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Tob Control. 2014 Jul;23(4):302-7.

which has been published in final form at

<http://dx.doi.org/10.1136/tobaccocontrol-2012-050548>

- Padrón A, Galán I, Rodríguez-Artalejo F. Second-hand smoke exposure and psychological distress in adolescents. A population-based study. *Tob Control* 2014;23:302–7. Impact Factor: 5.933 (Q1) (doi: <http://dx.doi.org/10.1136/tobaccocontrol-2012-050548>).  
<https://tobaccocontrol.bmj.com/content/23/4/302>

## **Second-hand smoke and psychological distress in adolescents. A population-based study**

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Word count: 2441

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## **ABSTRACT**

**Objectives.** To examine the association between duration and place of second-hand smoking (SHS) and psychological distress in adolescents.

**Methods.** Cross-sectional study conducted in 2008 and 2009 in a representative sample of 4<sup>th</sup>-year students of secondary education (mean age 15.7 years) in the region of Madrid, Spain. The 2215 students who were not smokers were selected for the analysis. Duration of SHS within and outside the home was obtained by self report. Psychological distress was defined as a score  $\geq 3$  points in the General Health Questionnaire (GHQ-12). The analyses were made using logistic regression adjusted for demographic variables, lifestyles and family characteristics.

**Results.** In the non-smoking adolescents, 27.8% (95% CI: 25.5-30.0) were exposed to SHS in the home, and 33.6% (95% CI: 31.3-36.0) outside the home. Compared to those with no SHS exposure in the home, the multivariate odds ratio for psychological distress was 1.23 (95% CI: 0.92-1.64) in individuals with SHS exposure <1 hour/day, 2.07 (95% CI: 1.30-3.28) for exposure 1-3 hours/day, and 2.24 (95% CI: 1.45-3.47) for exposure >3 hours/day (p for linear trend <0.001). No association was observed between SHS outside the home and psychological distress.

**Conclusions.** In non-smoking adolescents, duration of exposure to SHS in the home showed a positive dose-response relationship with the frequency of psychological distress.

**Keywords.** Mental health, second-hand smoke, adolescents.

**Abbreviations.** Second-hand smoke (SHS), General Health Questionnaire (GHQ-12), Body mass index (BMI), odds ratios (OR)

## **INTRODUCTION**

Exposure to second-hand smoke (SHS) causes low birthweight, respiratory disorders and late fetal death, with no known risk-free level of exposure (1). In addition, both prenatal and postnatal exposure may give rise to neurobehavioural developmental disorders from birth to adolescence (2). Nevertheless, in Spain one out of four children under age 15 is routinely exposed to SHS in the home (3).

Mental health disorders in adolescents are an important public health problem (4); in fact, suicide is one of the leading causes of death in young people (5), and in developed countries neuropsychiatric problems are responsible for 22% of disability-adjusted life years (DALY) lost (6), a figure which is probably higher in adolescents (4). Moreover, the frequency of both SHS exposure and psychological distress is increasing in this age group (3;7). To date, however, only one study has explored the relationship between SHS and general mental health in preadolescents and adolescents (8), with the finding of a positive association. Furthermore, little is known as to how the duration of SHS exposure and the setting in which it occurs affects mental health in adolescents.

Recent years have seen important advances in legislation to combat SHS in Spain. However, “Law 28/2005 on health measures against smoking” did not lead to reduced SHS exposure in the home (9;10), and achieved just small changes in exposure in bars and restaurants, because it only partially restricted smoking in these establishments (11). This gave rise in January 2011 to new legislation that has finally banned smoking in practically all enclosed public spaces (12). Thus, an analysis of the relationship between SHS and mental health in adolescents in places not yet regulated (e.g., the home) could help guide future policies and programmes for smoking prevention.

Accordingly, this study examined the association between duration and place of SHS and psychological distress in adolescents.

## **METHODS**

### **Study design and population**

The data were taken from the Risk-Factor Surveillance System for Non-communicable Diseases (SIVFRENT) in adolescents (13). This system monitors major health-related lifestyles in a representative sample of 4th-year students of secondary education in the region of Madrid (Spain).

The centres were stratified by geographic area (Madrid capital or other municipalities) and type of centre (public or private), with the probability of selection being proportional to the number of students enrolled. Two classrooms were randomly selected in each school. Students completed the questionnaire in the classroom in the presence of trained personnel. The participation of schools and students was voluntary after obtaining informed consent. The information was collected in 2008 and 2009 in 94 schools and 185 classrooms.

