 3.4. the main conclusions are presented.

3.2. Data and Methods

We used a sample of Portuguese adults, mainly aged 50 years and over, extracted from SHARE Wave 4 (Börsch-Supan 2013, 2016, Börsch-Supan et al. 2013a, 2013b; Malter and Börsch-Supan (eds.) 2013), using 2011 data. The sample covered 1103 individuals and their characteristics are described in Table 7. Despite the sample median age is 63.8, compared with the average age of 41.8 in 2011 in Portugal (Instituto Nacional de Estatística 2012), it is representative of the Portuguese individuals aged 45 and over. Concerning socioeconomic characteristics, the sample approaches the 2011 Portuguese annual gross disposable income per inhabitant, 11,531 euros (Instituto Nacional de

Estatística 2011), as well as occupation, as far as 48.0% of the Portuguese population aged 45 and over was retired, and 12.1% of the working population was unemployed (Instituto Nacional de Estatística 2012). In this sample, 46.3% of the respondents completed primary education, and 10.7% the basic education, which are similar characteristics of the adults Portuguese aged 45 and over, 45.0% of whom completed primary education and 11.3% basic education (Instituto Nacional de Estatística 2012). In what concerns to the marital status, 6.8% were divorced and 78.7% were married. This is not very different from the Portuguese profile, where 7.6% and 68.2%, were respectively divorced and married (Instituto Nacional de Estatística 2012). However, this sample has an overrepresentation of men (59.2% in our sample, compared with 45% in Portugal) (Instituto Nacional de Estatística 2016).

We were interested in studying the potential correlation between alcohol and tobacco, to better understand if the decisions to consume both were related. Our measure of tobacco consumption is a binary variable that takes the value 1 if the individual was a current smoker at the time of interview. In what concerns drinking patterns, choosing a measure of excessive alcohol consumption is not straightforward. As described previously, some levels of alcohol consumption are socially accepted and do not comprise adverse consequences, which derive from excessive consumption. Consequently, it is difficult to determine the accuracy of any given variable intended to capture harmful alcohol consumption. In this study, we adopted a measure commonly used, 'hazardous drinking', defined as having three or more drinks in one day, in line with previous authors (Cutler and Glaeser 2005), and also taking as a reference the drinking guidelines, which defined hazardous drinking limit as the limit above which people are at risk for their health (OECD 2015b).

From the contingency table presented below (Table 6), 14.2% of the respondents were current smokers, 22.3% were hazardous drinkers and 4.6% were smokers and hazardous drinkers. The implementation of a Person's Chi-square test led to the rejection of the null hypothesis (p-value= 0.001), suggesting the two variables are not independent.

Table 6 Contingency table

	Hdrink		
Smoke	0	1	Total
0	751	195	946
1	106	51	157
Total	857	246	1103

Pearson chi2(1) = (10.950)**

Given the purpose of analysing the individual's decisions regarding the consumption of alcohol and tobacco, within the same empirical framework, and the binary nature of the dependent variables, a bivariate probit model provides the appropriate specification. Moreover, this model also allowed estimating the correlation between the error terms of the two equations and controls for the potential bias that may arise from correlation. The bivariate probit model estimates a system of equations:

$$(11)\begin{cases} y^*_{1,i} = \propto_i + X'_i\beta_1 + \mu_1,\ y_1 = 1\ if y^*_1 > 0, 0\ otherwise \\ y^*_{2,i} = \phi_i + X'_i\,\beta_2 + \mu_2,\ y_2 = 1\ if\ y^*_2 > 0, 0\ otherwise \end{cases}$$

Where y_1 is a binary variable that takes the value 1 if the individual 'i' is a current smoker ($y^*_1 > 0$), and y_2 is a binary variable that takes the value 1 if the individual consumes excessive alcohol ($y^*_2 > 0$). μ_1 and μ_2 are the error terms of each equation, and the correlation between these two error terms is expected to be different from zero if the behaviours are correlated. A vector of explanatory variables (X) associated with individual's characteristics is included in both equations, and β_1 and β_2 are the coefficients of each explanatory variable.

The bivariate probit model is a 'joint model for two binary outcomes that generalises the index function model from one latent variable to two latent variables that may be correlated' (C. Cameron and Trivedi 2005). If the correlation between μ_1 and μ_2 is zero (ρ = 0), the model is equivalent to estimate two separate probit models, one for each equation.

According to Greene (2003), after the estimation of the bivariate probit model, we may compute several behavioural index functions of the covariates, and each of which has the potential to unveil the marginal effects of observing specific probabilities. The unconditional mean functions are given by the univariate probabilities (equation 12):

$$(12)\ \mathrm{P}[\mathrm{y_j}|\mathrm{X}] = \phi\left(\mathrm{X}'\,\gamma_\mathrm{j}\right),\ \mathrm{j} = 1{,}2$$

Where γ_1 contains all the nonzero elements of β_1 and γ_2 is defined likewise (Greene 2003).

To answer the main question of this study, given that we were interested in identifying the variables that are joint determinants of tobacco and alcohol consumption, we estimate the joint probabilities of tobacco and alcohol consumption, which is $\mathrm{y_1} = 1$ and $\mathrm{y_2} = 1$. The probabilities that enter the likelihood function are (equation 13):

$$(13)\ \mathrm{P}\ (\mathrm{y_1} = 1, \mathrm{y_2} = 1|\mathrm{X}),$$

Using this function, we can also estimate the impact of the covariates in the conditional probability of consuming tobacco, given that the individual is an alcohol consumer (equation 14):

$$(14)\ \mathrm{P}\ (\mathrm{y_1} = 1|\ \mathrm{y_2} = 1|\mathrm{X}),$$

The explanatory variables chosen were age, gender, level of education, marital status, occupation, income, other health-related behaviours (physical activity and eating habits) and depression. We also included a variable that counts the number of diseases, as a proxy for worse health status. Considering the typical assumption that individuals have identical risk preferences, which is, attitudes towards financial risk should affect

consumers' willingness to take a risk in a variety of situations, including health (Guiso and Paiella 2005), a measure of financial risk aversion was added, as a proxy for health risk aversion. This assumption is supported by previous findings that financial risk-averse individuals are more likely than the risk-prone to avoid health risks, related to exposure to chronical conditions and mortality risks (Eeckhoudt and Hammitt 2004; Guiso and Paiella 2005). Table 7 presents variables description and some statistics. Stata Statistical Software (Release 13) was used for all analyses.

