Trends in Respiratory Morbidity of Children in Relation to Their Passive Smoking Exposure

Abstract

Backround: The exposure of children to passive smoking has shown significant associations to respiratory morbidity. The youngest children between 0 to 2 years of age are usually more affected while with the child's increasing age a drop in respiratory illnesses incidence and a decrease of the effects of passive smoking are observed. During the repeated investigations of children involved in the ELSPAC study (European Longitudinal Study of Pregnancy and Childhood) the changes of the exposure to environmental tobacco smoke (at children´s age 6, 18 months and 5 years) and the differences in morbidity in the groups with different exposure were assessed.

Methods and Results: The data about health indicators and exposure were similarly obtained from the standardized questionnaire filled by mothers and physicians in the 6th, 18th month and in the 5th year of age of children, and assessed for 4 groups of children with different smoking habits of their mothers. The differences were statistically evaluated in the SPSS statistical program. The children of smoking mothers were more often exposed to environmental tobacco smoke; the children of middle and heavy smokers more than the children of light smokers. In the age of six months the children were slightly more often protected from passive smoking exposure than in the age of 18 months and 5 years: the differences were statistically significant ($p<0,01$). The attendance in kindergarten represents an important protective factor: the children were exposed less during the week-days than during weekends ($p<0,001$, resp. $p<0,01$). The respiration symptomatology and morbidity were significantly increased in the earlier periods of life of those children, whose mothers smoked. In the age of 5 years the smoking household environment influences only the higher incidence of asthmatic symptomatology (wheeze breathing, apnoe) and more frequent allergies to household dust and pollen with symptoms of dyspnoe and wheezing ($p<0,05$).

Conclusion: The ELSPAC study has provided evidence of the significant influence of the mother's smoking on the child exposure to passive smoking. The consequences of such exposure are manifested especially as increased respiratory and allergic morbidity.

Key words: passive smoking – children – respiratory morbidity - trends

Introduction

Children´s exposure to tobacco smoke in the course of intrauterine development and to environmental tobacco smoke (ETS) during childhood has been generally demonstrated as omnipresent and the most dangerous among harmful environmental effects influencing their health condition. According to the report from research of the European Union about respiratory tract health (1) involving data from nearly 8000 adult non-smokers from 36 towns in 16 countries, at least one parent of respondents smoked in the course of childhood in 65% of them.

The effects of maternal smoking during pregnancy on the baby´s birth weight was recognized and described in 1957 (2), and ten years later the first report on harmful impact of exposure to environmental tobacco smoke was published (3). Since then, hundreds of trials concerning relation between passive smoking and respiratory diseases and their complications as well as relation between passive smoking and disturbed behaviour and neurocognitive defects have been presented (4).

Exposed children have an increased risk of both the upper and lower respiratory tract infections and symptoms such as cough, phlegm production, otitis media, bronchitis and bronchiolitis, pneumonia as well as wheezing and asthma (1). The increased incidence of bronchiolitis caused by syncitial viruses in the respiratory pathways in children has been considered the main factor for the rise of allergenic reactions as these agents impair the process of physiological maturation of the immune system Th (5). Nearly two-fold risk of the lower respiratory tract infections in children exposed to ETS is decreasing after the second year of age. This trend may be influenced by the fact that older children spend less time with their parents –smokers (6).

A cohort of children from the town of Brno and the district of Znojmo born within 1991 – 1992 is involved in a prospective study of ELSPAC (European Longitudinal Study of Pregnancy and Childhood) that has been organized by 6 European countries (Great Britain, Isle of Man, Czech Republic, Slovakia, Russia, Ukraine). In the examination stages established previously (since the 18th month of prenatal life till the 18th year of age) there are gathered data not only about children, but also about both parents from the spheres of social, demographic, professional conditions, life-style, psychic state as well as data about health markers. The study was approved by the Ethical Commission, participants gave and signed informed consent. They are informed about methods of completing questionnaires in each

exploration. Objective medical examinations of children are carried out according to uniform methodology.

