

Environmental Risk Factors Associated with Behavioral Problems among Children with Attention Deficit Hyperactivity Disorder: Maternal Perceptions

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Received: January 18, 2024;

Revised: March 12, 2024;

Accepted: April 10, 2024

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ABSTRACT

OBJECTIVE This study aims to identify environmental risk factors associated with behavioral problems in children and adolescents with attention deficit hyperactivity disorder (ADHD).

METHODS A case-control study was conducted in children aged 4-15 years comprising 92 children diagnosed with ADHD and 92 controls without ADHD. Stratified sampling was used to select 184 participants residing in Chiang Mai and Lamphun provinces, Thailand. Data were collected from the mothers of the participants using a self-report questionnaire between May and August 2022. The questionnaire consisted of three parts: child characteristics (gender, age, underlying diseases, past illness history), mother's characteristics (age, income, occupational status, history of cigarette smoking and alcohol drinking), and maternal perceptions about caring for the child and the child's behavioral problems (exposure to chemicals/toxicants, frequent punishment, excessive use of digital media and games). Data were analyzed using descriptive statistics, chi-squared test, odds ratio (OR) and logistic regression using SPSS version 21.

RESULTS Most of participants were males (86.96%) while 13.04% were females. The results showed that the ADHD cases were significantly more likely than the controls to have underlying diseases such as G6PD, allergy, and asthma ($p = 0.006$). There was also a statistically significant correlation with smoking history in the mothers of ADHD cases (OR = 2.64; 95% CI: 1.36-5.13 $p = 0.004$). In terms of maternal perceptions, the mothers of ADHD children were significantly more likely than the controls to have frequently punished the child (OR = 6.26; 95% CI: 3.24-12.07; $p < 0.001$), to have children who were exposed to chemicals (pesticides and fertilizer) or toxicants (passive smoking) (OR = 4.14; 95% CI: 1.76-9.73; $p = 0.001$), and to have allowed their child to use digital media and play video games excessively (OR = 2.82; 95% CI: 1.55-5.16; $p = 0.001$). After adjustment for other environmental risk factors, frequent child punishment (ORadj = 4.32; 95% CI: 2.13-8.78; $p < 0.001$) and exposure of the child to chemicals/toxicants (ORadj = 2.66; 95% CI: 1.00-7.02; $p = 0.049$) were found to be significantly related with ADHD.

CONCLUSIONS Frequent child punishment was the most significant environmental risk factor related to behavioral problems among children with ADHD. This indicates the importance of healthcare providers developing strategies and/or interventions to enhance knowledge and awareness in mothers of ADHD which can improve treatment outcomes.

KEYWORDS ADHD, risk factors, behavioral problems, maternal perceptions

INTRODUCTION

Attention-deficit hyperactivity disorder (ADHD) is the most common neuro-behavioral developmental disorder. ADHD onset typically occurs in childhood and continues into adulthood. It substantially affects developmental, social, academic and occupational functioning of persons with ADHD (1). The main symptoms of ADHD often emerge in the preschool period and include hyperarousal and hyperactivity, disinhibited behaviors, emotional dysregulation, inattention, and executive dysfunction (2). The prevalence of ADHD varies worldwide and is increasing over time according to the American Psychiatric Association revised diagnostic criteria (DSM-V) released in 2013 which also establishes standards of clinical practice that are applicable to and valuable for in the diagnosis and management of ADHD (3). The result of a meta-analysis of 179 studies showed an estimated ADHD prevalence of 7.2% (4). Similarly, prevalence of parent-reported ADHD among U.S. children aged 2-17 years as reported by the National Survey of Children's Health (NSCH) was 9.4% (5). In Thailand, the ADHD prevalence was 8.1% (6).