Table 7 Variables description and statistics

Variables	Description	Mean	Std. Dev.
Dependent variables			
Smoke	Binary variable. 1 if current smoker at the time of the interview, 0 otherwise	0.142	0.350
Hdrink	Hazardous drinking. Binary variable. 1 if respondent has taken three or more drinks per day, on the days respondent drank, in three months before the questionnaire	0.223	0.416
Independent variables			
Male	Binary variable. 1 if male.	0.592	0.492
Age	The number of years that the respondent has lived	63.805	9.199
Education	Number of years the respondent has been in full-time education	6.490	4.455
Married	Binary variable. 1 if married	0.787	0.410
Divorced	Binary variable. 1 if divorced	0.068	0.252
Widowed	Binary variable. 1 if widowed	0.073	0.259
Unemployed	Binary variable. 1 if unemployed	0.071	0.256
Retirement	Binary variable. 1 if retired	0.561	0.496
Risk aversion	Financial risk aversion as a proxy for health risk aversion. 1 if the individual is not willing to take any financial risks.	0.882	0.323
Physical Activity	Binary variable. 1 if the individual does physical exercise more than once a month	0.480	0.500

Diet	In a regular week, how often the respondent consumes fruits or vegetables. Categorical variable 1) Every day; 2) 3-6 times a week; 3) Twice a week; 4) Once a week; 5) Less than once a week	1.165	0.497
Depression	Answer to the question: 'there been a time or times […] when you suffered from symptoms of depression which lasted at least two weeks?'. 1 if the answer is yes	0.300	0.459
Income	Value of annual income previous year, after taxes	9905.340	20361.45
Diseases	Number of diseases (among the following list: heart problems; high blood pressure or hypertension; high blood cholesterol; Stroke or cerebral vascular disease; diabetes or high blood sugar; chronic lung disease; cancer or malignant tumour; stomach or duodenal ulcer, peptic ulcer)	1.309	1.223

3.3. Results and discussion

Table 8 displays the estimated results of the bivariate probit model that was explained in the last section. In addition to the coefficients, the average marginal effects on the probabilities of smoking and drinking are shown. These are the effects of unitary variations of each explanatory variable on tobacco and excessive alcohol consumption probabilities. Given that the correlation coefficient between the error terms of the two equations, $\rho_{Alc,Toc} = 0.085$, is not statistically significant, low correlations between these behaviours were found. Therefore, we also could estimate the equations of alcohol and tobacco use separately, with two separate probit models.

In this study, we have found that age had a negative statistically significant effect on smoking and also on drinking. According to earlier findings of Manrique and Jensen (2004), focused on a sample of adult individuals with median age 49.6 years, older household heads had a lower probability of consuming tobacco and alcohol. Cameron and

Williams (2001) showed that individuals aged 40 years old and over were both less likely to have smoked and less likely to drink than those under 20 years. However, Su and Yen (2000), which found a positive effect of age on wine consumption but no significant effect on beer consumption.

In our model, gender had a statistically significant effect on both behaviours. Men were found to be more likely to smoke and also more likely to drink. Previous studies also concluded that men were more likely to consume both alcohol and tobacco (Manrique and Jensen 2004; L. Cameron and Williams 2001; Su and Yen 2000), as well as alcohol (Decker and Schwartz 2000; Nayga and Capps 1994; Quirmbach and Gerry 2016) or tobacco separately (Douglas 1998; Kidd and Hopkins 2004; Malhotra and Boudarbat 2008; Adda and Lechene 2013).

In this study, we have also found that individuals with more years of education were more likely to smoke, and less likely to take three or more drinks per day. Decker and Schwartz (2000) obtained different results, concluding that education increased both the probabilities of smoking and drinking, in a subsample of individuals with average age 45. However, other studies shown that adults who hold a degree were less likely to smoke whereas the opposite occurred to excessive alcohol consumption (L. Cameron and Williams 2001).

Regarding the marital status, being married significantly reduced the probability of smoking by 15.7%, when compared with single respondents, but did not affect alcohol consumption decisions, similar to what was found by Cameron and Williams (2001). However, Decker and Schwartz (2000) shown that being married reduced the consumption of the two goods. We have also found that widowers were less likely to smoke but more likely to drink.

Considering occupation, unemployed and retirement situation did not seem to influence tobacco and alcohol consumption, and Nayga and Capps (1994) also concluded employed individuals did not significantly consume less alcohol than unemployed individuals. Our results are different from those obtained by Su and Yen (2000), who concluded that employed individuals were more likely to consume alcohol. Manrique and

Jensen (2004) have found in their study that employment reduced the smoking probability. In our estimates, an increase in income reduced the probability of consuming tobacco, but the marginal effect was small.

Table 8 Bivariate probit smoking and hazardous drinking

	Smoke		Hdrink	
Variables	Coefficient	Mg. effect	Coefficient	Mg. effect
Male	0.751	0.130	1 260	0.298
	(0.130)***	(0.020)***	(0.122)***	(0.024)***
Age	-0.036	-0.007	-0.024	-0.006
	(0.009)***	(0.002)***	(0.007)***	(0.002)***
Unemployed	0.339	0.072	0.179	0.048
	(0.192)*	(0.045)	(0.186)	(0.052)
Retirement	0.152	0.028	0.003	0.001
	(0.149)	(0.027)	(0.131)	(0.034)
Education	0.068	0.013	-0.021	-0.005
	(0.013)***	(0.002)***	(0.012)*	(0.003)*
Married	-0.696	-0.157	0.089	0.023
	(0.175)***	(0.045)***	(0.192)	(0.048)
Divorced	-0.239	-0.041	-0.088	-0.022
	(0.237)	(0.036)	(0.265)	(0.065)
Widower	-0.579	-0.084	0.521	0.149
	(0.323)*	(0.035)**	(0.272)*	(0.083)*
Risk aversion	-0.045	-0.008	-0.050	-0.013
	(0.160)	(0.031)	(0.146)	(0.038)
Physical activity	-0.235	-0.044	0.131	0.034
	(0.109)**	(0.020)**	(0.095)	(0.024)
Diet	0.178	0.033	0.044	0.011
	(0.091)*	(0.017)**	(0.087)	(0.022)
Depression	0.086	0.016	-0.025	-0.006
	(0.123)	(0.024)	(0.111)	(0.028)
Income	-1.23E-05	-2.28e-06	-3.74e-06	-9.61e-07
	(4.65e-06)***	(8.63e-07)***	(2.74e-06)	(7.03e-07)
Diseases	-0.113	-0.021	-0.060	-0.015
	(0.049)**	(0.009)**	(0.041)	(0.010)
Constant	0.808		-0.073	
	(0.572)		(0.509)	
ρ	0.085			
	(0.075)			

N= 1057. Standard errors in parentheses. *** p<0.01. ** p<0.05. * p<0.1.

In relation to health-related habits, we have found that respondents that reported eating fruit or vegetables less frequently had higher probability of consuming tobacco and that the practice of physical activities was associated with reduced tobacco consumption. Moreover, the number of diseases was associated with reduced consumption of tobacco but had not a statistically significant effect on alcohol consumption.

3.3.1. Joint probabilities of smoking and drinking

In Table 9, the average marginal effects for the joint probabilities of smoking and drinking, which is $\mathrm{P}(\mathrm{y}_1 = 1, \mathrm{y}_2 = 1|\mathrm{X})$, are shown. This estimation enabled us to identify the variables that influenced the decision to use both alcohol and tobacco.

As it can be seen in Table 9, age reduced the joint probability of smoking and drinking, as well as being married, when compared to single individuals. Men, compared with women, were more likely to smoke and also drink. These results are in accordance with Manrique and Jensen (2004) findings, which concluded that age reduced the consumption of tobacco as well as the consumption of alcohol. This study has also shown that being male had a positive effect on the alcohol's equation and on the tobacco's equation. Although these authors applied a bivariate probit model, they did not estimate the joint probabilities of consuming the two goods, but only the probabilities of consuming each good, separately.

Occupation did not seem to influence combined consumption of alcohol and tobacco, while higher income levels reduced this combined consumption, but with small marginal effect. The number of years of schooling increased the probability of combined consumption of tobacco and hazardous drinking. We have also found that respondents reporting eating fruit or vegetables less frequently had increased probability of tobacco consumption and hazardous drinking and that the number of diseases reduced this probability. This effect indicates that a worse health status reduces the probability of consuming these two goods.

