

Exposure to second-hand smoke in the home and mental health in children: a population-based study

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ABSTRACT

Objectives. To examine the association between exposure to second-hand smoke (SHS) in the home and mental health among children.

Methods. Cross-sectional study of 2357 children representative of the Spanish population aged 4-12 years in 2011-2012. Duration of SHS exposure in children was reported by parents. Probable mental disorder was defined as a score >90th percentile in the parental version of the Strengths and Difficulties Questionnaire (SDQ). Statistical analysis was performed with logistic regression and adjusted for sociodemographic variables, lifestyle, neighborhood environment, and family characteristics, including parental mental health.

Results. Among study participants, 6.9% (95% confidence interval [CI] 5.7-8.0%) were exposed to SHS in the home during <1 h/day and 4.5% (95% CI 3.5-5.5%) during ≥1 h/day. Compared to children not habitually exposed to SHS, the multivariate odds ratios for probable mental disorder were 1.49 (95% CI 0.85-2.62) for SHS exposure <1 h/day and 2.73 (95% CI 1.38-5.41) for SHS exposure ≥1 h/day (p for linear trend=0.002). The corresponding odds ratios for attention-deficit and hyperactivity disorder (ADHD) were 2.18 (95% CI 1.30-3.64) for <1 h/day exposure and 3.14 (95% CI 1.63-6.04) for ≥1 h/day exposure (p for linear trend <0.001). No association was found between SHS and the rest of components of the SDQ.

Conclusions. Among children, SHS exposure in the home during ≥1 h/day is associated with a higher frequency of mental disorder. This association was mostly due to the impact of SHS on ADHD.

Abbreviations. SHS: second-hand smoke; SDQ: Strengths and Difficulties Questionnaire; OR: odds ratio; CI: confidence interval; ADHD: attention-deficit and hyperactivity disorder.

INTRODUCTION

Second-hand smoke (SHS) exposure in children increases the risk of respiratory conditions, otitis media and sudden-death syndrome, among other health problems.[1] Nonetheless, over 10% of children between 5 and 14 years of age in Spain are regularly exposed to SHS in the home.[2]

It is estimated that up to 20% of children and adolescents are affected by mental disorders.[3,4] Post-natal SHS has been related to worse mental health,[5-9] but the evidence is inconsistent. [1,9-12] In several studies, postnatal SHS exposure has been associated with behavioral disorders [5,6,8] and hyperactivity-inattention [8,9] in children after controlling for prenatal smoking. Also Hamer *et al.* [7] have reported similar findings for SHS exposure specifically in the home. By contrast, Fergusson *et al.* [10] did not find an association between maternal smoking after pregnancy and behavioral problems after accounting for prenatal maternal smoking. Likewise, other authors have reported that the association between SHS in the home and the increased risk for conduct problems was mostly explained by prenatal exposure.[9,12] When it comes to older children, SHS has been linked to mental symptoms in those aged 8-15 years, but the study failed to identify associations with specific diagnoses.[13] However, a recent investigation among adolescents did find a relationship between duration of SHS exposure in the home and psychological distress.[14]

A few studies have examined the relationship between postnatal SHS and a wide range of mental and behavioral disorders in children of different ages using the Strengths and Difficulties Questionnaire (SDQ), but they failed to reach conclusive results.[7-9,12] Finally, although parental mental health has been linked to both SHS exposure and children's mental health,[15-18] the single study which has accounted for parental mental health found that maternal smoking both during and after pregnancy were independently associated with behavior problems in children aged 5 years.[5]

Many countries have adopted smoke-free policies; however, these policies do not usually apply to private areas such as homes or vehicles [19,20] where most of the SHS exposure in children takes place. Thus, in this study we examined the relationship between duration of SHS exposure in the home and children's mental health while accounting for parental mental health.

