RESEARCH ARTICLE

The Anti-tobacco Legislation's Impact on Air Pollution in Romanian Foster Care Homes

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Objective: The research aimed to investigate the impact of the anti-tobacco legislation (2016) on air quality in Romanian foster care homes. **Methods**: The measurements took place in foster care homes situated in three Romanian counties. We recorded data three times (in 2014, in 2016 – six months after the implementation of the anti-tobacco legislation, in 2019). In 41 foster care homes were measured the indoor and outdoor Particulate Matter (PM$_{2.5}$) level in the air, using the TSI SidePak™ Personal Aerosol Monitor device. Descriptive statistics and t-test were used for data analysis (significant difference if p < 0.05). **Results**: The indoor PM$_{2.5}$ values were higher in every year than outdoor values. Analyzing the anti-tobacco legislation's impact on air quality, we found no difference between the indoor data measured in 2014 and in 2016, but there was a significant difference in the outdoor values (they were higher in 2016). Comparing the values measured after the implementation of the legislation (2016 vs. 2019) we found no difference in either indoor or outdoor values. **Conclusions**: The anti-tobacco legislation has not influenced the indoor air pollution (PM$_{2.5}$) level. The increased outdoor PM$_{2.5}$ values suggest that the residents of the foster care homes are smoking more in front of the house after the introduction of the anti-tobacco legislation in 2016.

Keywords: air pollution, foster care home, PM$_{2.5}$, anti-tobacco legislation

Introduction

Air is a basic need for plants, animals and humans, without it life would be impossible [1]. In general, a person exhales and inhales 7500 mL/min of air, of which 78.08% nitrogen, 20.95% oxygen, 0.93% argon, 0.04% carbon dioxide and other toxic or non-toxic gases, including pollutants too [2,3]. Air pollution mostly affects people in the urban area, it is estimated that affects a number of 3.5 billion people, according to predictions, this number may increase to 6 billion, by the time we reach 2050 [4]. Air pollution causes 7 million premature deaths every year and is still increasing [5]. There are two types of air pollutants: indoor air pollution (the sources may be: burning wood, coal, dung, crop, cigarette, e-cigarette and cooking fireplaces) and outdoor air pollution (the sources may be: fossil fuel, smelting, metal processing) [6,7]. According to a research conducted by the World Health Organization (WHO) in 2014, premature deaths attributable to air pollution were more than 4.3 million, which could be prevented by reducing smoking and secondhand smoke. Unfortunately, certain sources of air pollution, such as cooking or heating, cannot always be removed as they are necessary in everyday life [8].

In order to report air quality, the United States Environmental Protection Agency (EPA) has developed an Air Quality Index (AQI). The AQI is calculated for the following major pollutants regulated under the Clean Air Act:

particulate matter, carbon monoxide, nitrogen dioxide and ground-level ozone. To protect public health, the EPA established National Ambient Air Quality Standards for each of these pollutants [9].

Particulate Matter (PM) is a mixture of solid and liquid droplets. The smallest particles, with less than 2.5 μm (PM$_{2.5}$) in diameter are called "fine" particles. The main sources of PM$_{2.5}$ are motor vehicles, agricultural burning, wood burning or forest fires, certain industrial processes and other combustion processes [9]. Tobacco smoke from cigarettes and waterpipes are PM$_{2.5}$ sources too, which can remain on average in the air for 160 minutes after smoking [10,11]. Particles smaller than 10 micrometers can get into the bloodstream through lung tissue in the form of organic or inorganic particles. These particles are harmful to human health, dangerous for the respiratory system and increase the risk of cardiovascular diseases [9,10,12]. The PM$_{2.5}$ values are categorized by the revised AQI (EPA, 2012) as the followings: good (0.0 – 12.0 μg/m³), moderate (12.1 – 35.4 μg/m³), unhealthy for sensitive groups (35.5 – 55.4 μg/m³), unhealthy (55.5 – 150.4 μg/m³), very unhealthy (150.5 – 250.4 μg/m³), hazardous (>250.5 μg/m³). Since 2013 all the countries are using the same PM$_{2.5}$ AQI scale [9].

According to data collected in 32 countries between 2003 and 2007, Romania occupied the second place concerning the air pollution (PM$_{2.5}$ was 366 μg/m³), in contrast with the lowest values, measured in New Zealand (8 μg/m³) [13]. In indoor places where the open flame is not

used for cooking or heating, in most cases the source of indoor air pollution is indoor smoking [8].