Table 9 Marginal effects for the joint probabilities

Variables	Pr(Smoke =1, Hdrink = 1) (mg. effects)
Male	0.078
	(0.010)***
Age	-0.003
	(0.001)***
Unemployed	0.032
	(0.020)
Retirement	0.008
	(0.010)
Education	0.003
	(0.001)***
Married	-0.038
	(0.019)**
Divorced	-0.015
	(0.014)
Widower	-0.014
	(0.018)
Risk aversion	-0.005
	(0.012)
Physical activity	-0.007
	(0.008)
Diet	0.012
	(0.007)*
Depression	0.004
	(0.009)
Income	-8.50e-07
	(2.99e-07)***
Diseases	-0.009
	(0.003)***

N= 1057. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

3.3.2. Conditional probabilities of smoking in a subsample of alcohol consumers

As we were interested in shedding some light on health policy implications, combined treatment for both addictions may lead to more favourable outcomes, and treatment of smoking habit in alcoholics could be advantageous (Drobes 2002). Therefore, it is also useful to understand how the probability of smoking is affected by the explanatory variables considered, in the subsample of alcohol consumers. Conditional probabilities of experience tobacco consumption among alcohol consumers were also estimated, $\mathrm{P}(\mathrm{y}_1 = 1|\mathrm{y}_2 = 1|\mathrm{X})$, and results are presented in Table 10.

The results show that the smoking habit among alcohol consumers was reduced with age. Moreover, according to our estimates, gender influences tobacco consumption in the subsample of alcohol consumers, revealing that men who drink were more likely to also smoke. Being married and widower, compared with being single, influenced tobacco consumption among excessive alcohol consumers, reducing the probability of being a smoker. More educated individuals, who consume three or more glasses of alcohol per day, were more likely to smoke. Smoking probability among alcohol consumers was reduced in respondents with higher incomes, but the marginal effects were low. The other socioeconomic characteristics, namely unemployment and retirement situation did not influence tobacco consumption in the subsample of alcohol consumers. In this subsample, individuals with less healthy eating habits (who consume fruit or vegetables less frequently) and who were sedentary were more likely to consume tobacco, which suggests a predisposition to adopt unhealthy habits. Moreover, the number of diseases was associated with reduced tobacco consumption.

Table 10 Conditional predicted probabilities of smoking

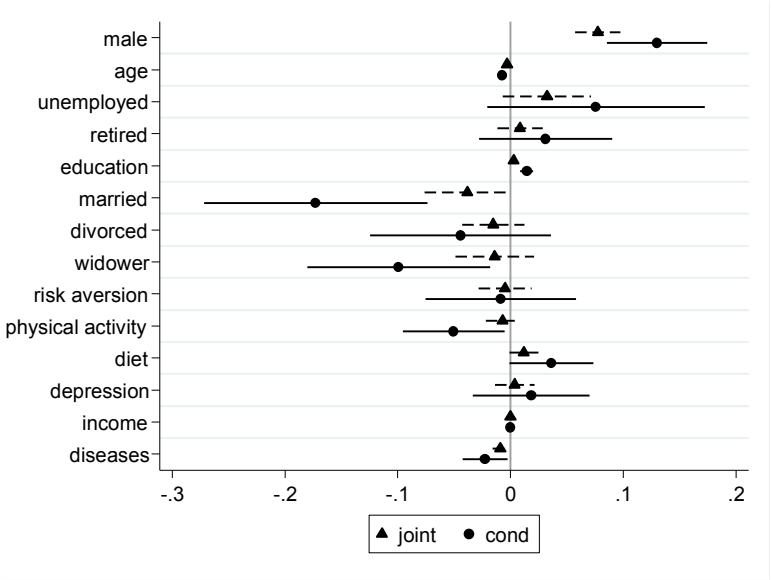
Variables	Pr(Smoke=1 |Hdrink = 1) (mg. effects)
Male	0.130
	(0.023)***
Age	-0.007
	(0.002)***
Unemployed	0.076
	(0.049)
Retirement	0.031
	(0.030)
Education	0.014
	(0.003)***
Married	-0.173
	(0.051)***
Divorced	-0.044
	(0.041)
Widower	-0.099
	(0.041)**
Risk aversion	-0.009
	(0.034)
Physical activity	-0.050
	(0.023)**
Diet	0.036
	(0.019)*
Depression	0.018
	(0.026)
Income	-2.49e-06
	(9.69e-07)**
Diseases	-0.023
	(0.010)**

N= 1057. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Additionally, we draw a graph displaying the regression coefficients, namely the variables' marginal effects on the joint decisions of consuming alcohol and tobacco, and the probabilities of smoking when being a hazardous drinker (Figure 7). We have found

that being a male and married were the variables that presented the greatest marginal effects on the joint probability. The same was found to the conditional probabilities.

Figure 7 Joint and conditional probabilities



Legend: Spikes for 95% confidence intervals.

3.4. Chapter concluding remarks

Tobacco and excessive alcohol consumption are both responsible for health, economic and social costs. In addition to the common nature of health risk behaviours, tobacco and alcohol are addictive goods. Considering that health risks are greater if their consumption is combined, it is relevant to better understand the links between these behaviours.

This study results revealed that tobacco consumption and hazardous drinking were not related, which suggests individuals do not share a common addictive behaviour predisposition. The individuals who drank three or more drinks a day seemed to have different incentives when compared with current smokers. One possible explanation could be related with the different levels of addiction concerning tobacco use and the

adopted measure of alcohol consumption. In spite of tobacco is being widely accepted as an addictive good, it is not easy to classify alcohol addiction. Alcohol consumption, *per se*, is not evidence of addiction and, in some cases, it can arise from social interaction rather than alcohol addiction.

Considering the obtained results, which made it possible to identify the individuals who were more likely to consume both goods, prevention policies should focus on males, younger and more educated individuals, as well as on individuals with unhealthy eating habits, because these variables were statistically significant and increased joint consumption. In addition, these characteristics also should be regarded if we want to control tobacco consumption, among alcohol consumers.

Some potential limitations of this study must be considered. First, the consumption spending on tobacco and alcohol was not available, given that the database used does not allow the identification of the type of beverages consumed or the brand of cigarettes. In addition, the ages at which respondents started smoking and drinking are unknown, preventing from identifying the history of consumption.

In sum, this work enabled to analyse alcohol and tobacco consumption together, identifying correlations between behaviours, and pointing out variables that could be used as policy instruments to develop concerted policies. This topic deserves further attention and investigation, namely from a policy perspective, given that prevention policies should take into account the links between behaviours (Room 2004), and eventually disparities among different types of drinkers (Geiger and MacKerron 2016). It could be useful to consider distinct measures of alcohol addiction, given that the limited available evidence suggests that the prevalence of tobacco use varies among levels of alcohol consumption (Bobo and Husten 2000). A better understanding and exploration of connections between addictive behaviours will enable policymakers to 'kill two birds with one stone' and to achieve extended health and economic gains. These potential links should not be neglected and should be further explored, contributing to a more efficient use of public resources.

4. Do drinking problems in the past discourage regular consumption?

4.1. Introduction

Alcohol consumption is considered as a major public health issue in the world (WHO 2014a). Harmful use of alcohol was ranked among the top five risk factors for disease and disability throughout the world, in 2010 (WHO 2011), and alcohol-attributable deaths and DALYs have increased worldwide, compared with 1990 (Lim et al. 2012). Globally, the harmful use of alcohol causes approximately 5.9% of all deaths, and 5.1% of the global burden of disease is attributable to alcohol consumption (WHO 2014a).