Relations between maternal smoking and children´s health conditions are assessed repeatedly. In examination realized at 6 months of age, the children whose mothers were light or medium smokers were repeatedly ill and hospitalized singificantly more often. Heavy smokers (20 and more cigarettes a day) were seen only sporadically at that perioid. The most frequent incidence of disturbed health condition was connected with acute diseases of both the upper and lower respiratory tracts, otitis media, gastrointestinal problems (diarrhoea, vomiting) and particularly with the occurrence of asthmatic symptomatology (wheezing breath, grasping for breath) (7). Similar results were provided by another examination of children performed at their age of 18 months. The criterion of passive smoke effects were the data about usual period of children´s exposure to environmental tobacco smoke. Even at that age, both inflammatory respiratory diseases and gastrointestinal and asthmatic symptoms occurred significantly more often in children exposed to environmental tobacco smoke, while the length of exposure was positively associated with the prevalence of patients (8).

Another evaluation of prevaling various diseases was realized at the time when children had reached 5 years of age. Then it was assessed whether and how the share of children exposed to environmental tobacco smoke had changed, and whether and what differences had occurred in the frequency of diseases in groups of children with various exposure.

Methods

Questionnaires were obtained for 3554 five-year-old children whose mothers also provided information about their smoking behaviour: according to it, children were divided into 4 groups:

- mothers – non-smokers (NS)
- mothers – light smokers, 10 cigarettes a day or less (S1)
- mothers – medium smokers, 11 – 19 cigarettes a day (S2)
- mothers – heavy smokers, 20 and more cigarettes a day (S3)

There were also found out the number of smokers in a family, intensity of children´s father´s smoking, average number of hours spent by a child in environmental tobacco smoke both on working days and weekends.

The data about children´s health condition in the period from the last examination (in the past 2 years) were obtained from mothers and attending physicians. The following markers were involved:

- the total evaluation of child´s health condition carried out by mother (permanently or mostly healthy, sometimes, mostly or permanently ill)
- hospitalization, spa treatment, therapeutical and preventive medical care, special investigations, operations, injuries
- symptoms of respiratory and gastrointestinal disorders, allergies, affections of sense organs, disturbances of motion, speech.

If any selected markers of health condition were also selected in a similar way from medical records or questionnaires made at 6 and 18 months of child´s age, they were processed for the mentioned 4 groups of children differing in their mothers´ smoking behaviour.
SPSS program (Pearson´s chi-square and Fisher´s test, probability rate, linear association, ANOVA) was used for statistical evaluation of differences.

Results

A group of children with mothers – non-smokers was the most numerous involving 2692 (75.7%) children of the whole set. Other 477 (13.4%) children had mothers – light smokers, the number of children with mothers – medium smokers was 322 (9.1%), and the other 63 (1.8%) children had mothers – heavy smokers. After delivery only 7% women were smoking in the whole set, during the first 6 months after labor, the prevalence of smokers increased to about 24% and remained on this level throughout the period of infancy, toddling and pre-school age (Table 1). The women smoking during pregnancy reduced the number of cigarettes smoked, and by the 6th month after delivery the occurrence of heavy smokers was only sporadic. Later on, the share of medium and heavy smoking women increased.
Maternal smoking was connected with smoker´s profile of the whole family. Non-smoking women had most often non-smoking partners, i.e. totally 71.1% children of the set were living in non-smoking families. Paradoxically, even 5.9% light and 3.5% medium smoking women defined their families as non-smoking. They probably wanted to express the fact that neither they nor any other member smoked at home. Most children whose mothers are smokers live in families with other smokers. The intensities of both maternal and paternal smoking correlated reciprocally positively (Table 2).

Maternal smoking influences the children´s exposure to passive smoking within their home environment: most children of non-smoking mothers and about two-thirds of children of mothers light smokers are not passive smokers. But only one-third of children of medium and about 15% children of heavy smokers are protected against their exposure to environmental tobacco smoke. At the age of 6 months, children were protected more often against exposure to passive smoking than at 5 years of age, namely in all the groups of smoking mothers: differences were statistically significant in most cases on 1% level of significance (Table 3). In most cases, 5-year-old children are exposed more on weekends than on week days, in a group of non-smokers and of mothers – light smokers the differences in the numbers of exposed children on various days of a week are statistically significant ($p<0.001$, resp. $p<0.01$).