Based on the WHO data, smoking and secondhand smoke account for 7 out of the top ten causes of death [13]. Ischemic Heart Disease is 3 times and stroke is 2.5 times more common in smokers. Trachea, bronchus and lung cancers are 20 times more frequent among smokers than among the general population; it is remarkable that the value for tuberculosis is 2.9. Concerning the chronic respiratory diseases, 80% of the patients were smokers or former smokers. Tobacco smoke is an important risk factor for lower respiratory infections and increases the risk of getting type 2 diabetes mellitus, boosting the insulin sensitivity [15-17]. According to WHO, 6 million people die every year because of smoking, and as this trend continues, the number could reach 10 million by 2025. Taking into consideration all these aspects, smoking is called the leading preventable cause of the premature deaths worldwide [17-19].

In Romania, smoking in public spaces was present even after the 20-th century. In order to reduce smoking, the Romanian Government adopted the anti-tobacco legislation among the last countries on the 17th of May 2016. The law states, that smoking is banned in enclosed public spaces (restaurants, bars, cafes etc.), commercial areas (stores, malls etc.), at workplace (offices, conference rooms etc.), in public institutions and in the common areas of residential buildings. Smoking is also banned in public transport stations, playgrounds for children, as well as in educational and medical institutions (according to Law no. 15/2016).

In disadvantaged groups, smoking is still present in a higher percentage, in comparison with the average population. A few data are available in regard to smoking and secondhand smoke exposure of children living in foster care homes in the world, no data are known with reference to Romania. Ferencz et al. claimed in 2016 that 20,156 children were in the evidence of the National Authority for the Protection of the Rights of the Child and Adoption in Romania and 31% of foster mothers and 30% of foster fathers were smoking. This "parental" smoking was correlated with an increased smoking rate among children [20,21].

The primary source of air pollution in foster care units is smoking when no open flame heating or cooking is used. We aimed to study the impact of implementation of the anti-tobacco legislation (2016) on air pollution in some of the foster care homes in Romania.

Material and methods

Our skilled team (doctors and medical students) has performed the measurements personally in three counties of Romania (Covasna, Harghita, Mures) for three times (2014, 2016 – six months after the implementation of the anti-tobacco legislation, 2019), in foster care homes owned by the National Authority for the Protection of the Rights

of the Child and Adoption. Measurements were performed in a total of 41 foster care units in the three counties (CV – 13, HR – 8, MS – 20) and they were not taken during the heating season. The number of residents in the foster care homes was not exceeding 12 persons.

A TSI SidePak™ Personal Aerosol Monitor device was used to sample and record the levels of $PM_{2.5}$ in the air. This instrument is used to detect the fine particles with diameter less than 2.5 μm through air absorption. The values were recorded every second by sampling for 10 minutes, then the average was displayed. One minute elapsed between indoor and outdoor measurements. In some houses an open flame was used for cooking and somebody was smoking indoor or outdoor before or during the measurement, which led to the measurement of outliers (excluded during the data analysis).

Statistical analysis

The outliers were detected by applying Tukey Fences method. After they were excluded, a Shapiro-Wilk normality test was made. All variables followed a normal distribution. Descriptive statistics and t-test were used for data analysis (significant difference if $p < 0.05$). The variables are expressed as mean ± standard deviation. The statistical analysis was performed using the IBM SPSS Statistics 22 program (IBM Corporation, USA).

Results

On average, the $PM_{2.5}$ value was 9.85 ± 4.6 μg/m³ outdoor and 13.32 ± 5 μg/m³ indoor, in a range of between 1.08 μg/m³ and 23.8 μg/m³ after excluding outliers. We found significant differences regarding the place and year of measurement.

Comparing the indoor and outdoor measurements, there was a higher $PM_{2.5}$ indoor value for every year, with significant differences for 2014 and 2016, nearly significant for 2019 as shown in Table I.

Analyzing the impact of the anti-tobacco legislation (Table II) we found a slight increase in the indoor measurements between 2014 and 2016, with no significant difference. The outdoor measurements between data sets in 2014 and 2016 showed a significant difference, with a higher $PM_{2.5}$ value in 2016.

Comparing the values measured after the implementation of the legislation we found no difference in either indoor or outdoor values (Table III).

Discussion

This study examines the effectiveness of the Romanian Anti-Smoking Law (2016) in the foster care homes by examining the air pollution measurement data.

From the AQI categories [9], the most of our indoor and outdoor $PM_{2.5}$ values were in the good (48.6%) or moderate (44.4%) category, but in some foster care units the air quality was unhealthy (6.5%) or even very unhealthy (<1%). The open flame cooking's impact on the values of

Table I. The $PM_{2.5}$ value measured every year in the foster care units indoor and in front of the house (outdoor).