Excessive alcohol consumption is responsible not only for health costs, but also for economic and social costs (WHO 2014a; OECD 2015a). Social impacts comprise death and disability through accidents and injuries, violence and other crimes caused by excessive alcohol drinking (Chaloupka, Grossman, and Saffer 2002; OECD 2015a). Economic costs of excessive drinking include health treatment costs, as well as productivity losses (Cook and Moore 2000; Kenkel and Wang 1999, 2001). Alcohol-attributable costs *per capita* in high-income countries ranged from 358 dollars to 837 dollars - PPP based (Rehm et al. 2009). The indirect costs due to productivity losses were the predominant cost category of all alcohol-attributable costs, for high-income countries, followed by direct health-care costs (Rehm et al. 2009).

Given that alcohol consumption is a risk factor of particular importance in the aetiology of certain chronic diseases, some of the disease burden associated with these diseases can be avoided (McDaid, Sassi, and Merkur 2015). Therefore, this is a subject of utmost importance to health policy. International organisations exert continuous efforts in collecting health data (WHO 2014a; OECD 2015b), in particular, to help countries to reduce harmful alcohol consumption (WHO 2014a). Considering that there is relevant data available in Portugal and that harmful alcohol use was among the five most important risk factors for DALYs, in 2010 (DGS 2015), which is similar to the worldwide estimates, we could learn from the Portuguese experience.

Previous empirical studies considered that rational addiction requires a complementarity of consumption over time, regardless of the consumption degree and

harmful effects. In this study, a different analysis perspective was chosen, and the interpretation of our findings was based on the premise that addiction implies a stream of consumption that produces harmful side effects, and that not all individuals who consume alcohol throughout life are addicted (Orphanides and Zervos 1995). As a matter of fact, much of alcohol consumption is social in nature and is socially accepted and encouraged in friendships and peer groups (Larsen et al. 2010).

Moreover, different types of alcohol consumers were identified, which could be classified based on how they responded to price changes (Manning, Blumberg, and Moulton 1995). There are different types of heavy alcohol consumers: the alcoholic, who is unresponsive to price; and the heavy drinking non-alcoholic, who drinks heavily from time to time, but whose annual consumption is smaller than that of an alcoholic (Grossman 1993). Other authors have also pointed out that alcohol-related harm is determined by the volume consumed and the pattern of drinking (WHO 2014a), and that adverse effects of alcohol spring from overuse or misuse (Grossman et al. 1993). In sum, there are different types of alcohol consumers, and not all individuals become addicted or experience the same type of consequences.

The objective of this chapter was to assess the extent to which individuals become abstainers after experiencing alcohol addiction or, if not, how often do they drink. Accordingly, we analysed the effect of past drinking problem on current frequency of alcohol consumption. If past alcohol addiction influences present alcohol consumption, prevention policies should regard the addictive nature of alcohol consumption, in order to achieve outcomes that are more effective. We followed the assumption that alcohol addiction implies a history of past consumption beyond a threshold that requires harmful consequences, which varies from individual to individual (Orphanides and Zervos 1995). Also, we assumed that this threshold is reached when the individual reports to have experienced a 'drinking problem', in the past. Given the discrete and ordered nature of the outcome variable (which is the current frequency of alcohol consumption), we adopted an ordered probit model to analyse our research question.

The organisation of the remainder of the chapter is as follows. Section 4.2 summarises some theoretical models that are relevant to frame the discussion. Section

4.3 describes the methods and the data, while Section 4.4 reports the main results and discusses them. Finally, we conclude the chapter in Section 4.5.

4.2. Theoretical models of addiction

In the context presented in the previous section, addiction theories insights are relevant. Given the addictive nature of alcohol, the analysis of its consumption is not suited to standard economic analysis. Therefore, alternative economic modelling approaches of the demand were developed to handle addictive behaviour specificities (Chaloupka, Tauras, and Grossman 1999).

Myopic models assume that current consumption of addictive substances depends on current and past factors, but do not take into account the future consequences. On the other hand, rational addiction models, first developed by Becker and Murphy (1988), consider addiction as a fully rational behaviour, assuming that consumption of an addictive good will depend on the past and current consumption, and on the future implications of addiction when making current choices. The main feature of Becker and Murphy's (1988) rational addiction model is that greater past consumption of addictive goods, such as alcohol, stimulates current consumption by increasing the marginal utility of current consumption more than the present value of the future marginal harm.

Several authors empirically tested and discussed Becker and Murphy's (1988) rational addiction model, with results that were consistent with that model (Baltagi and Griffin 2002; Bask and Melkersson 2004; Grossman, Chaloupka, and Sirtalan 1998; Pierani and Tiezzi 2011; Waters and Sloan 1995). However, other studies found no support for the rational addiction model (Baltagi and Geishecker 2006), and others identified stronger evidence of rational addiction in some countries than in others (Bentzen, Eriksson, and Smith 1999). The rational addiction model can be criticised because it implicitly assumes that addicted individuals are rational, perfect foresight and have full information (Chaloupka, Tauras, and Grossman 1999). Some authors proposed extensions to this model attempting to deal with these limitations (Orphanides and Zervos 1995; Suranovic,

Goldfarb, and Leonard 1999). In sum, some authors found statistically significant intertemporal links between alcohol consumption, but did not assume the premise that alcohol addiction does not affect all individuals who drink throughout life.

Orphanides and Zervos (1995) developed an economic model to address some limitations of the rational addiction theory. The authors introduce uncertainty into the model by assuming that individuals are not fully aware of the potential harm when they start consuming an addictive good. Individuals possess subjective beliefs concerning this harm, and those beliefs are optimally updated with information gained through consumption (Orphanides and Zervos 1995). These authors admit that harmful side effects of consuming a potential addictive good are not the same for all, and becoming addicted requires the accumulation of a stock of past consumption beyond some critical level, which depends on individuals' nature. In what concerns alcohol consumption, to most people, they receive only the beneficial immediate rewards of current consumption, and the stock of consumption has no serious effect on their welfare (Orphanides and Zervos 1995). For potential addicts, however, the same stream of consumption produces harmful side effects that these authors associate with addiction (Orphanides and Zervos 1995).

Nevertheless, according to Orphanides and Zervos (1995) a predisposition to addiction cannot be detected without the experience gained from repeated consumption of alcohol. Some individuals experiment and learn their addictive tendency before reaching their critical level, and reverse their consumption pattern, avoiding addiction. On the other hand, those who recognise their tendency after reaching that critical level become addicts. Individuals decide to risk the consumption of an addictive good – and to achieve immediate 'pleasure' – because they think that the good is not harmful to them individually, and not because they wish to become addicts *ex ante* (Orphanides and Zervos 1995). When individual become addicts, they regret having taken the risk, rather than being pleased as in rational addiction theories.

4.3. Data and methods

From an empirical point of view, the main purpose of this chapter was to investigate if past harmful alcohol consumption influences present patterns of alcohol consumption. For that, we used data from the SHARE Wave 4 (Börsch-Supan 2013, 2016, Börsch-Supan et al. 2013a, 2013b; Malter and Börsch-Supan (eds.) 2013), which was collected in Portugal in 2011.

To measure alcohol consumption in the present (at the date of the questionnaire, 2011) we adopted a metric that reflects the frequency of alcohol consumption. More specifically the question 'During the last 3 months, how often did you drink any alcoholic beverages?' was asked to the individuals. The following categories were considered: 0 - Not at all in the last three months (abstainer); 1 - Less than once a month; 2 - Once or twice a month; 3 - Once or twice a week; 4 - Three or four days a week; 5 - Five or six days a week; 6 - Almost every day. Although, ideally, we should have captured both frequency and level of consumption, as well as symptoms of addiction, no such data was available in the dataset.