In 5-year-old children the frequency of incidence of various studied symptoms and diseases given in Methodology was (with some exceptions) similar in all the four groups, namely even in the sphere of respiratory symptomatology and morbidity. The latter was increased highly significantly in previous life periods in children with smoking mothers (Table 4). On the contrary, in the period of pre-school age, out of numerous studied signs a smoker´s home environment has had effects only on more frequent incidence of asthmatic symptomatology: besides wheezing and apnoea that make mothers anxious seen twice up to three-times more often in children of medium or heavy smoking mothers ($p<0.05$). Among children of these two groups there are also more of them with revealed allergy to home dust and pollen, and manifestations of their allergic reactions also have more often character of dyspnoea and wheezing ($p<0.05$). The children whose mothers smoked were hospitalized significantly more frequently, namely in all the studied stages of investigation. No differences in preventive medical care, presented numbers of preventive examinations were seen between children from individual groups according to smoker´s behaviour of mothers. The demands on curative care and professional consultations were higher in children of smoking mothers, but they were statistically insignificant (Table 5).

Discussion

The risk of respiratory diseases associated with exposure to ETS is the highest at the lowest age (9, 10, 11). Although it is difficult to differentiate the level of cummulative risks of prenatal and postnatal exposure to noxious effects of a smoking mother, the intrauterine

development is a crucial period. A number of trials have shown clear associations between prenatal exposure to tobacco smoke (from a smoking mother) and decreased pulmonary functions of neonates (12, 13). The influence of exposure to ETS on the occurrence of pneumonia and bronchiolitis as well as necessary hospitalization due to respiratory diseases seems to be the most pronounced in the course of the first year of life (10, 14, 15). On the other hand, the incidence of cough in children of smoking parents decreases after the 13th year of age (16). Epidemiological data have described possible relationship between the exposure to ETS, and otitis media has been investigated several times with an explicit conclusion that with high probability there exists a causal relation between parents´ smoking and both acute and chronic forms of middle-ear diseases especially in children younger than two years (17).

It is not clear so far why harmful effects of parents´ smoking on the children´s respiratory tract become decreasing with their increasing age. Some hypotheses have provided this explanation: older children spend less time with their parents – smokers (6, 18, 19).

But, on the other hand, the trends of development of asthmatic respiratory manifestations associated with an exposure of a fetus/child to passive smoking have not shown similar decrease with a child´s increasing age. In children, their mothers´ smoking is mentioned in association with increased occurrence of wheezing up to six years of age (20), and is influenced even only by postnatal exposure when correcting the effects of prenatal exposure (21). Prenatal and postnatal exposure to tobacco smoke also brings considerable risk of the development of asthma manifested in adult age: in a Norwegian study the corrected attributive fractions of asthma occurrence in adults were caused by mothers´ smoking in 17.3%, and by the smoking of other family members in 9.3% (22).

The latest hypothesis has supposed that postnatal exposure to ETS functions as a triggering mechanism of wheezing attacks rather than a factor provoking asthma, while intrauterine exposure may increase the risk of asthma development (1). The findings supporting association between ETS and asthma are so strong that some authors believe in causal relationship. This hypothesis is also confirmed by the fact that severity of asthmatic diseases was improved even in children whose exposure to environmental tobacco smoke had been decreased (4).

Mother´s smoking during pregnancy and child´s exposure to ETS may provoke respiratory diseases by a mechanism that involves decreased mucociliary patency and opening of the respiratory pathways for microbes, decreased function of immune system, hyperplasia of adenoid vegetation (23). ETS contains a lot of chemical substances that – by their irritative

effects – cause excessive reaction of bronchi to allergens, impair the lung elasticity, decrease the function of lungs and change their daily variations (12, 24, 25, 26). In physiological conditions, the changes of adaptive immune competence after delivery involve decreased dominance of Th_2 and onset of Th_1. The delay of these changes and persistent incidence of fetal Th_1/Th_2 ratio offers the explanation of susceptability to severe viral infections and resulting allergic sensitizations in early childhood: they have been observed more often in children exposed to ETS (5).

The ELSPAC study has confirmed the findings provided by foreign trials (6): the frequency of most respiratory diseases provoked by acute inflammations of the upper and lower respiratory tracts and their middle-ear complications has decreased with age and stopped to be dependent on the child´s exposure to passive smoking. In contrast with that, however, asthmatic symptomatology (wheezing) increasing with children´s age was seen associated with their mothers´ smoking. That is in accordance with conclusions by US EPA (27) that in older children the effects of passive smoking are manifested more explicitly by symptomatology giving evidence for the respiratory tract obstruction.