METHODS

Study design and population

Data were taken from the 2011-2012 Spanish National Health Interview Survey, conducted on a sample representative of the children's population in Spain.[21] Study participants were selected on a multi-stage sampling, stratified according to the size of the municipality. Data were collected using face-to-face interviews from July 2011 through June 2012.

The response rate was 71.1% of surveyed households. The members of a total of 13.7% households were absent from their homes, 14.6% refused to participate, and 0.7% were unable to participate.[22] Data included interviews from 5495 households with at least one child under 15 years of age; if several children of this age lived in the same home, only one of them was selected at random to participate. Information regarding the participating child was collected from one of the parents, a legal guardian, or another adult if neither were available.

We excluded 1522 children under the age of 4 since the SDQ is not appropriate for this specific subgroup. We also excluded 807 children over the age of 12 because experimentation with tobacco products is not unusual at that stage [23] and any tobacco consumption may confound the SHS-mental health relationship examined here. We additionally excluded 701 children whose information was collected from other than parents or legal guardians. Lastly, we excluded 108 children with missing data on the variables of interest. Thus, the final analytical sample included 2357 children.

Study variables

Mental health of the child

We evaluated the child's mental health with the parental version of the SDQ which has shown good validity and reliability in its original version,[24] as well as in Spanish.[25,26] The SDQ consists of 25 questions grouped into 5 subscales: emotional symptoms, conduct problems, hyperactivity-inattention, peer problems, and prosocial behavior. Each question is scored from 0 to 2 based on the following answers: not true, somewhat true, certainly true. The global SDQ score is calculated as the sum of the four first subscales, ranging from 0 to 40.

Individuals with global or subscale scores above the 90th percentile have a substantially raised probability of independently diagnosed mental disorders.[24] As the SDQ scoring system is discrete, cut-off points in either the global or the subscale scores may not match their corresponding 90th percentile and, thus, an approximation is used.[27,28] Thus, we used the cut-off point of the immediately next percentile, as in previous studies.[27-29]

Second-hand smoke (SHS)

We assessed SHS exposure by asking the parent or legal guardian how long was the child exposed to tobacco smoke in the home (not habitually exposed [never or only sporadically], <1h/day, and \geq 1h/day).

Potential confounders

We collected information on the child's sex, age, country of birth (Spain or other), physical activity (playing sports or performing physical activity several times per week), and exposure to SHS outside the home. Adults were also asked their perception of the child's weight (underweight, normal weight, somewhat overweight, very overweight). Information regarding household structure (two-parent household or not) and parental characteristics (sex, employment status [working or unemployed at time of the interview], educational level [university, vocational training, secondary, primary, or no formal studies]) were also collected. Finally, to assess the social class of the family member who contributed the most to the

household expenses on a regular basis, we used the Spanish Society of Epidemiology classification (I to VI for the highest through the lowest class).[30]

The mental health of the parents interviewed was assessed with the General Health Questionnaire (GHQ-12), validated for the Spanish population.[31] The GHQ-12 consists of 12 questions with four possible answers each. Responses were classified using a binary scoring method, in which the options 'much less than usual' and 'same as usual' received 0 points, and 'more than usual' and 'much more than usual' received 1 point. The total score ranges from 0 to 12 points, and individuals scoring ≥ 3 were classified as having psychological distress.[31]

Parents classified their smoking status into one of the following categories: "yes I smoke daily," "yes I smoke but not daily," "I do not currently smoke but I have smoked before," "neither I smoke, nor I have ever smoked before on a regular basis." Parents who reported smoking at the time of the interview (either daily or not) were classified as current smokers. Household crowding was defined as residing in a house or flat having $<20 \text{ m}^2/\text{person}$ or $<1 \text{ room/person}$.[8] Lastly, five neighborhood environmental risk factors were evaluated by the adult interviewed: nuisance noise, dirty streets, air pollution from a nearby factory, air pollution due to other causes, and delinquency, violence, or vandalism in the house or neighborhood. Each question had 3 possible answers (none, a little, or a lot) ranging in value from 0 to 2 for an aggregate score from 0 to 10.