Our main explanatory variable ('drinking problem') should be a measure of alcohol addiction, interpreted as consumption beyond a critical level, with related harmful side effects, following the assumption of Orphanides and Zervos (1995) for addiction. The variable 'drinking problem' was extracted from the question 'Was excessive drinking a problem at any time of your life?'. This variable relates to excessive and problematic drinking in the past and fits the assumption of harmful side effects due to alcohol consumption. In addition, this measure provides a subjective evaluation of alcohol-related consequences. Self-assessed measures are widely used (Feunekes et al. 1999; Ross 2006) and actually, self-reported alcohol use is frequently under-reported due to social desirability and recalls bias (Bajunirwe et al. 2014). Considering this under-reported tendency, the variable 'drinking problem' appears to be a good proxy of the critical level of consumption.

We first analysed the interrelation between the two variables (past drinking problem and current alcohol consumption) using a contingency table and a statistical test (Pearson 1904) to understand if the two variables are statistically associated. Given that the dependent variable is a categorical and ordered variable, an ordered probit model was chosen (Jones et al. 2013). The real frequency of consumption is not observed and will be denoted by a latent variable (y_i^*), with a logical ordering in the answers. This ordered model can be represented as (equation 15):

$$(15)\ y_i^* = x'_i\beta + \varepsilon_i, \qquad \varepsilon_i \sim (0, \sigma^2)$$

where the latent y_i^* can be interpreted as the individual's 'propensity to drink'. ε_i is an unobserved error term independent from x_i. The assumption that ε_i is $NID\ (0, \sigma^2)$, yields to an ordered probit model (Verbeek 2004). The coefficients' interpretation is conditional upon normalization constraint, but the probabilities are insensitive to it (Verbeek 2004). The observed categorical response relates to as follows (equation 16):

$$(16)\ y_i = k \Leftrightarrow \mu^{k-1} \leq y_i{}^* < \mu^k, k = 1, \dots, 6$$

Where $\mu^0 < \mu^1 < \cdots < \mu^6,\ and\ \mu^0 = -\infty\ and\ \mu^6 = \infty.\ \mu^1, \mu^2\ \mu^3, \mu^4 and\ \mu^5,$ are the constant cut-points of the ordered probit model (Jones et al. 2013).

The coefficients of the covariates have a qualitative interpretation, and a positive coefficient indicates a positive effect on the frequency of consumption (Jones et al. 2013). The interpretation of the β coefficients is in terms of the underlying latent variable – a positive β means that the explanatory variable increases the propensity to drink –, or in terms of the effects on the respective probabilities – a positive β means that the probability that $y_i = 6$ will increase, while the probability that $y_i = 1$ will decrease.

However, we also wanted to know the effect of the covariates on the probabilities of reporting the categories of current alcohol consumption. Therefore, we also estimated

the effect of each covariate on the probabilities of observing each specific category. The implied probabilities are obtained by (equations 17-22):

$$(17)\ P\{(y_i = 1|x_i\} = \phi(-x'_i \frac{\beta}{\sigma})$$

$$(18)\ P\{(y_i = 2|x_i\} = \phi\left(\frac{\mu^1 - x'_i\beta}{\sigma}\right) - \phi\left(\frac{-x'_i\beta}{\sigma}\right)$$

$$(19) P\{(y_i = 3|x_i\} = \phi\left(\frac{\mu^2 - x'_i\beta}{\sigma}\right) - \phi\left(\frac{\mu^1 - x'_i\beta}{\sigma}\right)$$

$$(20)\ P\{(y_i = 4|x_i\} = \phi\left(\frac{\mu^3 - x'_i\beta}{\sigma}\right) - \phi\left(\frac{\mu^2 - x'_i\beta}{\sigma}\right)$$

$$(21)\ P\{(y_i = 5|x_i\} = \phi\left(\frac{\mu^4 - x'_i\beta}{\sigma}\right) - \phi\left(\frac{\mu^3 - x'_i\beta}{\sigma}\right)$$

$$(22)\ P\{(y_i = 6|x_i\} = 1 - \phi\left(\frac{\mu^5 - x'_i\beta}{\sigma}\right)$$

The ordered probit model applied had the main purpose to investigate the effect of past drinking problems on current alcohol consumption, but we also added control variables to our regression model, commonly used in the literature on alcohol consumption.

Alcohol addiction has been studied from a clinical point of view, through clinical trials that tried to identify factors predicting alcohol relapse (Kuria 2013; Miller et al. 1996). Relapses result from a combination of various factors, namely individual characteristics (Miller and Hester 1995), such as the occurrence of negative life events, cognitive appraisal variables, alcohol expectancies, motivation for change, client coping resources, craving experiences and affective status (Miller et al. 1996). Individuals with different craving experiences (reward or relief) might respond differently to distinct interventions aimed at relapse prevention (Glöckner-Rist, Lémenager, and Mann 2013). Moreover, age, gender, familiar risk factors, socioeconomic status, economic development and culture are identified factors that affect alcohol consumption, and alcohol-related harm (WHO 2014a). Relapses are also associated with craving, psychosocial distress and negative affect (Bottlender and Soyka 2004; Vieten et al. 2010).

Depressed individuals have a higher craving for alcohol after detoxification and rehabilitation (Kuria et al. 2012), which justifies the inclusion of a variable that accounts for depression.

A brief description of the variables that were studied in this chapter is shown in Table 11. These include personal characteristics such as age, gender, marital status, education, occupation, income, health-related habits, mental health and a proxy for health status based on the number of diseases. Stata Statistical Software (Release 13) was used for all analyses.

Table 11 Variables description

Explanatory variables	**Description**
Drinking problem	A binary variable of a self-assessed drinking problem. 1 if excessive consumption of alcohol was a problem at some point in respondent's life course.
Age	The number of years that the respondent has lived.
Male	Binary variable. 1 if male.
Education	Number of years respondent has been in full-time education.
Married	Binary variable. 1 if married.
Unemployed	Binary variable. 1 if unemployed.
Retirement	Binary variable. 1 if retired.
Smoke	Number of years the respondent smoked.
Physical Activity	Binary variable. 1 if the individual does physical exercise more than once a month.
Depression	Answer to the question: 'there been a time or times […] when you suffered from symptoms of depression which lasted at least two weeks?'. 1 if the answer is yes.
Income	Value of annual income in the previous year, after taxes.
Diseases	Number of diseases the individual suffers (among the following list: heart problems; high blood pressure or hypertension; high blood cholesterol; Stroke or cerebral vascular disease; diabetes or high blood sugar; chronic lung disease; cancer or malignant tumour; stomach or duodenal ulcer, peptic ulcer).
Dependent variable	
Frequency	Categorical and ordered variable, according to the self-assessed frequency of alcohol consumption values: 0 - Not at all in the last 3 months; 1 - Less than once a month; 2 - Once or twice a month; 3 - Once or twice a week; 4 - Three or four days a week (frequent drinker); 5 - Five or six days a week (regular drinker); 6 - Almost every day (daily drinker)

4.4. Results and discussion

The data covered 1103 adults, whose characteristics are depicted in Table 12. The average age of the respondents was 63.8 years. 59.3% were men and 78.7% were married. Of all respondents, 7.1% were unemployed, 56.0% and were retired. The median annual income of the sample was 9,896 euros. The average duration of smoking was 11 years. About 33.8% of all respondents in the sample consumed alcohol almost every day and 3.6% reported that suffered past drinking problems.

