Correlation of tobacco smoke exposure to intelligence quotient in preschool children

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Correlation of tobacco smoke exposure to intelligence quotient in preschool children

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Abstract

Background Exposure to tobacco smoke at home happens in 29-69% of children globally and 43% of Indonesian children. Smoke exposure during the developmental stage may affect cognitive abilities, as measured by intelligence quotient (IQ). There have been few studies conducted on the correlation of tobacco smoke exposure to IQ. This is the first study of this type in Indonesia.

Objectives To assess the correlation between tobacco smoke exposure and IQ in preschool children and to assess the correlation between serum cotinine levels and IQ in preschool children exposed to tobacco smoke.

Methods A cross-sectional study was conducted in the Tuminting district, Manado in January - May 2011. Subjects were collected by random sampling of 3-5 year-old children. In our study, 35 children were deemed to have been exposed to tobacco smoke by serum cotinine $\geq$ 0.05 ng/ml and 25 children were deemed to not have been exposed to tobacco smoke (cotinine < 0.05 ng/ml). Results were analyzed by t-test and simple correlation analysis using SPSS version 17 software with a significance level of $P < 0.05$.

Results There was a statistically significant difference in IQ between the two groups, with mean IQ of 106.54 in the group exposed to tobacco smoke and mean IQ of 109.36 in the group not exposed to tobacco smoke (P=0.01). The mean serum cotinine level in the group with tobacco smoke exposure was 1.77 ng/mL. There was no correlation between the mean level of cotinine and mean IQ in this group (r = -0.19 and P=0.14).

Conclusions The mean IQ in the group with tobacco smoke exposure was lower than that of the group not exposed to tobacco smoke. There was no correlation between mean serum cotinine level and mean IQ. **[Paediatr Indones. 2012;52:106-10]**.

Keywords: *tobacco smoke exposure, intelligence quotient, serum cotinine, preschool children*

Despite the extensive data on the negative impact of tobacco smoke exposure on cognitive abilities, as measured by IQ tests, there are still 29-69% of children globally and 43% of Indonesian children exposed to tobacco smoke.[1-3] Tobacco smoke exposure happens often to preschool-aged children at home. These passive smokers are exposed to the components of tobacco, just as active smokers are.[4-5] For research purposes, there have been several ways to define tobacco smoke exposure, including by questionnaire and by the use of several biomarkers. Cotinine, a metabolite of nicotine, is considered to be the best currently available biomarker of exposure to tobacco smoke.[6,7] Most studies about tobacco smoke exposure relied on parental reports of exposure, rather than the more precise and objective biological markers of tobacco exposure.[1,8] There have been no previous studies on the correlation of tobacco smoke exposure to IQ in Indonesian preschool children, particularly in Manado.

The aim of this study was to assess the correlation between tobacco smoke exposure and IQ in preschool children, as well as to assess the correlation

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between serum cotinine level and IQ in preschool children exposed to tobacco smoke.

Methods

A cross-sectional study was held in the Tuminting district, Manado, from January to May 2011. Random sampling was conducted among 3-5 year-old children at two out of nine randomly chosen villages, resulting in 35 children with tobacco smoke exposure and 25 children without tobacco smoke exposure who met the inclusion criteria. The inclusion criteria were healthy preschool children (3-5 years of age), with normal birth history (birth body weight > 2500 grams, >37 weeks gestational age and cried immediately after delivery), as well as no history of neonatal jaundice nor central nervous system infection. We excluded children who actively smoked and those with developmental disorders. Developmental disorders were assessed using *Kuisioner Praskrining Perkembangan* (KPSP, Developmental Prescreening Questionnaire). Informed consent was obtained from all parents and assent was obtained from all children after the nature of the procedures was explained and before testing commenced.

All subjects were screened for tobacco smoke exposure by asking the parent if the child lived with at least one smoker in the same house. Smoking was defined as daily cigarette smoking for at least the past 6 months. Tobacco smoke exposure was defined by their serum cotinine level, with 0.05-15 ng/mL cotinine for those with tobacco smoke exposure and less than 0.05 ng/mL or undetectable cotinine for those without tobacco smoke exposure. We measured serum cotinine by Cotinine Elisa kit, Bioquant, San Diego, CA, USA, with a reported detection limit of 0.05 ng/mL. IQ was measured by Wechsler Preschool and Primary Scale of Intelligence-3rd edition (WPPSI-III).

Results were analyzed by t-test and simple correlation analysis using SPSS version 17 software. A P value of < 0.05 was considered significant in the statistical analysis.

