Psychiatria Danubina, 2019; Vol. 31, Suppl. 1, pp S39-S43
Medicina Academica Mostariensia, 2018; Vol. 6, No. 1-2, pp 39-43 *Review*

HEALTH SEQUELAE OF TOBACCO EXPOSURE IN CHILDHOOD AND ADOLESCENCE

Marina Lampalo[1], Marjeta Majer[2], Irena Jukić[3], Hana Safić Stanić[3], Blaženka Barišić[1] & Sanja Popović-Grle[1]

[1]University Hospital Centre Zagreb, Clinic of Lung Diseases Jordanovac, Department of Allergic and Inflamatory Lung Diseases, Zagreb, Croatia
[2]University of Zagreb, School of Medicine, Andija Štampar School of Public Health, Department of Social Medicine and Organization of Health Care, Zagreb, Croatia
[3]Croatian Institute of Transfusion Medicine, Zagreb, Croatia

received: 12.9.2018; revised: 20.10.2018; accepted: 3.12.2018

SUMMARY

Tobacco consumption is one of the most common preventable cause of premature deaths worldwide. Persisting effects of exposure to tobacco smoke on children and adolescents are apparent during pregnancy and in early infancy, passive exposure to environmental tobacco smoke in home and elsewhere, and active smoking during adolescence. While, lung development in these stages of growth is not complete, tobacco smoke puts children and adolescents in danger of severe respiratory diseases and may interfere with the growth of their lungs. Active tobacco consumption by adolescents may have immediate adverse health outcomes such as addiction, impaired lung growth or reduced lung function. Much of the current evidence comes from longitudinal and cross-sectional longitudinal observational studies and propose that the strongest associations with smoke exposure are in the pregnancy and early childhood. The association of nicotine with respiratory system among children and adolescents is less clearly understood and the evidence primarily comes from in vitro and animal studies.

Key words: *tobacco smoking – children – adolescents - health outcomes*

* * * * *

INTRODUCTION

According to the World Health Organization (WHO 2011), tobacco consumption is one of the most common preventable cause of premature deaths worldwide, with about six million deaths per year. Nearly all tobacco use begins during adolescence and young adulthood. Even though prevalence of smoking among adolescents declined during last decades, recent data showed prevalence of approximately 20%, respectively (U.S. Department of Health and Human Services 2014, ESPAD group 2016). Tobacco use during adolescence increases the risk of persistent nicotine addiction, contributing to daily and continuous tobacco use in adulthood (U.S. Department of Health and Human Services 2012). Adverse health outcomes related to tobacco exposure in children and adolescence range from reduction of lung function and impaired lung growth to chronic respiratory diseases (Centres for Disease Control and Prevention 2004). The aim of this study was to give in insight of prevalence and health sequelae of tobacco smoking and/or tobacco exposure in children and adolescents.

EPIDEMIOLOGY OF TOBACCO USE AMONG ADOLESCENTS

Approximately 4.7 million middle and high school students were current tobacco users in 2015 in United States (US) (Kann et al. 2016). Around 7.2% of middle school students and 20.2% of high school students have used some type of tobacco product in 2016. Gender dissimilarity is noted and more male students consume some type of tobacco product (Singh et al. 2016). Furthermore, significant racial/ethnic and regional differences in smoking rates exist. Among high school students, white teens are more likely to smoke than black or Hispanic peers (Kann et al. 2016). WHO survey Health Behavior in School-aged Children (HBSC) conducted 2013/2014 in 42 countries with more than 210 000 students aged 11, 13, and 15 years showed average prevalence of tobacco smoking at least once per week of 1%, 3% and 12%, respectively (Inchley et al. 2016). Croatia participated in the HBSC survey with representative sample of 5741 students, and reported smoking prevalence at least once per week of 0.6%, 4%, and 23.5%, respectively (Pavić Šimetin et al. 2016). According to the smoking prevalence among 15-year old (23.5%) Croatia has taken the third place, after Greenland (27%) and Bulgaria (25.5%), while the lowest prevalence was found in Norway (4%), Iceland (3%) and Armenia (3%) (Inchley et al. 2016, Pavić Šimetin et al. 2016). Similar data were found in European School Survey Project on Alcohol and Other Drugs (ESPAD) report 2015, conducted among 96043 students in 35 European countries. They found lifetime prevalence rates of cigarette smoking among 15-16-year-old students ranged from 16% to 66%, while 21% smoked in the last 30 days.