Table 12 Descriptive statistics of the data

Explanatory Variables	**Percentage**	**Mean**	**Std. Dev.**
Drinking problem		0.036	0.187
Age		63.783	9.201
Male		0.593	0.492
Education		6.491	4.456
Married		0.787	0.410
Unemployed		0.071	0.256
Retirement		0.560	0.497
Smoke		11.109	16.623
Physical Activity		0.480	0.500
Depression		0.300	0.459
Income		9896.031	20354.140
Diseases		1.310	1.222
Dependent variable			
Frequency		2.582	2.714
Category 0	46.195%		
Category 1	4.341%		
Category 2	3.659%		
Category 3	6.732%		
Category 4 (frequent drinker)	2.780%		
Category 5 (regular drinker)	2.537%		
Category 6 (daily drinker)	33.756%		

Of those respondents who reported past drinking problems (Table 13), 85.0% were men and had achieved levels of education and income that are, on average, higher than the whole sample. In this subsample, the mean duration of the smoking habit was higher, compared to the whole sample. In addition, respondents of this subsample had

larger percentage of individuals who reported symptoms of depression (47.5% versus 30.0%). The individuals in the subsample, on average, consumed alcoholic beverages three or four days a week (more than the whole sample), and none of them abstained to drink during the three months before the interview. Regarding the number of diseases, used as a proxy for worse health status, the respondents in the subsample are characterised by comparatively worse health status.

Table 13 Descriptive statistics subsample of respondents with past drinking problems

Variables	Mean	Std. Dev.
Age	62.850	8.954
Male	0.850	0.362
Education	8.154	5.446
Married	0.600	0.496
Unemployed	0.100	0.304
Retirement	0.550	0.504
Smoke	23.525	20.261
Physical Activity	0.400	0.496
Depression	0.475	0.506
Income	10360.130	13280.230
Diseases	1.575	1.412
Frequency	4.400	1.985

To study the association between our dependent variable – current frequency of alcohol consumption (variable 'frequency') – and past drinking problems (variable 'drinking problem'), data was organized in a contingency table and tested using a Person's Chi-square test. The results are summarised in Table 14. We can observe that individuals who admitted having experienced past drinking problems did not show a tendency to become abstainers, given that all the respondents consumed alcoholic beverages in the three months before the questionnaire. Previous evidence also suggests that individuals with past drinking problems do not become abstainers (Kuria 2013; Moos and Moos 2006). Kuria (2013) concluded that individuals who had higher levels of alcohol-related

problems were more likely to relapse, and Moos and Moos (2006), described more lifetime drinking problems to be associated with relapse.

Table 14 2X2 table drinking problem and frequency of consumption

	Drinking problem		
Frequency	0	1	Total
0	46.20%	0.00%	46.20%
1	4.10%	0.24%	4.34%
2	3.41%	0.24%	3.66%
3	6.49%	0.24%	6.73%
4	2.73%	0.05%	2.78%
5	2.44%	0.10%	2.54%
6	32.68%	1.07%	33.76%
	2010	40	2050

Pearson X^2 (5) = 3.9683; P-value = 0.554

From the Pearson's Chi-square test, we do not reject the null hypothesis of independence between variables (p-value= 0.554). However, we considered opportune to deepen the analysis using a regression model. Due to the fact that the central explanatory variable, 'drinking problem', had no observations in the category $y = 0$, which is the probability of reporting a category greater than zero is 1, in the regression we considered the categories of alcohol consumption greater than zero ($y > 0$).

The ordered probit model presented below (Table 15) allow to identify the frequency of alcohol consumption, considering a set of explanatory variables, including the variable that accounts for past problems related to alcohol consumption. The coefficients presented in the second column of Table 15 have a qualitative interpretation. We also estimated the effect of each covariate on the probabilities of observing specific consumption categories.

Table 15 Ordered probit applied to frequency of consumption

Variables	Coef.	Y = 1	Y = 2	Y = 3	Y = 4 (frequent drinker)	Y=5 (regular drinker)	Y = 6 (daily drinker)
Drinking prob	-0.342*	0.046*	0.026*	0.029**	0.008*	0.004*	-0.117*
	(0.197)	(0.038)	(0.016)	(0.015)	(0.005)	(0.001)	(0.071)
Age	0.005	-0.001	-0.000	-0.001	-0.000	-0.000	0.002
	(0.005)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.002)
Male	0.680***	-0.091***	-0.056***	-0.069***	-0.017***	-0.011*	0.232***
	(0.088)	(0.014)	(0.009)	(0.010)	(0.003)	(0.002)	(0.032)
Education	-0.039 ***	0.005***	0.003***	0.004***	0.001***	0.001***	-0.013***
	(0.009)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.003)
Married	0.215**	-0.029**	-0.017**	-0.020**	-0.005**	-0.003*	0.074**
	(0.090)	(0.014)	(0.007)	(0.008)	(0.002)	(0.001)	(0.032)
Unemployed	0.079	-0.010	-0.006	-0.007	-0.002	-0.001	0.027
	(0.153)	(0.019)	(0.011)	(0.014)	(0.004)	(0.003)	(0.051)
Retirement	-0.044	0.006	0.003	0.004	0.001	0.001	-0.015
	(0.101)	(0.013)	(0.007)	(0.009)	(0.003)	(0.002)	(0.034)
Smoke	0.003	-0.000	-0.000	-0.000	-0.000	-0.000	0.001
	(0.003)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Phys. activity	0.187**	-0.025**	-0.014**	-0.017**	-0.005**	-0.003**	0.064**
	(0.078)	(0.011)	(0.006)	(0.007)	(0.002)	(0.001)	(0.026)
Depression	-0.150*	0.020*	0.011*	0.014*	0.004*	0.002*	-0.051*
	(0.084)	(0.011)	(0.006)	(0.008)	(0.002)	(0.001)	(0.029)
Income	-1.16e-06	1.55e-07	8.69e-08	1.08e-07	2.89e-08	1.82e-08	-3.97e-07
	(1.99e-06)	(1.49e-07)	(1.49e-07)	(1.85e-07)	(4.95e-08)	(3.12e-08)	(6.78e-07)
Diseases	0.036	-0.005	-0.003	-0.003	-0.001	-0.001	0.012
	(0.033)	(0.004)	(0.002)	(0.003)	(0.001)	(0.001)	(0.011)

N= 1052. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. $\chi^2(12)= 144.83$ ***. The cut-points: Cut1 = -0.810; cut2 = -0.407; and cut3 = 0.089; cut4 = 0.255; cut5 = 0.386.

Our central explanatory variable 'drinking problem' had a negative effect on the probability of being a daily drinker. Moreover, past problems related to alcohol consumption had a positive effect on the probability of drinking alcohol less than once a month, as well as on the other four lower categories. Considering the values of the predicted probabilities, past drinking problems, increased more the probability of reporting the first three consumption categories – drinking alcohol less than once a month, once or twice a month and once or twice a week.

Age had not a statistically significant effect, although previous findings suggested age reduces consumption (Vicente-Herrero and López-González 2014). Caution must be taken regarding the interpretation of these results because the sample in this study has a

lower variability among respondents' ages than the one from the study of Vicente-Herrero and López-González (2014). Males, when compared with females, were more likely to be daily drinkers and less likely to drink less than once a month. This result is consistent with Nayga and Capps who concluded that males were less likely to be abstainers (Nayga and Capps 1994). On the other hand, one extra year of school attendance reduced the probability of daily consumption by 1.3 percentage points and increased the probability to drink less than once a month by 0.5 percentage points.