The response rate was 81.3% for schools and 91.6% for students. A total of 8.3% of students did not participate because they were absent from class on the day of the survey, and 0.1% declined to participate. The overall study response rate (schools and students) was 74.5%, with information initially obtained from 4244 students.

### **Study variables**

Psychological distress was assessed with the General Health Questionnaire (GHQ-12), which has been validated for use in Spanish (14). Although the GHQ-12 was originally developed for adults, it has also been used satisfactorily in adolescents (15). This questionnaire has also

demonstrated good psychometric properties in the sample that participated in this study (16). The GHQ-12 is composed of 12 questions, each of which has four possible responses. Responses were classified using a binary (“classic”) scoring method, in which the options “much less than usual” and “same as usual” receive 0 points, and “more than usual” and “much more than usual” receive 1 point. The overall score ranges from 0 to 12 points. A cut-off of  $\geq 3$  points was used to classify individuals with possible psychological distress (17).

With respect to SHS, we asked how long the respondent was in enclosed areas with tobacco smoke (never or only sporadically, <1 hour/day, 1-3 hours/day, >3 hours/day), both within and outside the home. We also asked whether the father or mother smoked, and whether there were regular smokers in the home.

Information was collected on sociodemographic variables like age, sex and birthplace, and about family characteristics such as living with parents, parents’ employment status and parents’ educational level. With respect to lifestyles, respondents were asked if they engaged in any of 19 types of physical activity. Based on their replies, we identified persons who did vigorous physical activity (>5 METs) three or more times per week. In addition, using a brief food frequency questionnaire, we estimated fruit and vegetable consumption, classifying subjects according to whether they consumed  $\geq 3$  portions of fruits or vegetables per day. We also assessed alcohol consumption, and considered a high risk drinker to be one who met at least one of the following criteria: a) regular consumption of over 50 ml (in men) or 30 ml (in women) of pure alcohol per day, estimated from the usual intake of 8 types of alcoholic beverages; b) having had an episode of binge drinking in the last 30 days (consumption of  $\geq 6$  standard drink units in a single drinking session); and c) having been inebriated in the last 12 months. Drug users were considered to be those who had consumed any type of illegal substance in the last 12 months. Information was also collected on three risk behaviours for

eating disorders in the last 12 months: going 24 hours without eating, inducing vomiting, and taking laxatives, diuretics or other drugs (in all three cases, to lose weight or control body shape).

Based on reported data, we calculated the body mass index (BMI) as weight in kg divided by height in m squared. Finally, students reported on their body image, in particular, if they perceived themselves as very thin, thin, adequate weight, overweight or obese.

### **Statistical analysis**

The 7.5% of subjects who lacked information on any of the main study variables were excluded, and 0.8% of questionnaires were discarded due to inconsistent responses. From the 3893 subjects available for the analysis, we then selected the adolescents who had never smoked, resulting in a final analytical sample of 2215 individuals.

To examine the association between duration of exposure to SHS and psychological distress, separate logistic models were used for SHS within and outside the home. Duration of SHS was modelled using dummy terms. Five sequential logistic models were constructed with progressive adjustment for potential confounders of the studied association. The first (model A) was a crude model. The second (model B) included socio-demographic variables (age, sex, birthplace) and variables related to family characteristics (living with parents, parents' employment status, and parents' educational level). The third (model C) also included physical activity, consumption of fruits and vegetables, of alcohol and drugs, behaviours related to eating disorders, BMI and body image. The fourth (model D) additionally adjusted for father's smoking, mother's smoking, and presence of regular smokers in the home. Finally, the fifth (model E) also adjusted for SHS outside the home when the exposure of interest was SHS within the home, and vice versa.

The  $p$  for linear trend was calculated to evaluate the dose-response relationship between SHS and psychological distress. We also tested whether the relationship between SHS exposure and psychological distress varied with age and sex using likelihood ratio tests to compare models with and without interaction terms.

The analyses were made using the “Survey Data” module of Stata v.11.0 for Windows (1984-2010 StataCorp, Texas, USA), which takes account of the complex sampling design of the study.

## **RESULTS**

About 48.0% (95% CI: 45.4-50.6) of the non-smoking adolescents were exposed to SHS. Around 27.8% (95% CI: 25.5-30.0) were exposed to SHS within the home, and 33.6% (95% CI: 31.3-36.0) were exposed outside the home. The frequency of SHS within the home was higher in persons born in Spain and in those whose parents had lower educational level. Exposure to SHS outside the home was more frequent in older adolescents, in women, in individuals whose father was unemployed, and in those whose mothers had lower educational level (Table 1).

