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MODELLING ALCOHOL CONSUMPTION DURING ADOLESCENCE USING ZERO INFLATED NEGATIVE BINOMIAL AND DECISION TREES

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Abstract

Alcohol is currently the most consumed substance among the Spanish adolescent population. Some of the variables that bear an influence on this consumption include ease of access, use of alcohol by friends and some personality factors. The aim of this study was to analyze and quantify the predictive value of these variables specifically on alcohol consumption in the adolescent population. The useful sample was made up of 6,145 adolescents (49.8% boys and 50.2% girls) with a mean age of 15.4 years (SE= 1.2). The data were analyzed using the statistical model for a count variable and *Data Mining* techniques. The results show the influence of ease of access, alcohol consumption by the group of friends, and certain personality factors on alcohol intake, allowing us to quantify the intensity of this influence according to age and gender. Knowing these factors is the starting point in elaborating specific preventive actions against alcohol consumption.

Keywords: zero inflated negative binomial model, drinking behavior, social drinking, data mining, decision trees, adolescence.

Resumen

El alcohol es actualmente la sustancia más consumida entre la población española adolescente. Algunas de las variables que influyen en su consumo incluyen la facilidad de acceso, el uso de alcohol por parte de los amigos y algunos factores de personalidad. El objetivo del presente estudio era analizar y cuantificar el valor predictivo de estas variables específicamente sobre el consumo de alcohol en la población adolescente. La muestra útil estuvo formada por 6,145 adolescentes (49.8% chicos y 50.2% chicas) con una edad media de 15.4 años (ES=1.2). Los datos fueron analizados a través del modelado estadístico de una variable de recuento y técnicas *Data Mining*. Los resultados pusieron de manifiesto la influencia en el consumo de alcohol de la facilidad de acceso, el consumo de alcohol por parte del grupo de amigos y de factores de personalidad, cuantificándose la intensidad de dicha influencia en función de la edad y el género. El conocimiento de estos factores constituye el punto de partida en la elaboración de actuaciones preventivas concretas para el consumo de alcohol.

Palabras clave: modelo binomial negativa de ceros hinchados, consumo de alcohol, bebedor social, data mining, árboles de decisión, adolescencia.

Introduction

Alcohol is currently the most consumed substance among the Spanish population between 14 and 18 years of age, with the percentage of school children within this age group having consumed during the last year reaching 72.9% (Delegación del Gobierno para el Plan Nacional sobre Drogas, 2008). In this sense, the phenomenon of binge drinking in a public place has played an important role (Gual, 2006).

The consequences of alcohol abuse in adolescence have been widely described (Bentler, 1992) and include physical, neuropsychological, social and economic repercussions, with traffic accidents and greater odds of having alcohol-related problems in adulthood standing out (Rohde, Lewinsohn, Kahler, Seeley, & Brown, 2001). Another of the relevant consequences of the (early) use of alcohol is the greater odds of using illegal drugs in the future (Johnson, Boles, & Kleber, 2000). Along these lines, the escalation theory postulates that there are sequential steps in drug initiation, beginning with legal drugs which will make the later use of illegal drugs easier (Kandel & Logan, 1984; Kandel & Yamaguchi, 1993; Kandel, Yamaguchi, & Chen, 1992).

Some of the explanatory variables that stand out due to their influence on drug consumption in adolescence include environmental variables such as ease of access to the substances or the use of these by the peer group (Ciairano, Bosma, Miceli & Settanni, 2008; Dick et al., 2007; Morojele et al., 2002; Scholte, Poelen, Willemsen, Boomsma, & Engels, 2008). What is more, a relationship between the consumption of addictive substances and certain personality factors such as antisocial behaviour, sensation-seeking or impulsivity, has been observed (Franken, Muris, & Georgieva, 2006; Hittner & Swickert, 2006; Wong et al., 2006). Therefore, the causal models developed to predict the use of alcohol, tobacco and other drugs include regulations, substance availability, and certain individual factors (Birkmayer, Holder, Yacoubian, & Friend, 2004).

On the other hand, it should be in mind the different changes in maturity occurring in adolescence which have been related to the consumption of alcohol and other drugs (Brown et al., 2008; Niemäl et al., 2006; Schulenberg & Maggs, 2002; Tarter, 2002), or the differential development by gender shown by predictive factors (Bloor, 2006; Cleveland, Feinberg, Bontempo & Greenberg, 2008; White et al., 2006; Yeh, Chiang & Huang, 2006).