Statistical analysis

Data were analyzed using logistic regression models. The dependent variable was defined using a score above the 90th percentile for the global SDQ or its subscales as the cut-off, and the main independent variable was SHS exposure in the home. Duration of exposure was categorized into three levels using dummy terms: not habitually exposed, $<1\text{h/day}$, and $\geq 1\text{h/day}$. We fitted three logistic models with progressive adjustment for potential confounders. Model A was the crude model. Model B included all potential confounders described above except for parental

mental health. Model C further adjusted for parental mental health. The dose-response relationship between SHS and child's mental health problems was tested with the p for linear trend.

We also examined whether the studied association varied by the sex of the child or of the parent interviewed by using likelihood ratio tests which compared models with and without interaction terms. Finally, a sensitivity analysis was performed by including mother's tobacco consumption as an additional adjustment in Model C. Analyses were performed with Stata V.11.0 for Windows (StataCorp, Texas, USA).

RESULTS

Among study participants, 7.7% (95% confidence interval [CI] 6.5-8.9%) had a probable mental disorder, with a higher prevalence found in children not living in a two-parent household and in children of unemployed parents, with lower education or of lower social class (Table 1). Also, 6.9% (95% CI: 5.7-8.0%) of children were exposed to SHS in the home during <1h/day and 4.5% (95% CI 3.5-5.5%) during \geq 1h/day. Again, SHS exposure was more frequent in children not living in a two-parent household, with unemployed parents or having parents with lower education or of lower social class (Table 1).

The proportion of children at a higher risk for probable mental disorders was greater among those whose parents were under psychological distress and had a perception of the child's weight being either below or above normal. The frequency of probable mental disorders also increased as the neighborhood environmental conditions worsened (Table 2). The frequency of SHS exposure at home was greater in children exposed to SHS outside the home (Table 2).

Compared to children not habitually exposed to SHS in the home, the odds ratio (OR) of a probable mental disorder after adjusting for the main confounders (Model B) was 1.61 (95% CI 0.92-2.81) in children exposed to SHS during <1h/day and 3.16 (95% CI 1.63-6.12) in those exposed during \geq 1 h/day (p for linear-trend <0.001). When adjustment was further made for

parental mental health (Model C), the corresponding ORs decreased to 1.49 (95% CI 0.85-2.62) and 2.73 (95% CI 1.38-5.41), p for linear-trend=0.002 (Table 3). Results did not vary with the sex of the child (p for interaction=0.871) or with the participating parent (p for interaction=0.700). Further adjustment for mother's tobacco use slightly reduced the ORs (1.37; 95% CI 0.76-2.46 for <1h/day exposure and 2.58; 95% CI 1.29-5.18 for \geq 1h/day exposure).

Table 4 shows the results for the specific SDQ subscales. Children with any SHS exposure in the home had a higher risk of attention-deficit and hyperactivity disorder (ADHD) than their not habitually exposed counterparts; the OR for <1h/day exposure was 2.18 (95% CI 1.30-3.64) and for \geq 1h/day exposure was 3.14 (95% CI 1.63-6.04). Results were similar after adjustment for mother's tobacco consumption, with an OR of 1.98 (95% CI 1.16-3.39) for <1h/day exposure and 2.95 (95% CI 1.53-5.70) for \geq 1h/day exposure. None of the other SDQ subscales showed a statistically significant association with SHS exposure in the home. Lastly, to assess whether the association between SHS and global mental disorder simply reflected the impact of SHS on the ADHD, we repeated the analyses after excluding the hyperactivity-inattention items from the global SDQ score. Compared to children not habitually exposed to SHS, the multivariate odds ratios for probable mental disorder were 1.39 (95% CI 0.77-2.50, $p=0.270$) for SHS exposure <1 h/day and 1.32 (95% CI 0.61-2.87, $p=0.482$) for SHS exposure \geq 1 h/day.