The prevalence of psychological distress increased progressively with time of SHS exposure in both places ( $p$  for linear trend  $<0.001$ ) (Table 2).

SHS exposure in the home showed a positive dose-response relationship with frequency of psychological distress: the longer the exposure, the greater the frequency of psychological distress ( $p$  for linear trend  $<0.001$ ). This association was observed both in the crude model and after adjustment for all the potential confounders, although the magnitude of the association increased slightly in the more fully adjusted models (Table 3). Even after adjusting for SHS outside the home, and compared with those who had no SHS exposure in

the home, the multivariate odds ratio (OR) for psychological distress was 1.23 (95% CI: 0.92-1.64) in individuals with SHS <1 hour/day, 2.07 (95% CI: 1.30-3.28), in those with SHS 1-3 hours/day, and 2.24 (95% CI: 1.45-3.47) in those with SHS >3 hours/day; p for linear trend <0.001) (Table 3).

With respect to SHS exposure outside the home, the ORs for psychological distress were statistically significant only in the crude model for those exposed during >1 hour/day. This association lost statistical significance after progressive adjustment for the main confounders (Table 4).

No statistically significant interactions were found with age or sex in the relationship between SHS and psychological distress.

## **DISCUSSION**

This study shows that, in non-smoking adolescents, there is a positive dose-response relationship between duration of exposure to SHS in the home and frequency of psychological distress. SHS exposure for >1 hour/day is associated with a statistically significant excess in the frequency of psychological distress.

The high prevalence of exposure to SHS in non-smoking adolescents in Madrid is of concern for various reasons. First, the passive smoker is exposed to both smoke exhaled by the smoker (mainstream smoke) and smoke from the lighted cigarette (sidestream smoke), which contains the same substances that are harmful to the central nervous system but some of them at even greater concentrations (18;19). Second, the toxic substances remain in the environment (on surfaces and in dust) up to months after smoking and may be resuspended in the air or react with other substances to produce new toxicants (third-hand smoke). It is known that young children are very sensitive to this type of exposure (20). Finally, according

to the results of animal models, the neurological alterations produced by nicotine may be greater when the central nervous system is still developing than in adulthood (21;22).

Our results show that exposure to SHS is associated with greater frequency of psychological distress independently of other risk factors for mental health in adolescence, such as drug consumption, eating disorders, and body image (23-25). While substantial research has been made on the negative impact of active smoking on mental health (26), only one study has examined the effect of exposure to SHS in adolescents. Bandiera et al. found significant associations between passive smoke exposure and symptoms of several mental disorders in individuals between 8 and 15 years of age (8). Other authors have also observed an association between SHS and poorer mental health, as assessed with the Strengths and Difficulties Questionnaire (SDQ), in children in various age groups (27-29).

In our study the association between psychological distress and SHS was not observed outside the home. To our knowledge, the only study that has differentiated between places of exposure was conducted by Hamer et al. in children aged 8-12 years; these authors also found an association between mental health and SHS in the home, but not in public places (29). The different results by place of SHS exposure may be attributed to various reasons. First, it is possible that SHS exposure in the home is more intense than outside the home, even when the time of exposure is the same. In this regard, studies in adults have found that SHS exposure in the home contributes more to the intensity of overall exposure to SHS than exposure in other settings (30;31). Second, the possible harmful effect of SHS outside the home may be offset by a better mental health associated with social relationships during leisure time (32;33). Third, the association between SHS in the home and poorer mental health could be partly explained by prenatal exposure to tobacco. In our study, we had no information on smoking during pregnancy, therefore we were unable to distinguish the effect of prenatal

versus postnatal exposure. However, the associations remained after adjusting for maternal smoking, a variable that in several studies has been shown to correlate highly with prenatal exposure (34;35). Studies in children have observed an independent association between postnatal exposure and the risk of behavioural disorders (2). It has even been argued that exposure to SHS during childhood may be more harmful to neuronal development than intrauterine exposure (34;36).

Although we found no studies on the dose-response relationship between SHS and mental health in adolescents, our results are consistent with the gradient observed by other authors in the association between SHS exposure and neurobehavioral development in childhood (28;37).