The aim of the present study was to analyze and quantify the predictive value of different personality and environmental variables on alcohol consumption in the adolescent population using appropriate modelling techniques and *Data Mining* tools.

Method

Participants

Random cluster sampling was carried out in schools in Mallorca (Spain), from which 47 schools were selected out of 122. Thus, the total sample was made up of 9,300 students aged between 14 and 18 years. It is worth noting that the size of the sample represents 41.16% of the population it was extracted from ($N = 22,593$).

From the above sample, with the aim of being able to identify the variables that specifically influence alcohol consumption, only were selected the subjects who did not consume any addictive substance at all or who only drank alcohol (and who did not consume cannabis, cocaine, ecstasy, LSD, amphetamines or nicotine). Hence, the useful sample was made up of 6,145 adolescents (49.8% boys and 50.2% girls) with an average age of 15.4 years ($SE = 1.2$).

Variables and measurement instruments

The adolescents answered an anonymous questionnaire of our own elaboration which asked about the frequency of use of different addictive substances as well as a series of psychosocial variables which included demographic variables, substance availability, parenting style, consumption by friends, personality factors, social skills, academic performance, and consumption of substances in the family and criminal record.

Variables related to the surroundings (alcohol consumption by peer group and ease of access to the substance) and personality factors (impulsivity, sensation-seeking, self-concept and antisocial behaviour) were taken into account. The dependent variable was the number of *Standard Drink Units* (SDU) consumed per week, one of the most used measurements to record alcohol consumption which counts the quantity of alcohol ingested by a person. In Spain, the standard value of a SDU is 10 grams of pure alcohol.

Alcohol consumption by friends was introduced in the models through 4 variables (all, most, half, and few, with respect to none). Ease of access to the substance

was introduced using a binary variable (yes/no). Finally, the information on personality factors was included in the models using 4 quantitative variables: impulsivity (i.e., “I usually rush”), sensation-seeking (i.e., “I enjoy activities that involve risk”), antisocial behaviour (i.e., “burning or damaging other people’s property”) and self-concept (i.e., “I am satisfied with myself”), calculated from the adolescents’ answers to 19 binary personality items. The adaptation of these factors was previously checked using confirmatory factorial analysis and the 19 items were found to adjust to these 4 factors.

Data analysis

The data in this study were analysed using statistical modelling for a count variable (Stata 10.0) and Decision Trees (SPSS 15.0).

The dependent variables in this study were the SDUs, expressed as count data, what carries out the Poisson regression model (PRM) as the appropriate to analyze this sort of data (Long, 1997), rather than the linear regression model (Palmer, Llorens, & Perelló, 2005). The regression test by Cameron & Trivedi (1990) which evaluates equidispersion, one of the basic assumptions of the Poisson Regression Model (PRM), indicates that most of the sub-samples analyzed did not comply with the assumption of equidispersion, therefore alternative models to the PRM were calculated: *Negative Binomial Regression Model (NBRM)*, *Zero Inflated Poisson (ZIP)* and *Zero Inflated Negative Binomial (ZINB)*, with this last one best adjusting to the data in all cases. This model, as well as providing information about the factors that increase and decrease the number of SDUs consumed, is able to calculate the risk and protection factors associated with alcohol consumption.

On the other hand, with large databases, tools such as *Data Mining* are also considered appropriate (Larose, 2005 and 2006), with decision trees (DT) standing out as one of the most popular, simple, graphic techniques (Han & Kamber, 2006; Kantardzic, 2003; Witten & Frank, 2005; Ye, 2003). In order to organize the variables that predict alcohol consumption in adolescence, decision trees which, from the aforementioned variables, classified adolescents as either consumers of alcohol or abstainers, were constructed.

Results

Factors that increase or decrease the number of SDUs consumed

Tables 1 and 2 present the results of the analysis of factors that increase or decrease the number of SDUs consumed, according to age and gender. In the case of the quantitative variables, the results illustrate the number of SDUs consumed goes up x% for each point the variable rises. In relation to the categorical variables, results show, in comparison with the category of reference, that the presence of a variable increases the number of SDUs consumed by x%.

Table 1. Influence of personal and environmental variables on the number of SDUs consumed a week in boys (ZINB model).