ADHD is a condition resulting from the collective influence of genetic and environmental risk factors. It is difficult to identify the true causality of environmental risk factors in ADHD, as it relates to several affecting variables. Environmental factors during the prenatal and perinatal periods such as smoking and alcohol drinking (7-9) as well as factors during toddlerhood such as exposure to chemicals/toxicants, negative parenting, maltreatment, and excessive use of digital media (1, 10-13) may contribute to the risk of later onset of ADHD. Previous studies in Thailand have found that risk factors relating to ADHD among school-age children included male gender, a history of being punished by teachers, living with relatives, divorce or separation of father and mother, income insufficiency and family debt, and children who watch television, use a smartphone, and play video games more than 1-2 hours a day (14-16). Parents who care for children with ADHD may experience increased stress due to their children's problematic behaviors. These behaviors include less compliance, increased distraction as well as requiring more attention and assistance. These behaviors can lead to negative consequences: poor monitoring of children's behavior

and emotions, increased punishment, decreased supportive attitude, and increased conflict in the parent-child relationship. It has been suggested that healthcare providers should address parental perceptions of ADHD as part of the treatment (17), as well as efforts to increase parents' knowledge and ADHD symptoms awareness as a means of improving the children's quality of life (18).

There have been few studies about environmental risk factors in children with ADHD in Thailand. The present study aims to investigate the environmental risk factors associated with behavioral problems in children with ADHD through analysis of mothers' perceptions. The study results should be beneficial for aiding prevention of ADHD and for promotion of appropriate care for children with ADHD.

METHODS

A case-control study was conducted in children with and without ADHD aged 4-15 years. Stratified sampling was used to select 184 participants residing in Chiang Mai and Lamphun, Thailand. The study was approved by the Research Ethics Committee of the Department of Mental Health, Ministry of Public Health, Thailand (DMH. IRB.CO.A 010/2565).

The sample size was calculated using G*power version 3.1.9.4 (19) using completed parameters with large effect size (0.5) as recommended by Cohen (20) and Schlesselman (21), $\alpha = 0.05$, power = 0.95, and Df = 5. The calculated sample size was 80 participants per group. An additional 10% was added to minimize potential data collection errors, meaning 88 participants were needed in each group. The ADHD cases had been previously diagnosed according to the Diagnostic and Statistical Manual of Mental Disorders (DSM) criteria. The names of the ADHD cases were retrieved from the electronic medical records of Rajanagarindra Institute of Child Development, with ICD-10 (International Classification of Diseases-10) code F90.0-F90.9.

The demographic characteristics of the controls without ADHD, including gender, age, and living in Chiang Mai and Lamphun, were similar to those of the ADHD cases. Data were collected from the mothers of participants between May and August 2022 using a self-report questionnaire. The questionnaire consisted of three parts:

child characteristics (gender, age, underlying diseases, past illness history), mother's characteristics (age, income, occupational, history of cigarette smoking and alcohol drinking), and maternal perceptions about child care (exposure to chemicals/toxicants, frequent punishment, excessive use of digital media and games) and child behavioral problems.

Statistical analysis was performed using SPSS version 21 software (IBM corp.) For descriptive statistics, categorical data are presented as frequency and percentage, while numerical data are presented as mean $\pm$ SD or median (IQR) depending on the underlying distribution. Odds Ratios and Confidence Intervals (22) were analyzed and a $p < 0.05$ was considered statistically significant.

RESULTS

Demographic characteristics of the case and control participants

A total of 184 participants in this case-control study, including 92 cases with ADHD and 92 controls without ADHD. Most of participants were male (86.96%) while 13.04% were female (Table 1). The mean age of the case group was 8.95 with a standard deviation of 2.88 while the mean age of the control group was 8.52 with a standard deviation of 2.85. There was no significant difference in past illness history of head trauma and seizure between the groups, but the cases were significantly more likely than the controls to have underlying diseases such as G6PD, allergy, and asthma ($p = 0.006$).

Regarding comparison of mothers' demographic characteristics, there were significant differences

in both age ($p = 0.035$) and history of cigarette smoking ($p = 0.004$). However, there was no significant difference in sufficient income ($p = 0.624$), history of alcohol drinking ($p = 0.833$), or being unemployed ($p = 0.647$) (Table 2).