Results

Characteristics of the subjects are shown in **Table 1**. Of the 25 children without tobacco smoke exposure (low cotinine levels), only 15 lived without a smoker at home, while 10 children lived with at least one smoker at home. Of the 30 children with tobacco smoke exposure (cotinine $\geq$0.05 ng/ml), only 19 children lived with at least one smoker at home, while the remaining 16 children lived with no smokers at home, as shown in **Table 1**. There was no correlation between serum cotinine level and the presence of at least one smoker in the home, from the questionnaire (P=0.275).

We observed a significant difference in mean IQ between the two groups, 106.54 (SD 3.8) for the group exposed to tobacco smoke and 109.36 (SD 5.3)

Table 1. Characteristics of subjects

Characteristics	Not exposed to tobacco smoke* n=25	Exposed to tobacco smoke** n=35
Mean age, years (SD)	4.06 (0.72)	4.49 (0.92)
Male gender, n	12	14
Mean birth weight, kg (SD)	3.20 (0.5)	3.05 (0.65)
Questionnaire:		
No smokers at home, n	15	16
At least 1 smoker at home, n	10	19

*Serum cotinine level <0.05 ng/ml

**Serum cotinine level 0.05-15 ng/ml

Table 2. Mean IQs and serum cotinine levels in the two groups

	Not exposed to tobacco smoke (Serum cotinine < 0.05 ng/ml)		Exposed to tobacco smoke (Serum cotinine > 0.05 ng/ml)		P
	Mean (SD)	95% CI	Mean (SD)	95% CI	
IQ	109.36 (5.3)	107.17 to 111.55	106.54 (3.8)	105.24 to 107.85	0.01
Serum cotinine, ng/mL	undetected		1.77 (0.47)	1.6 to 1.93	

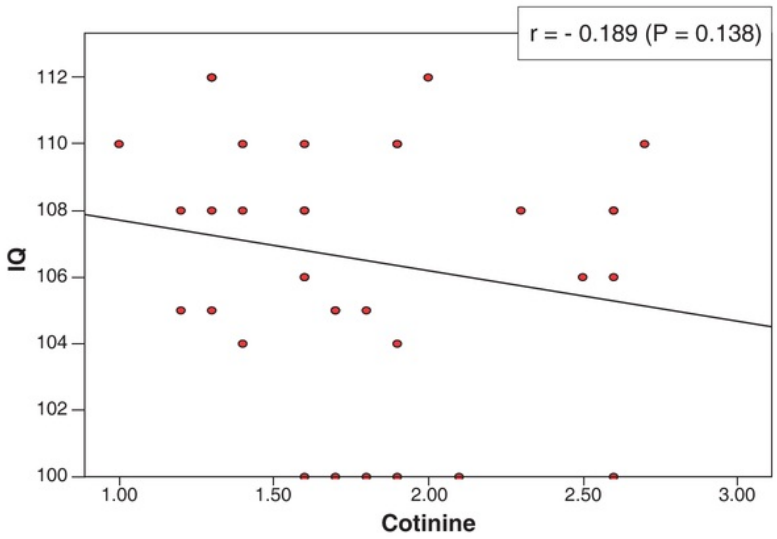

Figure 1. Correlation between cotinine level and IQ in the group exposed to tobacco smoke

for those not exposed to tobacco smoke (P=0.01), as shown in **Table 2**. The mean serum cotinine level in the group with tobacco smoke exposure was 1.77 (95% CI 1.6 to 1.9) ng/mL. There was no correlation between tobacco smoke exposure and IQ in the group exposed to tobacco smoke (r=-0.19 and P=0.138), as shown in **Figure 1**.

Discussion

We observed no correlation between serum cotinine level and the presence of a smoker at home, as assessed by questionnaire. Only 15/25 children without tobacco smoke exposure lived with no smokers at home, while only 19/35 children with tobacco smoke exposure lived with at least one smoker at home (P=0.275). Other studies have recommended the use of an objective biomarker to define tobacco smoke exposure, instead of solely relying on questionnaires. Max *et al* found that using serum cotinine to measure exposure yielded much higher prevalence rates than self-reports (50.9% vs. 14.6%).[9] A study from Mannino *et al* using a nationally representative sample of 5,658 US children, found that of the 3,464 children with no reported smoke exposure, only 24.4% had serum cotinine levels < 0.05 ng/mL.[10]

However, contrasting results from previous studies, showed 100% correlation between tobacco smoke exposure at home (as defined by questionnaires) and cotinine level, indicating that serum cotinine was elevated in all children with one or both parents smoking.[1,11] The reason for these differences may be due to the larger scale of their studies, with nationally representative samples, as well as regular conducting of and more detailed questionnaires. Unfortunately, there are no standardized or widely used questionnaires to define tobacco smoke exposure in children.