Age	Variable	% change in the number of SDUs expected
14 (n = 750)		
	All my friends drink alcohol	+961.9%
	Most of my friends drink alcohol	+771.2%
15 (n = 893)	Half of my friends drink alcohol	+431.8%
	Few of my friends drink alcohol	+502.4%
	Ease of access to alcohol	+358.1%
	Antisocial behaviour	+18.9%
16 (n = 771)	Antisocial behaviour	+25.2%
	Sensation-seeking	+14.5%
17 (n = 484)	Sensation-seeking	+18.8%
18 (n = 154)		

Note. Only statistically significant variables are shown. Quantitative variable interpretation: the number of SDUs consumed increases by x% for each point the variable increases. Categorical variable interpretation: the variable's presence increases the number of SDUs consumed by x% (in comparison with the reference variable).

In boys (Table 1) it can be seen that at 15 years of age the variables that increase the number of SDUs consumed a week more dramatically correspond to the consumption of friends and ease of access to alcohol. At 15 and 16 years antisocial behaviour (and at 16 and 17 years sensation-seeking) slightly increases the number of SDUs consumed. At 14 and 18 years of age, the variables analysed do not have a statistically significant influence on the consumption of SDUs.

In the case of girls (Table 2), it is possible to see the influence of peer consumption (for instance, at 14, if all friends consume alcohol, the number of SDUs drunk a week is multiplied by 1080.4%, with respect to if no friend consumes alcohol). At 15 and 18 years peer consumption decreases the consumption of SDUs per week. Finally, antisocial behaviour, impulsivity and sensation-seeking are also related to a rise in the number of SDUs consumed.

Table 2. Influence of personal and environmental variables on the number of SDUs consumed a week in girls (ZINB model).

Age	Variable	% change in the number of SDUs expected
14 (n = 862)	Most of my friends drink alcohol	+1080.4%
	All my friends drink alcohol	+909.6%
	Half of my friends drink alcohol	+439.0%
	Few of my friends drink alcohol	+418.9%
15 (n = 848)	Sensation-seeking	+14.3%
	Few of my friends drink alcohol	-77.2%
	Half of my friends drink alcohol	-74.0%
	All my friends drink alcohol	-61.3%
16 (n = 747)	Impulsivity	+6.8%
	Antisocial behaviour	+12.7%
17 (n = 498)	Antisocial behaviour	+18.8%
18 (n = 123)	All my friends drink alcohol	-79.3%
	Most of my friends drink alcohol	-75.8%
	Few of my friends drink alcohol	-86.0%

Note. Only statistically significant variables are shown. Quantitative variable interpretation: the number of SDUs consumed increases/decreases by x% for each point the variable increases. Categorical variable interpretation: the variable's presence increases/decreases the number of SDUs consumed by x% (in comparison with the reference variable).

It is worth noting that in both genders the greater the number of group members who consume alcohol, the greater the number of SDUs drunk by the adolescents.

Risk factors for alcohol consumption

Tables 3 and 4 present the risk factors for alcohol consumption according to gender and age. The column, “% change in the odds of continuing being a non consumer”, represents the change in the odds of continuing as a non consumer of alcohol.

In boys (Table 3), the risk factors that appear in all the age groups are related to alcohol consumption by the group of friends. For instance, at 15 years of age, if all the friends consume alcohol, the odds of continuing being abstinent in this substance decreases 94%, whereas sensation-seeking decreases the odds of carrying on without consuming alcohol by around 20%.

Table 3. Risk factors for alcohol consumption in boys (ZINB model).

Age	Variable	% change in the odds of continuing being a non consumer
14 (n = 750)	All my friends drink alcohol	-95.0%
	Most of my friends drink alcohol	-89.4%
	Half of my friends drink alcohol	-88.1%
	Few of my friends drink alcohol	-72.6%
15 (n = 893)	All my friends drink alcohol	-94.0%
	Most of my friends drink alcohol	-85.9%
	Sensation-seeking	-19.5%
16 (n = 771)	All my friends drink alcohol	-90.6%
	Most of my friends drink alcohol	-87.7%
	Half of my friends drink alcohol	-77.6%
	Sensation-seeking	-22.6%
17 (n = 484)	All my friends drink alcohol	-93.4%
	Most of my friends drink alcohol	-88.4%
	Self-concept	-29.1%
18 (n = 154)		

Note. Only statistically significant variables are shown. Interpretation: the presence of the variable increases/decreases the odds of continuing as a non-consumer.