Comparison of maternal perceptions showed that compared to the controls, the case mothers were significantly more likely to have used frequent child punishment because of behavioral problems ($p < 0.001$), let their child use digital media and play games excessively ($p = 0.001$), and allowed their child to be exposed to chemicals (pesticides and fertilizers) or toxicants (passive smoking) ($p = 0.001$). However, there was no significant difference in regularly leaving the child alone ($p = 0.236$).

Binary logistic regression model

In the final binary logistic regression model (Table 3), all environmental risk factors, including history of cigarette smoking, allowing their child to be exposed to chemicals/toxicants, frequent child punishment, and excessive use of digital media and gaming were adjusted. The results showed that the cases were significantly more likely than the controls to have frequent child punishment (ORadj = 4.32; 95% CI: 2.13–8.78; $p < 0.001$), and to let their child be exposed to chemicals (pesticides and fertilizer) or toxicants (passive smoking) (ORadj = 2.66; 95% CI: 1.00–7.02; $p = 0.049$).

DISCUSSION

Parenting and family environment have significant impact on child development and may lead to a risk of developmental disorders including

Table 1. Comparison of demographic characteristics of children between ADHD group and Control group (n=184)

Personal factors	ADHD (n=92) n (%)	Control (n=92) n (%)	p-value
Age (years) (mean $\pm$ SD)	8.95 $\pm$ 2.88	8.52 $\pm$ 2.85	0.304 ^a
Sex			
Male	80 (86.96)	80 (86.96)	1.000 ^b
Female	12 (13.04)	12 (13.04)	
Past history			
Head trauma	10 (12.20)	6 (6.52)	0.433 ^b
Seizure	8 (8.70)	4 (4.35)	0.371 ^b
Other underlying disease (G6PD, allergy, asthma)	31 (33.70)	14 (15.22)	0.006 ^b

^aIndependent t-test; ^bFisher's exact test

Table 2. Comparison of mothers' demographic characteristics and perceptions about caring and child behavioral problems between ADHD group and Control group (n=184).

Factors	ADHD (n=92) n (%)	Control (n=92) n (%)	p-value	OR	95% CI
Mother's age (years) (mean±SD)	38.98±6.32	36.96±6.56	0.035 ^a	-	-
Sufficient income	64 (69.57)	68 (73.91)	0.624 ^b	-	-
Being unemployed	36 (39.13)	32 (34.78)	0.647 ^b	-	-
History of cigarette smoking	36 (39.13)	18 (19.57)	0.004 ^b	2.64	1.36-5.13
History of alcohol drinking	14 (15.22)	12 (13.04)	0.833 ^b	-	-
Allowing child to be expose to chemicals (pesticides and fertilizers) or toxicants (passive smoking)	26 (28.26)	8 (8.70)	0.001 ^b	4.14	1.76-9.73
Leaving child alone regularly	13 (14.13)	7 (7.61)	0.236 ^b	-	-
Frequent child punishment because of their behavioral problems	57 (61.96)	19 (20.65)	<0.001 ^b	6.26	3.24-12.07
Excessive use of digital media and gaming	63 (68.48)	40 (43.48)	0.001 ^b	2.82	1.55-5.16

^aIndependent t-test; ^bFisher's exact test

Table 3. Binary logistic regression model^a of environmental risk factors associated with behavioral problems in children with ADHD

Risk factors	Adjusted OR ^b	95% CI	p-value
History of cigarette smoking	1.16	0.52-2.58	0.719
Letting their child be exposed to chemicals (pesticides and fertilizers) or toxicants (passive smoking)	2.66	1.00-7.02	0.049
Frequent child punishment because of their behavioral problems	4.32	2.13-8.78	<0.001
Excessive use of digital media and gaming	1.81	0.88-3.66	0.097

^aHosmer and Lemeshow Test Chi-square = 5.597 and Significance = 0.347; ^bModel was adjusted for history of cigarette smoking, letting their child be exposed to chemicals/toxicants, frequent child punishment and excessive use of digital media and gaming

ADHD. The results of this case-control study showed that two environmental risk factors were significantly associated with behavioral problems in children with ADHD based on maternal perceptions. The strongest significant factor was frequent child punishment with 4.3 times the risk of behavioral problems in the case group compared to the controls. The cases mothers reported that the main causes of punishment were hyperactive, disruptive, and aggressive behaviors. The punishment forms that the parents used almost every week were scolding, blaming, and withdrawal of favorite activities. Hitting was also sometimes used as punishment.