The highest rates of smoking in the last 30 days were found in Italy (37%), Bulgaria (33%) and Croatia (33%), and the lowest in Iceland (6%), Moldova (9%), and Norway (10%) (ESPAD group 2016, Pejnović Franelić et al. 2016). European Health Interview Survey (EHIS) conducted in Croatia in 2014/2015 among 5446 participants aged 15 and older reported daily smoking prevalence of 29.5% in males, and 20.8% in females, placing Croatia on fifth place among European Union countries, after Bulgaria, Greek, Hungary and Cyprus. According to EHIS, daily smoking prevalence among 15-24-year-old participants was 23.2% in males, and 17.6% in females (Antoljak et al. 2016). Global Youth Tobacco Survey (GYTS) as a part of Global Tobacco Surveillance System was conducted in Croatia in 2016, among 3 250 students aged 13-15 years. Results showed that at the time 15.9% of students smoked some tobacco product, and 14.6% have smoked cigarettes. Out of that number, 46.6% showed signs of addiction (Mayer et al. 2017).

Trends and projections

As U.S. Department of Health and Human Services claims, from 2011 to 2016, current cigarette smoking declined among middle and high school students. Comparing 2011 and 2016, a decrease from 4.3% is apparent among middle school students, and another 15.8% among high school students (U.S. Department of Health and Human Services 2014). Survey from 2015 presents similar data. The results indicate that tobacco smoking by adolescents has declined by more than a half since its most recent peak in late 1990s (Johnston et al. 2016). In European countries, ESPAD report 2015 showed decreasing trend in daily cigarette use among 15-16-year-old students, from 20% in 1995 to 12% in 2015, while lifetime prevalence rates of smoking decrease was from 67% to 47%, respectively, with closed gender gap during that period. In 1995 boys showed higher prevalence of all indicators of smoking comparing to girls, while in 2015 these differences were no apparent. Closed gender gap was not found in a pattern of use such as daily smoking and early onset, which are still more prevalent among boys. Comparing to ESPAD average, in Croatia decreasing trend in lifetime smoking prevalence is lower, and ranged from 69% in 1995 to 62% in 2015, while daily cigarette use increased from 22% to 23%, respectively (ESPAD group 2016, Pejnović Franelić et al. 2016).

HEALTH SEQUELES OF TOBACCO USE AMONG CHILDREN AND ADOLESCENTS

Etiology, pathogenesis and proposed mechanisam

Adolescents' habitual smoking causes various health problems including upper respiratory infection, immature lung development, reduced maximum vital capacity, and lung cancer. The evidence indicate that it can lead to the increased number and severity of respiratory illnesses and decreased physical fitness. Adults who smoked as adolescents can have lungs that never fulfill to grow to their potential size and never perform at full capacity. This condition is an outcome of pernicious chemicals found in tobacco smoke, which slow down lung growth, and such damage is permanent. Abundance data suggest that cigarette smoking is generally associated with alterations in mechanisms of the host defense system. Ciliary function is flawed and mucous volume is much increased due to mucous gland hypertrophy, leading to obvious respiratory symptoms such as cough, dyspnea and an increased amount of phlegm (Arcavi & Benowitz 2004).

Environmental tobacco smoke exposure considerably increases the danger of lower respiratory tract infections among children. Studies conducted in 2006 and 2008 used mouse models to investigate the cigarette smoke effects on inflammatory processes, viral clearance and secondary immune protection. It mainly affected primary antiviral inflammatory processes, whereas secondary immune system remained intact. In a study taken afterwards, the incidence of influenza in healthy young males was higher among smokers (Lee et al. 2012). In studies examining the role of secondhand smoke, a group of scientists exposed one-week-old guinea pigs to filtered air or secondhand smoke for five weeks. Secondhand smoke exposure increased the excitability of afferent lung C-fibers and neurons in the CNS reflex pathway. This pathway could underline the increased risk for respiratory symptoms attributable to secondhand smoke exposure (Centers for Disease Control and Prevention 2004). Harmful impact of cigarette smoke was shown in vitro assays that revealed altered cellular viability and proliferation, inducing DNA damage, altering cellular behavior, and diversity in the pattern of gene expression and protein production (Johnson et al. 2009). Impaired immunoglobulin responses to immunization and dose-dependent decreases in responses to T cell and B cell mitogens have been reported for both short-term in vitro and in vivo exposures to tobacco smoke (Centers for Disease Control and Prevention 2006). More evidence regarding harmful consequences of passive smoking were shown after exposing rat fetuses to tobacco smoke. Arrested lung growth and lung hypoplasia have been reported and, with fewer and larger saccules which were more compliant and had reduced parenchymal tissue, septal crests, increased density of interstitial tissue, inadequate development of elastin and collagen and remarkably reduced surface area for gas exchange (Centers for Disease Control and Prevention 2006, Rehan et al. 2009).