In girls (Table 4), the statistically significant risk factors are related to environmental factors: ease of access decreases the odds of continuing being a non consumer by 57.3% at 15 years of age, whereas consumption by friends decreases the odds of continuing without drinking this substance between 63 and 97%.

It is worth noting that in general and for both genders the greater the number of drinking friends in a peer group, the smaller are the odds of continuing to be an abstainer.

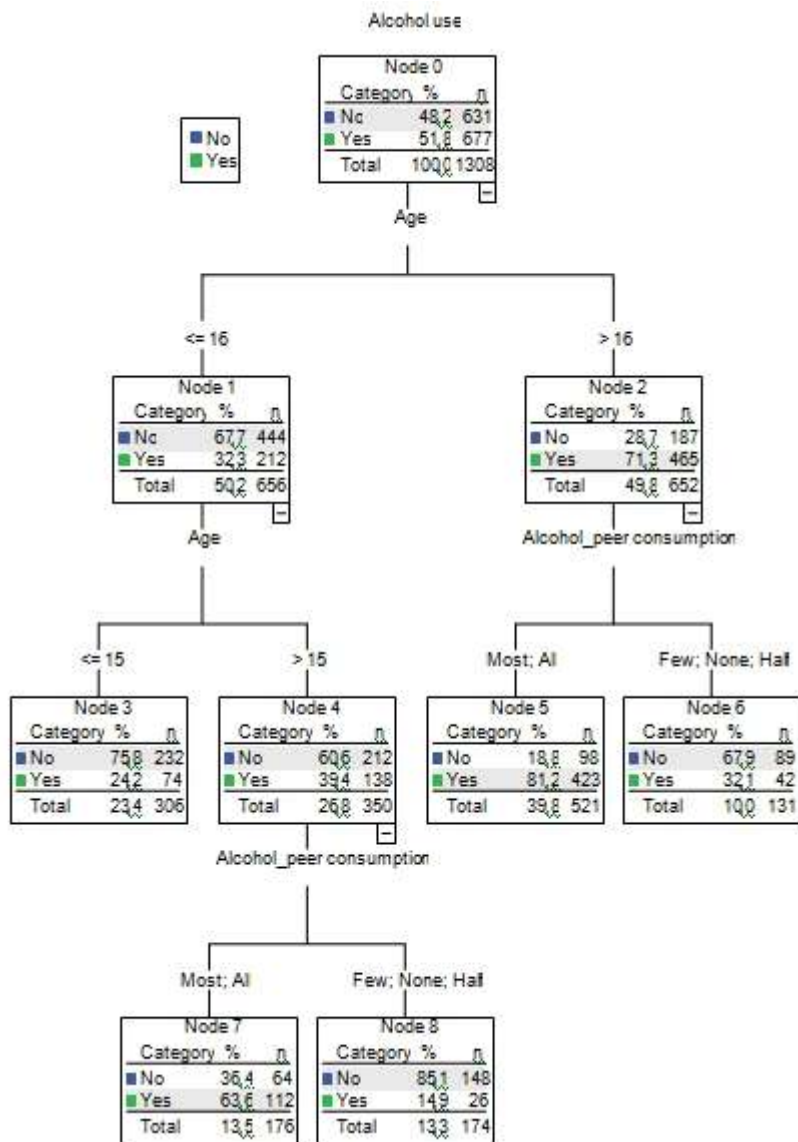
Table 4. Risk factors for alcohol consumption in girls (ZINB model).

Age	Variable	% change in the odds of continuing being a non consumer
14 (n = 862)		
	All my friends drink alcohol	-96.8%
15 (n = 848)	Most of my friends drink alcohol	-85.8%
	Half of my friends drink alcohol	-82.2%
	Few of my friends drink alcohol	-63.0%
	Ease of access	-57.3%
16 (n = 747)	All my friends drink alcohol	-85.3%
	Most of my friends drink alcohol	-74.2%
17 (n = 498)		
18 (n = 123)	All my friends drink alcohol	-94.8%

Note. Only statistically significant variables are shown. Interpretation: the presence of the variable increases/decreases the odds of continuing as a non-consumer.