Consistent with this, previous studies have reported that parents of children with ADHD used significantly more corporal punishment than the control group parents (23). In addition, 95% of parents of children with ADHD physically abused their children (24). This evidence strongly supports that children with ADHD are at significantly increased risk of parent abuse. Such risk might

be a result of emotional dysregulation (25) and co-occurring disorders in children with ADHD such as oppositional defiant disorder, conduct disorder, anxiety, and depression (26).

ADHD results in parents having more difficulty looking after their children and consequently punishing them more frequently. This is congruent with several Thai studies demonstrating that a history of being punished was correlated with ADHD in elementary school children (14-16). Another factor associated with behavioral problems in children with ADHD is allowing the child to be exposed to chemicals and toxicants. The kinds of chemicals reported by the case mothers were pesticides and fertilizer, but specific chemical names, routes of exposure, and duration of exposure could not be precisely identified. Exposure to toxicants from tobacco smoke from passive smoking by family members living together, was associated with 2.7 times the risk of behavioral problems compared to the controls. These results are consistent with a population-based retrospec-

tive cohort study (2005–2012) conducted in Spain which showed an association between ADHD occurrence and exposure to pesticides (27). Similarly, another study reported that the children of smokers were approximately 1.5–3 times more likely to have ADHD or ADHD symptoms than children of non-smokers (13). Previous studies also found that ADHD was associated with pre-natal maternal active or passive smoking and/or postnatal tobacco smoke exposure (7, 8).

However, In the present study after adjustment for all variables, the results showed no relationship between the incidence of behavioral problems and excessive use of digital media and gaming in children with ADHD. This is in contrast to the result of a Thai case-control study which reported that children who watched television more than one hour a day were 3.2 times more likely to have ADHD or ADHD symptoms than children who watched television less than one hour a day. Playing video games and using a smartphone were not risks factors (14).

In addition, this study showed an association between risk of behavioral problems and personal factors of children with ADHD related to having underlying diseases such as G6PD, allergy, and asthma. These results support a previous study that investigated the coexistence of other health-related conditions in individuals with ADHD which found that asthma was more common in ADHD children (OR = 2.19; 95% CI = [2.16, 2.22]) (28). The results of the present study have direct implications for patient care, including diagnosis and individual therapy. A strength of this case-control study is the sufficient sample size that provides more reliable and accurate findings. Another strength is that the case and the control groups had almost exactly the same characteristics, especially living in similar communities, which reduced the possibility of confounding bias.

There were, however, also several limitations. The first limitation is generalizability as the samples do not represent the general population in Thailand. Additionally, this study could not identify associations between other related factors and behavioral problems due to lack of data, e.g., types of punishment, types and duration of exposure to chemicals or toxicants, participants' age at initial use of digital media, duration of digital media and game usage. Further studies investi-

gating these aspects are recommended.

CONCLUSIONS

Frequent child punishment is the most significant environmental risk factor related to behavioral problems among children with ADHD. Allowing children to be exposed to chemicals (pesticides and fertilizers) or toxicants (passive smoking) appears to be related to ADHD through alteration of neurological development in early childhood (29). It is important for healthcare providers to develop strategies and interventions to enhance the knowledge and awareness of mothers of children with ADHD and contribute to improvement of treatment outcomes.

ACKNOWLEDGEMENTS

We would like to thank the Rajanagarindra Institute of Child Development for their assistance in recruiting patients. We are also grateful to all the participants for providing us with useful data and giving us permission to publish it.

FUNDING

This study received a grant from the Thailand Science Research and Innovation Funding (Fundamental Fund). The funder was not involved in the study design, data collection, data analysis, preparation of the manuscript, or decision to publish.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

ADDITIONAL INFORMATION

Data availability statement

The data used in this study are not publicly available due to Rajanagarindra Institute of Child Development's policy, but are available from the corresponding author upon reasonable request.

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