Table 1. Frequency of probable mental disorders* and of levels of exposure to second-hand smoke (SHS) in the home among 4 to12 year-old children in Spain, by sociodemographic and clinical variables.

	N	Probable mental Disorder % (95% CI)	Not habitually exposed % (95% CI)	SHS <1h/day % (95% CI)	SHS ≥1h/day % (95% CI)
Total	2357		88.7(87.2-90.1)	6.9(5.7-8.0)	4.5(3.5-5.5)
Age (years)					
4-10	1842	7.8(6.4-9.1)	89.3(87.7-90.9)	6.7(5.4-8.0)	4.0(3.0-5.0)
11-12	515	7.6(4.9-10.3)	86.1(82.5-89.7)	7.5(4.9-10.1)	6.4(3.7-9.0)
Sex					
Male	1222	8.6(6.8-10.4)	89.8(87.8-91.8)	6.3(4.7-7.8)	3.9(2.6-5.2)
Female	1135	6.8(5.2-8.4)	87.5(85.3-89.7)	7.5(5.7-9.2)	5.1(3.6-6.5)
Country of birth					
Spain	2216	7.7(6.4-9.0)	88.6(87.1-90.2)	6.9(5.7-8.1)	4.5(3.5-5.5)
Other country	141	8.1(3.0-13.2)	88.8(83.1-94.4)	6.4(2.4-10.4)	4.9(0.6-9.1)
Family structure					
Two-parent	1995	7.0(5.7-8.2)	89.6(88.0-91.1)	6.5(5.3-7.8)	3.9(2.9-4.9)
Not two-parent	362	12.1(8.1-16.1)	83.3(78.8-87.9)	8.8(5.5-12.1)	7.9(4.5-11.4)
Parental working status					
Employed	1557	6.1(4.7-7.4)	89.7(87.9-91.5)	6.9(5.4-8.3)	3.4(2.3-4.5)
Unemployed	800	11.0(8.5-13.5)	86.6(83.9-89.3)	6.8(4.8-8.8)	6.6(4.6-8.5)
Parental education level					
University	483	4.3(2.2-6.5)	93.4(90.6-96.1)	5.2(2.7-7.6)	1.5(0.2-2.8)
Vocational training	554	6.9(4.4-9.3)	90.3(87.5-93.2)	6.9(4.4-9.3)	2.8(1.3-4.3)
Secondary	345	6.7(3.6-9.8)	92.5(89.4-95.7)	4.9(2.6-7.2)	2.6(0.3-4.8)
Primary	814	9.7(7.4-11.9)	83.3(80.3-86.3)	8.9(6.6-11.1)	7.8(5.6-10.0)
No formal schooling	161	15.2(8.9-21.6)	85.5(79.5-91.4)	6.6(2.5-10.7)	7.9(3.4-12.4)
Social Class					
Class I (highest)	309	5.9(2.7-9.0)	93.4(90.0-96.8)	4.8(1.9-7.6)	1.8(0.0-3.8)
Class II	201	6.0(2.0-10.0)	92.3(88.5-96.1)	7.1(3.3-10.8)	0.6(0.0-1.6)
Class III	505	5.9(3.5-8.2)	91.2(88.3-94.1)	6.9(4.2-9.5)	1.9(0.6-3.2)
Class IV	347	8.6(5.4-11.8)	87.9(83.8-91.9)	7.5(4.4-10.5)	4.7(1.9-7.5)

Class V	709	9.7(7.2-12.2)	86.4(83.4-89.3)	6.6(4.5-8.7)	7.1(4.8-9.3)
Class VI (lowest)	254	9.0(5.2-12.8)	82.0(76.5-87.5)	10.1(5.9-14.3)	7.9(4.0-11.8)
Don't Know/No answer	32	7.1(0.0-16.3)	80.5(64.6-96.4)	4.5(0.0-13.5)	15.0(1.2-28.8)
Mental disorder					
Probable	182	7.7(6.5-8.9)	77.5(70.4-84.6)	9.6(4.9-14.4)	12.9(6.9-18.8)
Not probable	2175	92.3 (91.1-93.5)	89.6(88.1-91.1)	6.6(5.4-7.8)	3.8(2.9-4.7)

*According to the Strengths and Difficulties Questionnaire (SDQ)

CI: Confidence interval.