Our study has several limitations. First, given its cross-sectional design, no causal relationships can be inferred. Second, the data were self-reported; however, there is evidence that SHS exposure evaluated with biomarkers correlates acceptably well with self-reported exposure (38). Third, the GHQ-12 is merely a screening instrument, and cannot be used to establish a clinical diagnosis (14). Nevertheless, the GHQ-12 is a valid instrument to identify psychological distress (14) and has shown good psychometric characteristics in the adolescent population that participated in this study (16). Fourth, no information was available on the parents' mental health, so that this factor could not be considered in our analyses (39;40). Finally, it cannot be ruled out that the absence of students on the day of the survey was related to some mental health problem but, since the percentage of absence was not high (8.3%), this is unlikely to have affected the results substantially.

The main strengths of the study are that it was based on a representative sample of the adolescent population, had a high participation rate, and took account of characteristics of the sampling design in the data analysis. We also controlled for numerous potential confounders,

which made it possible to evaluate the independent association between SHS and psychological distress.

In conclusion, duration of exposure to SHS in the home showed a positive dose-response relationship with the frequency of psychological distress in non-smoking adolescents. This finding could have important public health implications given that the “Law on health measures against smoking” (9) has not been successful in reducing exposure to SHS in the home (10). Given that one out of four adolescents is routinely exposed to SHS in the home, these results suggest that additional interventions are needed to reduce SHS and the burden of mental health problems in adolescence.

### **Acknowledgments**

This work was funded by the Madrid Regional Authority for Health, Spain. We thank the study participants for their generous contribution.

Table 1. Prevalence of exposure to second-hand smoke (SHS) in non-smoking adolescents, by sociodemographic variables

	N	SHS at home % (95% CI)	p	SHS outside home % (95% CI)	p
<b>Total</b>	2215	27.8 (25.5-30.0)		33.6 (31.3-36.0)	
<b>Age, years</b>			0.605		0.004
15	925	27.1 (24.2-30.1)		32.4 (29.1-35.8)	
16	948	27.4 (23.7-31.1)		32.0 (28.6-35.3)	
17	342	30.4 (24.2-36.6)		41.5 (36.5-46.6)	
<b>Sex</b>			0.784		0.015
Male	1177	27.5 (24.9-30.2)		31.4 (28.3-34.4)	
Female	1038	28.0 (24.8-31.2)		36.2 (33.3-39.2)	
<b>Country of birth</b>			<0.001		0.275
Spain	1898	30.5 (28.0-33.1)		34.1 (31.6-36.6)	
Elsewhere	317	11.4 (7.5-15.2)		30.9 (25.6-36.2)	
<b>Living with parents</b>			0.153		0.412
With both parents	1906	27.1 (24.8-29.5)		33.9 (31.5-36.4)	
Not with both parents	309	31.7 (25.4-38.0)		31.7 (26.6-36.9)	
<b>Father's work</b>			0.237		0.022
Works	2065	27.5 (25.2-29.7)		33.0 (30.6-35.4)	
Does not work	150	32.0 (24.0-40.0)		42.0 (34.1-49.9)	
<b>Mother's work</b>			0.562		0.669
Works	1587	27.4 (25.0-29.8)		33.9 (31.2-36.6)	
Does not work	628	28.7 (24.6-32.7)		33.0 (29.2-36.7)	
<b>Father's education</b>			0.004		0.090
University	722	22.9 (19.9-25.8)		30.5 (26.7-34.2)	
Secondary	547	29.3 (25.0-33.5)		32.5 (28.0-37.1)	
Primary	597	29.6 (25.6-33.7)		36.5 (32.3-40.7)	
No education	115	39.1 (29.4-48.8)		40.9 (31.9-49.9)	
No answer	234	29.1 (22.1-36.1)		35.0 (28.8-41.2)	
<b>Mother's education</b>			0.038		0.028
University	686	23.6 (20.4-26.9)		30.0 (26.8-33.2)	
Secondary	599	27.7 (24.2-31.3)		33.6 (29.8-37.3)	
Primary	655	31.8 (27.4-36.1)		37.7 (33.9-41.5)	
No education	95	31.6 (20.1-43.1)		37.9 (26.8-49.0)	
No answer	180	27.2 (20.5-33.9)		30.6 (23.9-37.2)	

Table 2. Distribution of duration of exposure to second-hand smoke and prevalence of psychological distress in non-smoking adolescents, by time of exposure