Clinical, public health and epidemiological studies

Children in particular, seem to be the most susceptible population for the harmful effects of the environmental tobacco smoke (Saldías & Díaz 2011). A survey-type study was conducted among 3108 high school students in Poland, aged from 15 to 19 years. When it comes to male subjects, stratified by the smoking habit, 21% of non-smoker subjects reported chronic bronchitis while same symptoms were reported by 71% of smokers. Regarding females, chronic bronchitis was reported by 23% of non-smokers and 75% of smokers. All summarized, the number of persons mentioning symptoms of chronic bronchitis was much higher in the group of smokers, presenting tobacco smoke as a key cause of chronic bronchitis in adolescents (Saracen 2017).

In a longitudinal study of 669 children and adolescents aged 5 to 19 years in East Boston, Tager et al. found that among adolescents who began to smoke at the age of 15, the predicted FEV_1 level at 20 years was only 92% of the expected FEV_1 level for nonsmokers. Subsequently, they analyzed spirometric measurements from at least one FVC in females and males aged five years and older. For girls, a linear increase in FEV_1 levels ended approximately one year earlier for current smokers than for nonsmokers without respiratory symptoms (Tager et al. 1985).

When it comes to infants and lung development, maternal smoking exposure reduces lung function in children, and miscellaneous studies propose that this effect on lung function is attributable primarily to exposure during pregnancy. Maternal smoking during pregnancy might impair in utero airway development or alter lung elastic properties. It has been shown that maternal cigarette smoking, especially postnatal increase the severity of RSV infection in infants (Saldías & Díaz 2011).

In 1991 Sherill et al. assessed lung function growth curves in smokers classified as asymptomatic. They detected that among females, cessation of lung function growth occurred at 22 years of age in asymptomatic smokers and at 23 years of age in asymptomatic women who had never smoked. Among female smokers with respiratory symptoms, lung function growth ended at 21 years of age, three years earlier than for those who had never smoked. Among asymptomatic men, the authors didn't find any dissimilarity in the age of lung growth cessation between nonsmokers and smokers. Among symptomatic male smokers, however, lung growth cessation occurred at a younger age compared with symptomatic nonsmokers (Sherrill et al. 1991).

Number of studies reported associations between parental smoking and occurrence of lower respiratory tract illness in young children. More than 50 studies have been systematically reviewed, with children age up to three years taken into account. In most of the studies a dose-response relationship was evident, and the associations with paternal smoking were still present after adjustment for perplexed factors (Saldías & Díaz 2011). Exposure to secondhand smoke in infancy and childhood, and active smoking during childhood and adolescence, further contribute to impaired lung growth and the risk of developing respiratory diseases (U.S. Department of Health and Human Services 2014). Earlier studies suggest that the risk was higher during the first six months of life, and gradually decreased to slightly above normal by the age of three. It was detected that exposure to secondhand smoking can increase risk for acute respiratory tract infections in older children. A dose-response between the degree of exposure to environmental tobacco smoke and acute respiratory infection was found in a cohort of 9-year-old children (Saldías & Díaz 2011).

Studies also showed correlation of smoking habits and other risk behavior. Cross-sectional Swiss Health Survey of Chiolero et al., conducted in 2002 among 18005 participants aged 25 years or more showed that those who smoked had more frequently low leisure time physical activity, low fruit/vegetable intake and high alcohol intake than those who didn´t consumed tobacco. In males, the odds ratio of multiple risk behaviors besides smoking were 1.14 (95% CI: 0.97-1.33) for ex-smokers, 1.24 (95% CI: 0.93-1.64) for light smokers (1-9 cigarettes/day), 1.72 (95% CI: 1.36-2.17) for moderate smokers (10–19 cigarettes/day), and 3.07 (95% CI: 2.59-3.64) for heavy smokers (≥20 cigarettes/day) comparing to non-smokers. Similar odd ratio was found for women: 1.01 (95% CI: 0.86-1.19), 1.26 (95% CI :1.00-1.58), 1.62 (95% CI:1.33-1.98), and 2.75 (95% CI:2.30-3.29), respectively (Chiolero et al. 2006). In a retrospective study among 1147 adolescents mean age 18.1 year, in Hong Kong, Ho et al. found that 45.5% of participants who smoked reported at least one other risk behavior, and 35.8% two or more (Ho et al. 2018).