However, less frequent exposure of older children to the environment polluted with harmful substances from cigarette smoke has not been confirmed. In a set of mothers involved in the ELSPAC study, smoking in medical history was reported by more than 41% women, in the period of 9 months before conception about 23% women were smoking, and about 7% mothers were smoking throughout pregnancy. The same prevalency of women–smokers was revealed in the sample during examinations carried out 6 weeks after birth (28). Of course, as early as the child´s age of 18 months, nearly one to fourth of mothers smoked again, and this frequency did not substantially change in the next period. Unfortunately, a share of medium and mainly heavy smoking women was increasing significantly in the total representation of smoking women. Then the effort for not smoking in places where a child was staying to protect it at least partially against the effects of emitted harmful substances started to decrease. Inconsiderate behaviour of smokers towards their children was shown especially by the data obtained from examinations performed at the age of 5 years – weekends are for children greater burden than week-days as in the course of them most children attend pre-school institutions. Neither the occurrence of respiratory problems with which the children from smokers´ families are affected significantly more often can frighten their parents away from smoking in their homes.

Health consequences of exposure to passive smoking seen more frequently in children than in adult active smokers are caused by many factors:

- adult active smokers are a selective sample of people who managed to adapt themselves particularly to acute effects of smoking (healthy smoker effects) while in a population of passively exposed children the prevalence of persons with higher susceptibility to the effects of chemical harmful substances can be significantly higher (27)
- within the same space, children can be exposed to higher concentration of such dangerous substances that are heavier than air as the respiratory zone of children is in the height different from that of adults (29)
- children have higher minute volume of inspired air (related to kg of body weight) than adults (30)
- respiratory frequency and absorption area of the lung alveoli are influencing respiratory minute volume that – in relation to kg of body weight and m^2 of the lung absorption area – is about 130 ml in a newborn and about 2 ml in an adult (31)
- according to experimental studies, the youngs of experimental rats have quicker absorption of liposoluble substances in the lungs, which was justified by structural differences influencing the porous character of the lung tissue. The comparison of histological and physiological parameters of an animal model with man has provided a number of reasons for hypothesis that the similar situation occurs in humans (30).

The inner exposure of children is therefore expressively higher than that of adults exposed to the same external conditions. The consequences of the damage to an organism with chemical noxious substances are usually more severe for children even due to the fact that complicated protective and detoxication mechanisms are just forming and maturing gradually as well as excretory systems (31).

Conclusion

The ELSPAC study has confirmed the effects of exposure to ETS in children on their respiratory morbidity that was developing after birth by the age of 5 years in a similar way as that presented in other foreign trials: the prevalence of the upper respiratory tract diseases and of cough was decreasing with age, higher incidence of wheezing was persistent particularly in children of mothers – heavy smokers even in the 5th year of their lives. The described trend cannot be explained by a lower exposure of children to ETS. In the Czech Republic there exist a number of programs on the base of school and pre-school training also involving parents´

cooperation devoted to the education to non-smoking. But the protection of children against exposure to ETS must be a priority task of physicians and the whole society: in this respect, political teams as well as mass media have incomprehensibly failed.

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Abbreviations:

ELSPAC – European Longitudinal Study of Pregnancy and Childhood

EPA – Environmental Protection Agency: a professional organization in the US dealing with the study of environmental pollution and effects of exposure on health condition

ETS – Environmental Tobacco Smoke: a mixture composed of cigarette smoke emitted from a lit end of a cigarette and from the air expired by a smoker

S1 – 10 cigarettes/day or less
S2 – 11 – 19 cigarettes/day
S3 – 20 and more cigarettes/day
NS – women – non-smokers

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Tab. 1: Mothers´ smoking habits in different periods of ELSPAC measurements (% of children)

Age of children:	**after delivery**	**6 months**	**5 years**
Non-smoking mother (NS)	91,8	76,2	75,7
Light smoker (S1, < 10 cig/day)	7,1	16,8	13,4
Medium smoker (S2, 11-20 cig/day)	0,9	7,0	9,1
Heavy smoker (S3, > 20 cig/day)	0,2	0,0	1,8

Tab. 2: Smoking in families of 5-year-old children (%)

N smokers at home/ mothers´smoking	**NS**	**S1**	**S2**	**S3**
None	71,1	5,9	3,5	0,0
One	26,1	34,0	32,2	30,2
Two	2,1	52,9	56,8	61,9
Three	0,4	5,2	6,3	7,9
Four and more	0,2	2,0	1,2	0,0
An average	0,33***	1,63	1,70	1,78
S.d.	0,6	0,8	0,7	0,6
Number of cigarettes daily smoked by husband on average	3,69***	8,50	12,29	18,94
S.d.	7,3	7,9	10,1	12,6