Figure 1 shows a decision tree for alcohol consumption (n = 4,528) calculated using the QUEST (*Quick, Unbiased, Efficient Statistical Tree*) algorithm (Loh & Shih, 1997). The tree obtained allows predicting whether an adolescent will consume alcohol or will remain an abstainer with a risk of 0.234. The decision tree correctly classifies 74.3% of the non consumers of alcohol and 79% of the consumers of this substance, highlighting age and peer consumption as the most relevant variables to predict alcohol consumption in adolescence. That is, for instance, if an adolescent is 16 years old and most of his/her friends consume alcohol, the decision tree classifies this person as a consumer, whereas if only half, few, or none of the friends use this substance, the adolescent in question will be a non consumer of alcohol.

Figure 1. Decision tree for alcohol consumption in adolescence (QUEST algorithm).



Discussion

The aim of this study was to analyze and quantify the predictive value of personality and environmental variables specifically on alcohol consumption in the adolescent population as well as to implement *Data Mining* techniques which would make it possible to extract interesting relationships from the data. With this aim in mind, adolescents who did not consume any psychoactive substance were compared with adolescents who only drank alcohol.

Along the lines of other research, the results show the influence of environmental variables such as ease of access and alcohol consumption by the group of friends on alcohol drinking (Komro, Maldonado-Molina, Tobler, Bonds, & Muller, 2007; Martins, Storr, Alexandre, & Chilcoat, 2008; Molyneux et al., 2004), with the magnitude of this influence depending on the number of drinking people in the group (Simons-Morton & Chen, 2006). On the other hand, certain personality traits also influence alcohol drinking, albeit in a more modest way (Giancola, Mezzich, & Tarter, 1998; Inglés et al., 2007; Martins et al., 2008; Petterson, Hawkins, & Catalana, 1992). That is, the proven relationship between antisocial behaviour and the use of addictive substances, whether legal or illegal, stands out (Jessor & Jessor, 1980; Llorens, Palmer, & Perelló, 2005; Robins, 1980). Finally, as pointed out in other research, the risk and protection factors vary and act with different intensity depending on age and gender (Piko, 2006; Yeh et al., 2006).

The influence of the consumption behaviour of the group of friends' on an adolescent's alcohol consumption should not bemuse us if we bear in mind that adolescence is characterised by the search for a new reference in order to build up one's own personal identity, making the group the main affective, attitudinal and behavioural reference. As far as ease of access to the substance is concerned, it would seem that Spain is still, due to its socio-cultural characteristics, a country that is very tolerant towards alcohol consumption and trade, despite prohibiting its sale to under 18s; and has one of the lowest prices in Europe.

Other studies (Piko, 2006) have found gender differences in the social influences on alcohol drinking in the sense that boys appear to be more sensitive to social influences, while in girls the best friend's role is the socially dominant influence. Perhaps the gender of the friends who consume or certain characteristics they may have (Dick et al., 2007) could explain some of the paradoxical results concerning peer influence found in this research (pay attention to remember that in girls aged between 15 and 18 years friends' consumption decreases the number of SDUs consumed).

The results of this work should be interpreted while taking into account some limitations. First of all, the data should be analyzed from a transversal perspective. In this sense, we could ask ourselves whether friends influence the consumption of substances or, as Fowler et al. pointed out (2007), adolescents who consume tend to choose friends similar to them. Nevertheless, Gaughan (2003) found that peer influence

is maintained after controlling for this tendency. Moreover, the data analyzed are self-reported and do not include the viewpoint of different family members.

The interest of this study lies in having a large sample size covering a third of the schools on the island of Mallorca, analyzing the data using a technique that is appropriate for count data, and using *Data Mining* techniques which allow to extract relevant associations in large dimension matrixes. Focused on the specific field of addictions, few studies have used the aforementioned tools to analyze the data (Kitsantas, Moore, & Sly, 2007; Llorens, Perelló, & Palmer, 2005). Furthermore, an evolutionary, gender differentiated, multifactorial view of the variables related to alcohol consumption during adolescence is offered, quantifying the role of each one of them and analyzing the variables that are specifically related to alcohol consumption, and the threshold to the consumption of other addictive substances (Kandel et al., 1992; Kandel & Yamaguchi, 1993). A fine knowledge of these factors is essential not only in order to understand the addictive problem, but also because it is necessary to determine the starting point in drawing up specific prevention actions against alcohol consumption.

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