Table 2. Frequency of mental disorders* and level of exposure to second-hand smoke (SHS) in the home among 4 to12 year-old children in Spain, by risk factors and environmental variables

	N	Mental Disorder* % (95% CI)	Not habitually exposed % (95% CI)	SHS <1h/day % (95% CI)	SHS ≥1h/day % (95% CI)
Physical Activity					
No	1937	7.5(6.2-8.8)	88.5(86.8-90.1)	6.9(5.6-8.2)	4.7(3.5-5.8)
Yes	420	8.5(5.3-11.8)	89.5(86.2-92.9)	6.8(3.9-9.7)	3.7(1.8-5.6)
Weight perception					
Normal	1876	6.7(5.4-8.0)	89.6(88.0-91.1)	6.6(5.3-7.8)	3.9(2.9-4.9)
Underweight	235	14.1(9.0-19.1)	86.5(81.2-91.7)	6.8(3.2-10.5)	6.7(2.6-10.8)
Somewhat / very overweight	246	9.0(5.0-13.1)	83.6(78.0-89.1)	9.3(4.8-13.8)	7.2(3.4-10.9)
SHS exposure outside home					
Yes	12	4.0(0.0-13.3)	27.9(0.0-59.0)	29.4(0.0-60.1)	42.7(5.7-79.7)
No	2345	7.7(6.5-9.0)	88.9(87.5-90.4)	6.8(5.6-7.9)	4.3(3.3-5.3)
Parental psychological distress					
Yes	456	16.2(12.1-20.3)	80.7(76.4-85.1)	10.5(7.1-13.9)	8.8(5.6-11.9)
No	1901	5.8(4.6-6.9)	90.5(89.0-92.0)	6.0(4.8-7.2)	3.5(2.5-4.4)
Household crowding					
Yes	1283	7.7(6.1-9.4)	89.0(87.0-90.9)	5.9(4.5-7.4)	5.1(3.7-6.5)
No	798	6.9(5.0-8.9)	89.2(86.8-91.6)	8.0(5.8-10.1)	2.8(1.6-4.0)
Don't know / No answer	276	9.3(5.5-13.1)	86.0(81.2-90.8)	8.9(4.9-12.9)	5.1(2.1-8.1)
Neighborhood environment					
0 (best)	1028	6.0(4.4-7.6)	88.9(86.6-91.1)	6.8(5.0-8.5)	4.4(2.9-5.8)
1-2	865	8.0(5.9-10.1)	89.3(86.9-91.6)	6.7(4.8-8.5)	4.1(2.6-5.5)
≥3 (lowest)	464	10.8(7.7-14.0)	87.2(83.6-90.8)	7.3(4.5-10.2)	5.5(3.1-7.9)

*According to the Strengths and Difficulties Questionnaire (SDQ)

CI: Confidence interval.

Table 3. Association between exposure to second-hand smoke in the home and mental disorders* in 4 to 12 year-old children in Spain

	Duration of exposure to second-hand smoke in the home			
	Not habitually Reference	<1hour/day Odds ratio (95% CI)	≥1hour/day Odds ratio (95% CI)	<i>P for linear trend</i>
Model A	1	1.68 (0.94-3.01)	3.94 (2.19-7.09)	<0.001
Model B	1	1.61 (0.92-2.81)	3.16 (1.63-6.12)	<0.001
Model C	1	1.49 (0.85-2.62)	2.73 (1.38-5.41)	0.002
Sensitivity analysis†	1	1.37 (0.76-2.46)	2.58 (1.29-5.18)	0.007

*According to the Strengths and Difficulties Questionnaire (SDQ)

CI: Confidence Interval

Model A: Crude logistic regression model.