According to the ESPAD report 2015, among the students who have smoked at least once, 93% have used alcohol, 32% cannabis, 12% inhalants, 10% tranquillizers or sedatives, and 8% new psychoactive substances (ESPAD group 2016).

As for the nicotine impact on adolescents' and children's respiratory system, the current knowledge is very limited and is mainly based on animal and in vitro studies. It interferes with the development of respiratory system and its function in many levels, discussed in earlier studies (Rehan et al. 2009).

CONCLUSIONS

Although there are only a restricted number of longitudinal surveys that include children and adolescents who smoke actively, the findings of health consequnces

of tobacco exposure are consistent for various groups of individuals. Lung function growth is delayed during childhood and adolescence, ceases prematurely and begins to decline in late adolescence and early adulthood. Finding of a dose-response connection between smoking and the level of FEV_1/FVC strengthens the fact that active smoking has a causal role in respiratory symptoms presence. Additionally, the inflammatory process caused by smoking would be initiated at any age, and the lungs of young smokers show evidence of airways inflammation and injury. It is also crucial to point out the remarkably noxious impact passive smoking has on infants and young children and the development of their respiratory system. Nicotine is shown to have a crucial role in development of individual's respiratory system but further studies are warranted to clarify this interrelation.

Acknowledgements: None

Conflict of interest : None to declare.

Contribution of individual authors:

Marina Lampalo and Marjeta Majer had substantial contribution to the conception and design of the study.

Marina Lampalo, Marjeta Majer, Irena Jukić, Hana Safić Stanić, Blaženka Barišić and Sanja Popović-Grle had substantial contribution to the literature searches and analyses.

Marina Lampalo, Marjeta Majer, Irena Jukić, Hana Safić Stanić, Blaženka Barišić and Sanja Popović-Grle drafted the manuscript and revised it critically for important intellectual content, and approved the final version

References

1. *Antoljak N, Benjak T, Brkić Biloš I, Dečković-Vukres V, Erceg M, Ivičeević Uhernik A et al.: European Health Interview Survey (EHIS) in Croatia 2014-2015: basic indicators [Internet]. Croatian Institute of Public Health, Zagreb, 2016. [cited 2018 Nov 22]. Available from: https://www.hzjz.hr/wp-content/uploads/2017/04/EHIS_kor.pdf*
2. *Arcavi L & Benowitz NL: Cigarette smoking and infection. Arch Intern Med 2004; 164: 2206-16*
3. *Chiolero A, Wietlisbach V, Ruffieux C, Paccaud F & Cornuz J: Clustering of risk behaviors with cigarette consumption: a population-based survey. Prev Med 2006; 42:348-53*
4. *ESPAD group: ESPAD report 2015: results from the European School Survey Project on Alcohol and Other Drugs [Internet]. European Monitoring Centre on Drugs and Drug Addiction, Lisbon, 2016 [cited 2018 Nov 20]. Available from: http://www.espad.org/sites/espad.org/files/ESPAD_report_2015.pdf*
5. *Ho KY, Li HCW, Lam KKW, Chan SSC, Wang MP, Chan VWF et al.: Exploratory study on the relationship between smoking and other risk behaviours among young smokers. J Clin Nurs 2018; 27: 2859-67*
6. *Inchley J, Currie D, Young T, Samdal O, Torsheim T, Augustson L et al. eds.: Growing up unequal: gender and socioeconomic differences in young people's health and well-being [Internet]. Health Behaviour in School-aged Children (HBSC) Study International Report from the 2013/2014 Survey. WHO Regional Office for Europe, Copenhagen, 2016 (Health Policy for Children and Adolescents, No. 7.) [cited 2018 Nov 27]. Available from: http://www.euro.who.int/__data/assets/pdf_file/0003/303438/HSBC-No.7-Growing-up-unequal-Full-Report.pdf?ua=1*
7. *Johnson MD, Schilz J, Djordjevic MV, Rice JR & Shields PG: Evaluation of in vitro assays for assessing the toxicity of cigarette smoke and smokeless tobacco. Cancer Epidemiol Biomarkers Prev 2009; 18:3263-304*
8. *Johnston LD, O'Malley PM, Miech RA, Bachman JG & Schulenberg JE: Monitoring the future: national survey results on drug use, 1975-2015: overview, key findings on adolescent drug use. Institute for Social Research, The University of Michigan, Ann Arbor, 2016*
9. *Kann L, McManus T, Harris WA, Shanklin HL, Flint KH, Hawkinset J et al.: Youth risk behavior surveillance – United States, 2015. MMWR Surveill Summ 2016; 65:1-174*
10. *Lee J, Taneja V & Vassallo R: Cigarette smoking and inflammation: cellular and molecular mechanisms. J Dent Res 2012; 91:142-9*
11. *Lee LY, Gu Q & Lin YS: Effect of smoking on cough reflex sensitivity: basic and preclinical studies. Lung 2010; 188:S23-7*
12. *Mayer D, Pavić Šimetin I, Belavić A & Hemen M: Global Youth Tobacco Survey (GYTS) Croatia 2016 [Internet]. Croatian Institute of Public Health, Zagreb, 2017 [cited 2018 Nov 22]. Available from: https://www.hzjz.hr/wp-content/uploads/2017/05/GYTS_HZJZ_WEB_000.pdf*
13. *Pavić Šimetin I, Mayer D, Musić Milanović S, Pejnović Franelić I & Jovičić D: Health Behaviour in School-aged Children (HBSC) Study: basic indicators of health and well-being in Croatia 2013/2014 [Internet]. Croatian Institute of Public Health, Zagreb, 2016 [cited 2018 Nov 19]. Available from: https://www.hzjz.hr/wp-content/uploads/2016/03/HBSC2014.pdf*
14. *Pejnović Franelić I, Markelić M, Muslić Lj, Musić Milanović S, Pavić Šimetin, Mayer D et al.: The European School Survey Project on Alcohol and Other Drugs - ESPAD: Croatian national results 2015 [Internet]. Croatian Institute of Public Health, Zagreb, 2016 [cited 2018 Nov 20]. Available from: https://www.hzjz.hr/wp-content/uploads/2016/10/HR_ESPAD_2015_RGB_3.pdf*
15. *Rehan VK, Asotra K & Torday JS: The effects of smoking on the developing lung: insights from a biologic model for lung development, homeostasis, and repair. Lung 2009; 1875:281-9*
16. *Saldias F & Diaz O: Cigarette smoking and lower respiratory tract infection [Internet]. In: Martín-Loeches I (ed): Bronchitis, 67-86. InTech, London, 2011 [cited 2018 Nov 22]. Available from: http://www.intechopen.com/books/bronchitis/cigarette-smoking-and-lower-respiratory-tract-infection*