	N	Distribution of exposure to SHS % (95% CI)	Prevalence of psychological distress % (95% CI)	p
<b>Exposure at home</b>				<0.001
None or sporadic	1,600	72.2 (70.0-74.5)	28.8 (26.3-31.3)	
<1 hour/day	345	15.6 (13.8-17.4)	29.3 (24.5-34.0)	
1-3 hours/day	143	6.5 (5.4-7.5)	39.9 (31.4-48.3)	
>3 hours/day	127	5.7 (4.8-6.7)	47.2 (38.8-55.6)	
<i>P for linear trend</i>			<0.001	
<b>Exposure outside the home</b>				0.002
None or sporadic	1,470	66.4 (64.1-68.7)	29.4 (26.9-31.8)	
<1 hour/day	608	27.4 (25.2-29.6)	30.8 (27.0-34.5)	
1-3 hours/day	95	4.3 (3.4-5.2)	41.1 (31.4-50.7)	
>3 hours/day	42	1.9 (1.3-2.5)	50.0 (36.5-63.5)	
<i>P for linear trend</i>			<0.001	

Table 3. Odds ratios (OR) and 95% confidence intervals (CI) for psychological distress in non-smoking adolescents, by duration of exposure to second-hand smoke (SHS) in the home

	Duration of exposure to SHS in the home							
	None/ sporadic Ref.	<1 hour/day OR (95% CI)	p	1-3 hours/day OR (95% CI)	p	>3 hours/day OR (95% CI)	p	<i>P for linear trend</i>
Model A	1	1.02 (0.79- 1.33)	0.865	1.64 (1.14- 2.36)	0.009	2.21 (1.56- 3.13)	0.000	<0.001
Model B	1	1.11 (0.85-1.45)	0.442	1.72 (1.19- 2.50)	0.005	2.03 (1.43- 2.89)	0.000	<0.001
Model C	1	1.01 (0.77-1.33)	0.919	1.66 (1.12- 2.45)	0.012	1.78 (1.24- 2.56)	0.002	0.001
Model D	1	1.22 ( 0.92-1.63)	0.165	2.07 (1.32-3.26)	0.002	2.30 (1.49- 3.57)	0.000	<0.001
Model E	1	1.23 (0.92-1.64)	0.155	2.07 (1.30- 3.28)	0.002	2.24 (1.45-3.47)	0.000	<0.001

Model A: Crude logistic regression model.

Model B: Adjusted for age, sex, place of birth, living with parents, parent's work and parents' education.

Model C: Like Model B with additional adjustment for physical activity, fruit and vegetable consumption, alcohol consumption, drug consumption, eating disorders, body image and body mass index.

Model D: Like Model C with additional adjustment for father's smoking, mother's smoking, and existence of regular smokers in the home.

Model E: Like Model D with additional adjustment for passive smoke exposure outside the home.

Table 4. Odds ratios (OR) and confidence intervals (CI) for psychological distress in non-smoking adolescents, by duration of exposure to second-hand smoke (SHS) outside the home

	Duration of exposure to SHS outside the home							
	None/ sporadic Ref.	<1 hour/day OR (95% CI)	p	1-3 hours/day OR (95% CI)	p	>3 hours/day OR (95% CI)	p	<i>P for linear trend</i>
Model A	1	1.07 (0.88-1.30)	0.511	1.67 (1.12- 2.49)	0.012	2.40 (1.40-4.13)	0.002	0.002
Model B	1	1.05 (0.86-1.29)	0.632	1.49 (0.99- 2.26)	0.057	1.97 (1.07-3.62)	0.029	0.023
Model C	1	1.00 (0.81-1.23)	0.985	1.16 (0.74- 1.80)	0.512	1.56 (0.80-3.04)	0.185	0.312
Model D	1	0.99 (0.81-1.23)	0.951	1.16 (0.74-1.83)	0.515	1.56 (0.79-3.07)	0.194	0.331
Model E	1	0.97 (0.79-1.20)	0.787	1.03 (0.65-1.62)	0.913	1.31 (0.68-2.52)	0.422	0.734

Model A: Crude logistic regression model.

Model B: Adjusted for age, sex, place of birth, living with parents, parent's work and parents' education.

Model C: Like Model B with additional adjustment for physical activity, fruit and vegetable consumption, alcohol consumption, drug consumption, eating disorders, body image and body mass index.

Model D: Like Model C with additional adjustment for father's smoking, mother's smoking, and existence of regular smokers in the home.

Model E: Like Model D with additional adjustment for passive smoke exposure outside the home.

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