	$PM_{2.5}$ value measurement place (µg/m³)		p value
	Indoor	Outdoor	
2014	10.72 ± 5.59	4.71 ± 2.41	< 0.001
2016	13.02 ± 5.50	10.75 ± 2.98	0.045
2019	12.57 ± 3.67	10.62 ± 4.98	0.061

Table II. The $PM_{2.5}$ value measured indoor and outdoor in the foster care units before and after the implementation of the anti-tobacco legislation.

	$PM_{2.5}$ value measurement year (µg/m³)		p value
	2014	2016	
Indoor	10.72 ± 5.59	13.02 ± 5.50	0.105
Outdoor	4.71 ± 2.41	10.75 ± 2.98	< 0.001

Table III. The $PM_{2.5}$ value measured indoor and outdoor in the foster care units at 6 months (2016) and 3 years (2019) after the implementation of the anti-tobacco legislation.

	$PM_{2.5}$ value measurement year (µg/m³)		p value
	2016	2019	
Indoor	13.02 ± 5.50	12.57 ± 3.67	0.403
Outdoor	10.75 ± 2.98	10.62 ± 4.98	0.897

$PM_{2.5}$ was demonstrated in other studies [22], so it is recommended to exclude these kind of $PM_{2.5}$ sources. As a person spends 85% of its time indoor, the indoor $PM_{2.5}$ values are worrisome [23].

The anti-tobacco legislation was implemented in 2016 in Romania, and it bans indoor smoking (in foster care homes too). Our results show that indoor values from 2014 to 2016 did not differ significantly. These results are in contradiction with the awaited effect of the anti-smoking law, as it was expected that indoor air pollution would decrease. It is in opposition to the global trend too, which shows that there was a 23% decrease of the $PM_{2.5}$ values between 2010 and 2019 [24]. Several studies reveal that some people still smoke in enclosed places where smoking is banned by law, this may explain the unimproved indoor air quality in our study too [25,26]. In addition, smoking around buildings can degrade indoor air quality. With an open window, tobacco smoke can partially enter inside the buildings, thus polluting the indoor air quality.

Analyzing the outdoor air quality, there is a significant growth of data sets between 2014 and 2016, which can be explained by high smoking rate next to the foster care buildings. As several studies have shown, tobacco smoke directly influences the increasing tendency of outdoor $PM_{2.5}$ values. A French study also proved that after the implementation of anti-tobacco legislation the number of smokers near the buildings had increased [27,28].

Our data showed that between 2016 and 2019 there was a slight, but non-significant decrease in the indoor values of $PM_{2.5}$, the outdoor values remained the same.

Study limitations
Our study has some limitations, which need to be considered when interpreting the results. The sample size was small, which may lead to Type I statistical error. In some cases, the measurements are incomplete, which can also affect the results. During the measurements we used an Air Quality Monitor Meter $PM_{2.5}$, which is an air quality device used worldwide, but it does not detect only particles from tobacco smoke. Measured values can be affected by a number of factors in addition to tobacco smoke.

Conclusion
Based on our results there were no differences regarding the indoor air pollution ($PM_{2.5}$ values) in the foster care homes before, after 6 months, and after 3 years from the implementation of the anti-tobacco legislation. The increased outdoor $PM_{2.5}$ values suggest that the residents of the foster care homes are smoking more in front of the house after the introduction of the anti-tobacco legislation in 2016. As our study shows, it can be said, that in the short and long terms, the legislation is directly linked to the increased outdoor $PM_{2.5}$ values. For more comprehensive results, there is a need for further measurements.

Author's contribution
NT (Conceptualization; Methodology; Data collection; Data analysis and interpretation; Project administration; Resources; Visualization; Writing - review and editing)

LK (Conceptualization; Methodology; Data analysis and interpretation; Statistical analysis; Visualization; Writing - review and editing)

PB (Conceptualization; Data analysis and interpretation; Supervision; Validation; Visualization; Writing - review and editing)

VN (Data analysis and interpretation; Supervision; Validation; Writing - review and editing)

ILF (Conceptualization; Methodology; Data collection; Resources; Writing - review and editing)

AT (Conceptualization; Methodology; Data collection; Writing - review and editing)

ZA (Conceptualization; Formal analysis; Investigation; Supervision; Methodology; Project administration; Resources; Validation; Visualization; Writing - review and editing)

Conflict of interest
None to declare.

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