Note.: NS = nonsmokers, S1 = light smokers, S2 = medium smokers, S3 = heavy smokers

Statistic significance: *** = p <0,001

Tab. 3: Children´s exposure to ETS at homes (%)

Note: As only few mothers reported heavy smoking after delivery, the group S3 was added to the group S2

	NS	**S1**	**S2**	**S3**
At the age of 6 months				
Whole day	0,2	0,1	0,7	
More than 5 hours	0,1	0,3	2,3*	
Less than 5 hours	6,1	13,6*	43,1***	
No exposure	93,6	86,0*	53,9***	
At the age of 5 years				
Working day/weekend				
Whole day	0,3/0,7	0,4/0,9	0,9/2,2*	1,6/4,8**
More than 5 hours	0,4/0,6	1,1/0,4	4,1*/7,8**	7,9*/14,3**
3 to 5 hours	0,8/1,0	1,9/3,2	10,3**/9,7**	22,2**/19,0**
1 to 3 hours	1,6/3,3	5,8*/7,3*	16,3**/15,3**	27,0**/23,8**
Less than 1 hour	5,2/9,6	18,9*/25,8*	28,5**/28,8**	23,8*/22,2*
No exposure	91,8/84,8	71,8*/62,4*	39,8**/36,3**	17,5***/15,9***

Statistic significance: * = p<0,05, ** = p<0,01, *** = p <0,001

Tab. 4: Health problems of children whose mothers have different smoking habits (the observed/ expected ratio O/E) at children´s different periods of age (6 months, 18 months, 5 years)
Note: As only few mothers reported heavy smoking after delivery, the group S3 was added to the group S2

Marker of health status	**Age**	**NS**	**S1**	**S2**	**S3**
Cold	6 m	1	1,30***	1,20**	
	18 m	1	1,07*	1,12**	
	5 y	1	1,10	1,12	1,13
Cough	6 m	1	1,24***	1,27***	
	18 m	1	1,10*	2,82***	
	5 y	1	1,01	1,00	0,89
Several days‘ period of cough	6 m	1	1,25**	1,33***	
	18 m	1	1,10*	1,11*	
	5 y	1	1,00	0,98	0,98
Wheezing	6 m	1	1,41**	1,51**	
	18 m	1	1,33*	1,41*	
	5 y	1	1,07	1,16	1,13
Several days‘ period of wheezing	6 m	Not measured			
	18 m	1	1,26*	1,22*	
	5 y	1	1,21*	1,34*	1,36*
Breathless	6 m	1	0,98	1,54*	
	18 m	1	0,69	1,64*	
	5 y	1	0,81	1,18	0,48
Bronchiolitis, pneumonia	6 m	Not measured			
	18 m	1	1,03	1,12**	
	5 y	1	0,90	0,96	0,80
Otitis media	6 m	1	1,37*	1,78***	
	18 m	1	1,09	1,84**	
	5 y	1	0,91	0,86	0,73
Hospitalization	6 m	1	1,32**	1,84***	
	18 m	1	1,10	1,27*	
	5 y	1	1,02	1,11*	0,69

Statistic significance: * = $p<0,05$, ** = $p<0,01$, *** = $p<0,001$

Tab. 5: Need of health-care (an average number of physician treatment/examination visits)

Type of the care		**NS**	**S1**	**S2**	**S3**
Preventive care:					
Age 18 months	Average	4,5	4,4	4,5	
	s.d.	1,8	1,8	1,7	
Age 5 years	Average	1,7	1,8	1,8	1,9
	s.d.	1,1	1,0	0,9	1,4
Curative care:					
Age 18 months	Average	5,8	6,1	6,2	
	s.d.	5,2	4,8	4,7	
Age 5 years	Average	17,4	17,9	20,1**	14,5
	s.d.	11,3	11,2	11,9	10,5
Specialist consulting:					
Age 18 months	Average	1,0	0,9	1,2	
	s.d.	1,8	1,5	2,0	
Age 5 years	Average	2,0	1,9	1,9	1,3
	s.d.	2,9	2,9	2,4	1,9

Statistic significance: ** = $p<0,01$

Fig. 1 a) – d): Overview of ETS exposure of children born to non-smoking (NS) and smoking (S1 = 1-10 cig/day, S2 = 11 – 20 cig/day, S3 = more than 20 cig/day) mothers at different children´s age (6 months, 5 years).