We found a significant difference in IQs between the two groups, with higher mean IQs in children without tobacco smoke exposure than in children with exposure to tobacco smoke. There was a 2.84 point difference (109.36 vs. 106.54, respectively). Our observation was consistent with a study by Yolton *et al.* They found significantly lower scores in math, reading and block design in the group with higher serum cotinine level (0.05-10 ng/mL) than in those with lower serum cotinine level (< 0.05 ng/mL).[8] Their differences were 1.93 points for the math score, 2.7 points for the reading score and 0.55 point for the block design score. Another study by Bauman *et al* on 5-10 year-old children using the Peabody Picture Vocabulary Test (PPVT) to measure IQ, reported the mean IQ to be 112.11 for the group with tobacco smoke exposure and 116.76 for those without exposure.[12] They used questionnaires to define tobacco smoke exposure in their study.

Similarly, Yolton *et al* also found lower IQs, assessed by Stanford-Binet test, in 48 month-old children with tobacco smoke exposure (103.21) than in children without tobacco smoke exposure (113.28).[1]

Previous studies on tobacco smoke exposure and cognitive functions have had several limitations, especially in the method used to define tobacco smoke exposure and measure IQ, possibly varying the results. Moreover, not all studies have used biomarkers as an objective tool to define tobacco smoke exposure in their subjects.[14,15]

The mean level of serum cotinine in the group with tobacco smoke exposure was 1.77 ng/mL (95% CI 1.6 to 1.9). This level was higher than that observed by Yolton *et al.* They reported the mean serum cotinine to be 1.16 ng/mL (95% CI 0.10 to 13.07).[8] Other studies also reported lower mean serum cotinine, with 0.12 ng/mL for 3-5 year-old children and 0.09 ng/mL for 6-11 year-old children.[16] However, our results were similar to those of Mannino *et al* in which the mean serum cotinine level was 1.66 ng/mL.[10]

Cotinine, the major proximate metabolite of nicotine, has been widely used and considered to be the best currently available biomarker of tobacco exposure. The half-life of nicotine averages 2-3 hours. With intermittent exposure, nicotine levels in the body rise and fall throughout the day. The half-life of cotinine averages about 17 hours. Because of the longer half-life, cotinine levels tend to build up throughout the day, and cotinine is eliminated over a much longer period of time compared to nicotine. With intermittent nicotine exposure, cotinine levels remain relatively constant throughout the day and remain at near steady-state values.[6,7] The higher mean serum cotinine level found in our study suggests a higher tobacco exposure to our subjects.

Several studies compared cotinine levels in people of different ethnicities, with varying results. Mannino *et al* found lower cotinine levels in Mexican-Americans, compared to non-Hispanic Whites and non-Hispanic Blacks.[10] However, Wilson *et al* found higher cotinine level in African-Americans.[7] Another study found no differences in cotinine levels between Hispanic, Black and White children in the United States.[17] Until now, there has been no study to assess serum cotinine levels in Indonesian children, particularly in Manado. Generally, it is thought that there is no difference in metabolism and level of cotinine between races. As such, differences in cotinine level can be used to show the level of tobacco exposure.[6,7]

In our study, we found no correlation between cotinine level and IQ (r=-0.19). Similar results were found in a previous study of 280 children, aged 3 years, showing no correlation between tobacco smoke exposure at home and IQ (r=-0.21).[18] In contrast, Yolton *et al* showed a strong inverse correlation between cotinine and math score (r=-1.63), between cotinine and reading score (r=-2.37), while there was no significant correlation for block design or digit span score.[8]

The lack of a significant inverse correlation in our study may be due to other factors' influence on IQ, as not all factors can be controlled for. For example, we could not control the genetic, social and environmental factors, as they were beyond the scope of the study. However, as far as we know, this is the first study in Indonesia using serum cotinine measurement to objectively define tobacco smoke exposure in children. The prevalence of smokers is high in Indonesia, especially in Manado, resulting a in high prevalence of tobacco exposure in children. We hope this study will raise awareness of the negative impacts of tobacco on cognitive abilities in young children, and reduce tobacco exposure, since cognitive dysfunction happens at an early age, as shown by the lower IQ of children exposed to tobacco smoke.

A limitation of this study is that we did not use a more detailed questionnaire, such as one that included the type and number of cigarettes smoked, as well as the length of smoking.

In conclusion, we found a lower mean IQ in the group of children with tobacco smoke exposure than in the group without tobacco smoke exposure. There was no correlation between serum cotinine level and IQ in the group with tobacco smoke exposure. Further research is needed to clearly define the correlation between cotinine level and IQ, where other potential confounding factors for IQ can be controlled.

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