Concerning respondents' marital status, being married increased frequency of daily consumption. This result is different from the one from Kerr et al. (2009), who concluded that married respondents had lower alcohol consumption (Kerr et al. 2009). Previous studies showed that peer influence induced individuals to drink alcohol when those around them were also drinking alcohol (Larsen et al. 2010). Spousal influence was also found to be a determinant of alcohol consumption and other health behaviours (Barlow 2011; Dollar et al. 2009; Homish and Leonard 2008, 2005; Leonard and Homish 2005; Leonard and Eiden 2007). Evidence suggests that marriage exerts an influence both with respect to excessive drinking and the development of alcohol disorders (Leonard and Eiden 2007).

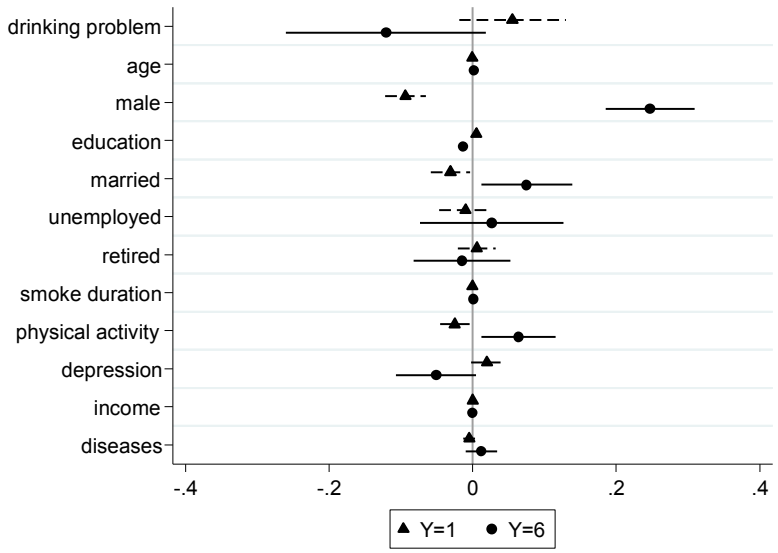
Previous findings suggested that the presence of depression in alcohol-dependent persons is likely to influence negatively treatment outcomes (Kuria et al. 2012), and our results show that having a history of depression increased the probability of reporting the first four categories of consumption, but reduced the frequency of daily alcohol consumption, possibly due to medical advice. The number of diseases, used as a proxy for worse health status, did not influence alcohol consumption. Concerning health-related behaviours, the smoking habit had not a statistically significant effect. On the other hand, being sedentary reduced daily consumption, although it increased all other categories of consumption, with higher effect on the first category.

The current study did not find any statistically significant association between unemployment and retirement and frequency of alcohol consumption, nor of income, which suggests alcohol consumption is not caused by economic motivations. In previous studies, unemployment and income emerged as important determinants of alcohol

consumption (Ogwang and Cho 2009). Su and Yen (2000) concluded that employed individuals were more likely to consume alcohol, and Meng et al. (2014) described that lower income levels increased abstention (Meng et al. 2014).

To better understand if the marginal effects are large enough to be considered important, we also draw a graphical display of regression results (Jann 2014). Figure 8 includes the marginal effects of observing the extreme categories of alcohol consumption, namely 'less than once a month' $(\mathrm{Y} = 1)$ and 'almost every day' $(\mathrm{Y} = 6)$. These results should be confronted with the Table 15 presented before, in which the statistically significant effects were also shown. Regarding the probability of observing the highest category of consumption $(\mathrm{Y} = 6)$, the variables with a greater effect were past drinking problems and gender. These variables also had larger effect on the probability of reporting the category of consumption $\mathrm{Y} = 1$, which is drinking less than once a month.

Figure 8 Marginal effects Y=1 and Y=6



Legend: Spikes for 95% confidence intervals.

One of the specification issues in ordered models is the parallel regression assumption, because of the latent variable formulation. We implemented the approximate likelihood-ratio test of equality of coefficients across response categories.

The null hypothesis of proportional odds assumption was not rejected, which supports the bivariate probit model. Moreover, given that our dependent variable is an ordered response, the possibility that the estimated probabilities are not increasing in i for all values of x, which can happen if β_i are allowed to differ, does not seem reasonable, and we lose efficiency if we estimate an unordered model (Wooldridge 2010).

4.5. Chapter concluding remarks

In the current chapter, we investigated whether self-assessed past drinking problems, as a measure of alcohol addiction, was related to current alcohol consumption. We wanted to test if individuals who experienced drinking problems regretted their past decisions and stopped drinking.

The main difficulty in developing studies focused on alcohol consumption is to choose the adequate concept and measure of harmful consumption. It is not easy to identify what levels of alcohol consumption are 'undesirable'. If we consider a measure of level of consumption in a single occasion we can capture a heavy episodic drinking, but we are not able to identify if this consumption is prejudicial. Another possibility is to measure the frequency of consumption, but again we cannot conclude that alcohol consumption entails negative consequences only because the individual drinks every day. It may be useful to consider a measure that combines both the frequency and the level consumed, and that includes the classification of the consequences arising from alcohol use.

The problems related with measurement increase if we want to assess alcohol addiction, and the use of valid instruments is of central importance (Conway et al. 2010; Samet et al. 2007). It could also be relevant to not only measure addiction propensity but also addiction severity, given that alcohol addiction affects people differently. Many addicted people keep their jobs, families, responsibilities and social interaction, and are called high-functioning alcoholics (Benton 2009; Johnson et al. 2000; Yechiam et al. 2005). Usually, these individuals keep their addiction hidden from society, but they are addicted

as well as those who experience severe, noticeable side effects (for example car accidents, loss of family and friends, being fired from work). Despite the existence of instruments to diagnose alcohol dependence, which also allows the identification of the severity of dependence (Samet et al. 2007), if we considered only the diagnosis of alcohol consumption, we cannot identify undiagnosed alcohol dependents.

Accordingly, the difficulties to measure alcohol addiction reveal that health policy debates are needed to clarify how to measure health risk behaviours. For more insightful analyses, it is required a definition of a measurement approach and valid instruments to quantify alcohol addiction, as well as the severity of manifested addiction.

In order to overcome these problems, our main explanatory variable ('drinking problem') is related to excessive and problematic drinking in the past and fits the assumption of harmful side effects due to alcohol consumption. The results of this chapter show that individuals did not become abstainers after having experienced past drinking problems, which reveals interdependence between past and present alcohol consumption, possibly due to addiction. Moreover, past drinking problems have a positive effect on the probabilities of consuming alcohol less than once a month up to five or six days a week, but reduced the probability of choosing the highest category of alcohol consumption. It thus seems that drinking problems in the past do not discourage respondents from consuming alcohol regularly.

These remarks can shed some light on prevention policies concerning alcohol consumption. Our results showed harmful alcohol consumption in the past is an important determinant of present alcohol consumption. Then, to reduce non-communicable avoidable diseases related to alcohol consumption, it is important to consider the individuals' decisions regarding alcohol consumption during their lifetime. Interventions must contemplate different targets based on drinking patterns, namely to distinguishing between heavy and moderate drinkers.