17. *Saracen A: Cigarette smoking and respiratory system diseases in adolescents. Adv Exp Med Biol 2017; 944:81-85*
18. *Sherrill DL, Lebowitz MD, Knudson RJ & Burrows B: Smoking and symptom effects on the curves of lung function growth and decline. Am Rev Respir Dis 1991; 144:17-22*
19. *Singh T, Arrazola RA, Corey CG, Husten CG, Neff LJ, Homa DM et al.: Tobacco use among middle and high school students - United States, 2011-2015. Morb Mortal Wkly Rep 2016; 65:361–7*
20. *Tager IB, Muñoz A, Rosner B, Weiss ST, Carey V & Speizer FE: Effect of cigarette smoking on the pulmonary function of children and adolescents. Am Rev Respir Dis 1985; 131:752-9*
21. *The health consequences of smoking: a report of the Surgeon General: Centres for Disease Control and Prevention (U.S.), Atlanta (GA), 2004*
22. *The health consequences of involuntary exposure to tobacco smoke: a report of the Surgeon General: Centers for Disease Control and Prevention (U.S.), Atlanta (GA), 2006*
23. *U.S. Department of Health and Human Services: Preventing tobacco use among youth and young adults: a report of the Surgeon General [Internet]. Atlanta (GA), U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health, 2012 [cited 2018 Nov 24]. Available from: http://www.surgeongeneral.gov/library/reports/preventing-youth-tobacco-use/full-report.pdf*
24. *U.S. Department of Health and Human Services: The health consequences of smoking - 50 years of progress: a report of the Surgeon General. U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health, Atlanta (GA), 2014*
25. *World Health Organization: WHO report on the global tobacco epidemic, Warning about the dangers of tobacco [Internet]. World Health Organization, Geneva, 2011 [cited 2018 Nov 24]. Available from http://www.who.int/tobacco/global_report/2011/en/*

Correspondence:
Marjeta Majer, MD, PhD
University of Zagreb, School of Medicine, Andrija Štampar School of Public Health,
Department of Social Medicine and Organization of Health Care
John Davidson Rockefeller Street 4, 10 000 Zagreb, Croatia
E-mail: mmajer@snz.hr