Model B: Adjusted for sex of participating parent, child's sex, child's age, child's country of birth, family structure, parental employment, parental educational level, social class, physical activity, parental perception of child's weight, exposure to second-hand smoke outside the home, household crowding, and neighborhood environmental factors.

Model C: As model B with additional adjustment for parental mental health.

†Sensitivity analysis: As model C with additional adjustment for mother's tobacco consumption.

Table 4. Association between exposure to second-hand smoke and specific mental disorders* in 4 to 12 year-old children in Spain

	Duration of exposure to second-hand smoke in the home			
	Not habitually exposed	<1h/day	≥1h/day	<i>P for linear trend</i>
	Reference	Odds ratio (95% CI)†	Odds ratio (95% CI)†	
Emotional symptoms	1	1.18 (0.63-2.22)	1.27 (0.65-2.49)	0.404
Conduct problems	1	1.56 (0.86-2.83)	1.28 (0.56-2.94)	0.292
Hyperactivity-Inattention	1	2.18 (1.30-3.64)	3.14 (1.63-6.04)	<0.001
Sensitivity analysis‡	1	1.98 (1.16-3.39)	2.95 (1.53-5.70)	<0.001
Peer problems	1	0.74 (0.35-1.58)	0.82 (0.36-1.91)	0.465
Prosocial behavior	1	0.71 (0.35-1.48)	0.69 (0.23-2.04)	0.337

*According to the subscales of the Strengths and Difficulties Questionnaire (SDQ)

CI: Confidence Interval

† Logistic regression model adjusted as model C in table 2.

‡Sensitivity analysis: Sensitivity analysis for Hyperactivity-Inattention: As model C with additional adjustment for mother's tobacco consumption.

DISCUSSION

Children between 4 and 12 years of age who are exposed to SHS in the home showed a greater frequency of mental disorder, specifically ADHD, than those who are not exposed or have sporadic exposure only.

The high prevalence of SHS exposure in the home among Spanish children is of public health concern because SHS contains higher concentrations of certain toxic substances than the smoke inhaled by the active smoker.[1,32] In addition, some of these substances remain in the home environment (on surfaces and as dust particles) during months after tobacco consumption, and may be re-suspended in the air or react with other substances creating new pollutants, an exposure come to be known as “third-hand smoke.”[33] Children are especially vulnerable to “third-hand smoke” exposure,[33] furthermore, the neurological effects of nicotine are greater and longer-lasting in children than in adults.[34,35]

Four previous studies have examined the association between SHS in the home and SDQ-based mental health in children, with inconclusive results.[7-9,12] Only Hamer *et al.* found a positive dose-response relationship between SHS in the home and worse mental health.[7] However, three studies using the SDQ concluded that SHS in the home was associated with increased risk for hyperactivity-inattention,[7-9] with two of them finding a robust dose-response relationship in addition to an association between SHS and conduct disorders.[7,8] In contrast, Rückinger *et al.* [12] found that the association between SHS exposure in the home and an increased risk for mental disorders was mostly explained away by prenatal exposures.

In our data, the association between SHS exposure in the home and mental disorders in children remained robust after controlling for many potential confounders such as social class,[8,36] parental education,[8,36] family structure,[8,36] and parental mental health.[15,16,18] The latter is a potential confounder since it is associated with parental tobacco consumption [17] and, thus, a greater SHS exposure in the home, and because it is also associated with the child's

mental health.[15,16,18] Additionally, parents with poorer mental health may have a more negative interpretation of their children's mental health.[10] Only Williams *et al.*[5] accounted for this potential confounder in their analysis. In our study, the associations between SHS and mental health in general, and ADHD in particular, were reduced only slightly after adjusting for parental mental health.