Some limitations of this work should be noted. We have measured alcohol addiction in the past, but addiction in the present was not observed, because we just had information on current frequency of consumption. Moreover, we do not know the exact

moment when the past drinking problems occurred. Our dataset does not include neither genetic factors, which may influence drinking patterns (Agrawal et al. 2013; Edenberg 2007), nor parental alcohol-related behaviour (Edwards et al. 2017; Stafström 2014).

5. Final conclusions

The need to contain public health expenditures is a central question in an economic context of growing pressure on national budgets. One potential strategy to achieve this objective is to apply effective and efficient prevention policies to reduce avoidable diseases, and related treatment costs. Nowadays, noncommunicable diseases are the major public health concern and are accountable for the most of the deaths and disease burden in the world. Tobacco and alcohol consumption are listed among the 10 leading risk factors that cause death and disability in the world, linked with nearly all of the noncommunicable chronic diseases, with economic consequences as well. If these behaviours are reduced, deaths and diseases could be avoided, with economic and health gains.

This work aimed to contribute with empirical evidence to support prevention policies, related to unhealthy behaviours, thus favouring NHS sustainability. More specifically, we were interested in identifying the variables that influence tobacco and excessive alcohol consumption and empirically discuss the more opportune moment to implement prevention policies concerning tobacco cessation. The potential links between alcohol and tobacco consumption were also studied, which could prompt the adoption of concerted policies. Moreover, we discussed the addictive nature of tobacco and alcohol and analysed addiction's effect in what concerns to alcohol consumption.

This dissertation was structured to provide empirical evidence to assess and discuss the determinants of tobacco and excessive alcohol consumption, as unhealthy and addictive behaviours, and the need to reduce their prevalence through prevention policies. In Chapter 1 we have clarified the importance of this subject, pointing some of the tobacco and excessive alcohol consumption consequences and the relevance to the public health of better understanding these behaviours.

In Chapter 2 we analysed tobacco consumption decisions. A conceptual policy intervention framework was developed, discussing the more opportune moment to intervene to reduce tobacco consumption. This framework was supported using duration models, namely nonparametric estimates based on years of smoking habit. Additionally, parametric approaches were used to identify variables that influence quitting decisions.

In our conceptual framework, we have shown that timing to intervene should combine individuals' motivations and the expected health gains. The results extracted from the nonparametric analyses revealed that policies implemented in the first 25 years of smoking habit are, possibly, more effective in inducing the decision to quit smoking. The survival function diminishes sharply in that period, approaching 0.5, and the probability of quitting admits a tendency of increase. There is not an obvious optimal point to intervene, but there is no advantage in delaying intervention in the points of the hazard function where the quitting probability is equal to the previous period. For the same quitting probability, the sooner the intervention, the larger the expected policy result and, as consequence, the health gains are greater.

The parametric estimates based on the number of years of smoking, allowed identifying the determinants of quitting decisions. We found that unemployment and higher education reduced the hazard of quitting, which increases the duration of the smoking habit. Gender and marital status were also important determinants of the number of years of smoking. Men were less likely to quit smoking earlier and married, divorced and widowers were more likely to stop smoking, compared with single. In what concerns health-related habits and health status, although we did not find a statistically significant effect of alcohol consumption or physical activities, healthy eating habits presented a positive effect on quitting probability, as well as worse health status. This last effect suggests that individuals decide to stop smoking possibly to improve their health. Moreover, the income's effect on the hazard of quitting was virtually non-existent. This result may explain, to some extent, why policies focused on price increases do not seem to have the expected impact in Portugal.

Our results suggest the need to explore synergies among different areas, such as health policy and social and education policies, due to the positive impact of unemployment situation and education on the duration of the smoking habit. Policies could further be differentiated based on gender and marital status. It could be relevant for policy purposes to use different strategies encouraging smoking cessation besides price increases.

Chapter 3 includes a theoretical and empirical discussion of the similarities and correlations between alcohol and tobacco consumption, given that they are both unhealthy habits and addictive behaviours. We included alcohol and tobacco consumption equations in the same empirical model, a bivariate probit model, which allowed testing correlations between the error terms of alcohol and tobacco equations. The results showed that tobacco consumption was not correlated with the used measure of alcohol consumption, which can reveal that different addiction degrees are associated with distinct health behaviours. The individuals who admitted having three or more drinks a day seem to have different incentives compared with the group of current smokers.

This work has also allowed identifying variables that influenced individuals to concurrently use alcohol and tobacco, and that encourage drinkers to also smoke. If policymakers want to reduce both alcohol and tobacco consumption, or tobacco consumption among alcohol consumers, it is important to define the priority targets based on age, gender, marital status, education, health status and health-related habits. Older and married individuals were found to be less likely to drink three or more drinks a day and also to smoke. On the other hand, males were more likely to consume both alcohol and tobacco. Individuals with less healthy eating habits were more likely to engage in tobacco and alcohol use and worse health status was found to reduce the simultaneous consumption of these two goods. Additionally, it is important to account the positive effect of education on joint consumption, as well as on tobacco consumption among alcohol consumers. In addition, data has shown that physical activities should be encouraged if we want to reduce the consumption of tobacco among individuals who consume three or more drinks a day.

In chapter 4 we analysed the effect of addiction on current alcohol consumption, using an ordered probit model. Our assumption was that not all individuals who consume alcohol throughout life are addicted, and addiction requires the occurrence of problems related to excessive alcohol consumption in the past. We tested the influence of a drinking problem in the past, which we associate with addiction, in the current frequency of alcohol consumption. Given that the dependent variable was an ordered categorical

variable, we have discussed the probabilities of reporting each of the categories of alcohol consumption.

Our results showed that individuals do not become abstainers after having experienced past drinking problems, which reveal a link between alcohol consumption at different points in time, possibly due to addiction. Moreover, past drinking problems had a positive effect on the probabilities of consuming alcohol less than once a month up to five or six days a week, but reduced the probability of choosing the highest category of alcohol consumption. It thus seems that drinking problems in the past do not discourage regular consumption. These remarks suggest that policies must consider the individuals' decisions regarding alcohol consumption during their lifetime.

Behavioural decisions concerning health are difficult to evaluate. Available statistical information on this topic is mostly collected through surveys and individuals reveal their perception with respect to their own behaviour. Therefore, unhealthy behaviours could be under-reported.

This dissertation revealed some difficulties concerning data availability and measurement of health-related behaviours, as well as the lack of clear concepts firmly established. It could be particularly useful to clarify the concept and the measures of alcohol addiction and problematic alcohol consumption, given that alcohol consumption, *per se*, may not entail negative consequences or prove addiction. In fact, although it is widely accepted that current tobacco consumption is associated with an addictive behaviour, this is not straightforward regarding alcohol consumption decisions. Further studies can benefit from health policy discussion on the appropriate measurement techniques and valid instruments. For example, it could be useful to construct an index for measuring addiction based on consumption's characteristics – namely number of glasses/cigarettes per day, years of consumption, days of consumption – and experienced problems related to unhealthy habits – such as health consequences and related costs, number of hospital admissions due to diagnosis of alcohol abuse, treatments to stop smoking or drinking, interpersonal difficulties with family and friends, work problems and absenteeism from work. This kind of tools can help us understand the severity of addiction.

The available data used in this dissertation captures tobacco and alcohol consumption, at a moment in time, but does not allow distinguishing between individual's consumption over time. Moreover, we were not able to recognise different levels of addiction that can be an important factor explaining unhealthy habits. It is also important to continue and deepen the discussion started in this dissertation, on the more opportune moment to intervene, in order to reduce tobacco consumption. In particular, it could be valuable to continue examining the role of the duration of the smoking habit when choosing policy targets.

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