The association between SHS in the home and worse mental health outcomes may be explained in part by prenatal exposure to tobacco. Unfortunately, the two exposures are difficult to differentiate since prenatal and postnatal maternal tobacco use are highly correlated.[11,37] Several studies have found that maternal smoking during pregnancy is associated with behavioral disorders in children.[5,9,10] Moreover, in some investigations the association between SHS in the home and the increased risk for conduct problems was mostly explained by prenatal exposure.[9,12] In our study, adjusting for postnatal tobacco consumption did not modify the results substantially, but since postnatal maternal tobacco use simply reflects current smoking, we cannot rule out that the observed associations could be partly due to residual confounding (i.e., prenatal smoking or other unknown or unmeasured factors). On the other hand, some authors suggest that the association between prenatal tobacco exposure and behavioral problems is influenced by other risk factors in behavioral development such as growing up in disadvantaged conditions,[38,39] parental mental health,[38,39] and country of birth.[39] Low maternal educational achievement has also been suggested as a potential confounding factor between child's mental health and prenatal tobacco exposure.[36] We were able to take into account in our analyses all these variables, thus, although there could be some residual confounding from variables not included, we believe the direct association observed between childhood SHS exposure and risk for mental disorders to be robust.

Limitations

Our results should be interpreted in the context of the study's limitations. First, due to the cross-sectional nature of the data, we were unable to establish causality between SHS exposure in the

home and mental health. Second, data were reported by parents, who may provide somewhat biased information. However, there is evidence that the data on tobacco consumption in the home provided by parents are valid estimates of children's SHS exposure when compared to data from biomarkers.[40] Third, it is possible that excluding children whose information was provided by persons other than their parents or legal guardians may have introduced certain selection bias. Fourth, the SDQ for parents is a screening instrument and it does not provide a clinical diagnosis. Still, it has proven a reliable and valid instrument. In addition, values over the 90th percentile in both the general SDQ as well as SDQ main subscales have proven to be good predictors of risk for mental health disorders.[24] Fifth, we had no information on past exposure to SHS. Smoking in the home may have changed during a child's lifetime, and exposure to SHS in early childhood may be more influential to the children than exposure in later stages of childhood. Sixth, we adjusted for the mental health of only one of the parents. Finally, although we adjusted for a number of potential confounders, we cannot rule out certain residual confounding from unmeasured factors such as the children's birth weight or the co-existence of other health conditions.

Strengths

Major strengths of this study include the large population-based sample representative of the child population in Spain and analyses adjusted for a wide array of potential confounders. In fact, this is the first examination of the link between SHS in the home and children's mental health using the SDQ that also adjusts for parental mental health.

Conclusions

In children SHS exposure in the home for one hour or more per day was associated with a higher frequency of mental disorder, and specifically of ADHD. Longitudinal research confirming these results is needed. Given that legislation in Spain is not directly aimed to

reduce SHS exposure in the home, additional actions may be required to reduce children's exposure to SHS.

What this paper adds

- ▶ Previous research on the association between post-natal second hand smoke (SHS) exposure and children's mental health is inconclusive. Furthermore, past studies using the Strengths and Difficulties Questionnaire (SDQ) have not accounted for the role of parental mental health in this association.
- ▶ In a population-based sample of 4 to 12 year-olds in Spain, we showed a significant and substantial dose-response association between SHS exposure in the home and a higher frequency of global mental problem, measured with SDQ. Unlike most previous findings, our results were adjusted for parental mental health.
- ▶ SHS exposure during even less than one hour per day was also associated with a higher frequency of attention-deficit and hyperactivity disorder. However, no association was found between SHS and the rest of components of the SDQ. Thus, the association between SHS and global mental problem was mostly due to the impact of SHS on the attention-deficit and hyperactivity disorder.

Competing Interests

None

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Contributors

All authors have contributed substantially to the research, have reviewed the manuscript for important intellectual content, and agree with its contents and with the decision to submit it for publication.

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