ISSN: 0976-3031

Available Online at http://www.recentscientific.com

CODEN: IJRSFP (USA)

International Journal of Recent Scientific Research
Vol. 10, Issue, 07(A), pp. 33353-33358, July, 2019

International Journal of Recent Scientific Research

DOI: 10.24327/IJRSR

Research Article

PREVALENCE OF ASTHMA IN CHILDREN UNDER 5 YEARS OLD EXPOSED TO AIR POLLUTION IN ABIDJAN, (CÔTE D'IVOIRE)

Kouao Ahua Kouassi René[1]*, Kouame Kouadio[2], Silue Siele[3], Attoh Toure Harvey[4], Coulibaly M'begnan[5], Konan Leandre[6] and Yoboue Veronique[7]

[1]University Félix Houphouet Boigny de Cocody
[2]Institut Pasteur of Côte d'Ivoire, Côte d'Ivoire, West Africa
[3]Universty Peleforo Gon Coulibaly
[4,5,6,7] University Félix Houphouet Boigny de Cocody

DOI: http://dx.doi.org/10.24327/ijrsr.2019.1007.3655

ARTICLE INFO

Article History:
Received 6th April, 2019
Received in revised form 15th May, 2019
Accepted 12th June, 2019
Published online 28th July, 2019

Key Words:

Air pollution; PM 2.5; Children; Asthma.

ABSTRACT

Objectives: To examine the relationship of pollutants resulting from biomass combustion and the risk of asthma in children under five years in Yopougon municipality.

Methods: The study was done in 104 households located in 2 different sites, *Andokoi* and*Lubrafrique* in Yopougon. The International Study of Asthma and Allergies in Childhood questionnaire was used and the indoor and outdoor concentrations of $PM_{2.5}$ with device 3M EVM-7 were measured.

Results: Average indoors concentration of $PM_{2.5}$ (73 ± 9 µg/m^3 site Andokoi and 30 ± 5 µg/m^3 site Lubafrique) and outdoors (85 ± 8 µg/m^3 site Andokoi and 35 ± 3 µg/m^3 site Lubafrique) were above World Health Organization guideline for air quality. The prevalence of wheezing in the last 12 months among children under 5 years old at site Andokoi and Lubafrique were 18.3 % [95% CI (0.08 – 0.30)] and 18.2% [95% CI (0.06 – 0.28)] respectively. In addition, asthma symptoms at site A increased with the level of $PM_{2.5}$ regards to biomass burning. Logistics regression analysis found association between dry cough at night and outdoor concentration of $PM_{2.5}$ (OR= 1.01 [95% CI (1.001 – 1.020)]) and association between wheezing and indoor concentration of $PM_{2.5}$ (OR= 1.02[95% CI (1.002 – 1.040)]) at site Andokoi but not at site Lubafrique. Nonetheless, no significant association was found between concentration of $PM_{2.5}$ and wheezing among children at the two sites.

Conclusions: Children under 5 years in Yopougon municipality are exposed to high level of $PM_{2.5}$ which can raise the asthma symptoms risks.

INTRODUCTION

Household indoor air pollution associated with burning of biomass fuel for cooking and heating is responsible for 7 million deaths and particularly in which five hundred and forty-three thousand (543,000) deaths in children under 5 years annually[1]. Early childhood exposure to household indoor pollution increased the lifetime risk for developing acute respiratory tract infections, asthma and chronic obstructive pulmonary disease[2,3]. In low and middle income countries (LMICs), even in cities, a substantial fraction of the population lives in poor house and burning biomass fuel for cooking[4,5,6,7]. In sub-Saharan Africa, biomass fuels remain the main energy source for 82 % of rural population and 60 % of urban population[8]. Biomass fuel combustion is responsible for the emission of toxics pollutants in air including particulate matter (PM), black carbon (BC), polycyclic aromatic hydrocarbons (PAH), etc.[8,9]. In most culture, women have the responsibility of home cooking activities and could be exposed to high level of pollutant during daily cooking[10].Also, children were exposing to high level of pollutant when they were carried at the back or placed near their mother during the cooking period[11,12]. A systematic analysis in Africa found in sub-Saharan Africa, 13.9 % of asthma prevalence in children under 15 years[13].There are some evidences of relationship between indoor air pollutants (bio aerosol, PM, NO_2, PAH, etc…) and

Corresponding author:* **Kouao Ahua Kouassi René
University Félix Houphouet Boigny de Cocody

asthma/wheezing development, but the causal relationship remains inconsistent[3]. The previous study[14], underlined the association between the onset of the cough in asthma group and $PM_{2.5;}$ and suggested that chemical and microorganisms absorbed on the surface of $PM_{2.5}$ played an important role in the development of asthma. In addition of $PM_{2.5}$, the long-term exposure in early life to others pollutants such as ozone (O_3), nitrogen dioxide (NO_2), etc. were also associated with asthma onset in children[15,16]. The diagnosis of asthma in children under 5 years of age is not reliable due to logistical, ethical and the variability of the wheezy illnesses[17], but the associations between air pollutants and asthma onset remain positive[15]. Although, it is evidence that asthma and air pollutants are associated, those results are not consistent. In a study conducted in Nigeria, used the International Study of Asthma and Allergies in Childhood (ISAAC) questionnaire and spirometry, two validated methods to diagnose asthma in children aged 5 to 11-years-old found the prevalence of wheezing ranged 6.4% to 8.7%[11]. Nevertheless, the results did not find a relationship between exposure to biomass smoke and asthma risk. In addition, another study conducted in Japan during air pollution episode didn't find an association between daily concentration of $PM_{2.5}$ and asthma[18]. Despite the negative results, all the studies suggested that children living in the house with poor air quality were more likely to develop respiratory infections[19].

In Côte d'Ivoire, studies conducted by the Institute for Health Metrics and Evaluation found that between 2005 and 2016, air pollution increased and became a threatening risk factor for death and disability among all age groups[20]. It is worth remembering that 8 864 490 inhabitants in 2015 rely on biomass (charcoal and wood) for cooking, although the government subsidies the butane gas[21,22]. We conducted a cross-sectional study to examine the relationship of pollutants resulting from biomass combustion and the risk of asthma in children under five years in Yopougon municipality (Abidjan, Côte d'Ivoire).

METHODS

This study assessed the $PM_{2.5}$ concentrations and children under 5 years old with respiratory health status living in the urban area of Yopougon municipality (Abidjan, Côte d'Ivoire). We developed a methodology based on field investigation (Time-Activity Diary questionnaire, International Study of Asthma and Allergies in Childhood questionnaire) and $PM_{2.5}$ daily measurements in each household.

Study Design, and Participant's Recruitment

A cross-sectional study was conducted during one year at Yopougon municipality of Abidjan Côte d'Ivoire from August 2016 to August 2017 after the approval of the National Ethics Committee. 104 children under 5 years old within two neighborhoods in Yopougon municipality were enrolled using fisher's formula as previously described our study[23].The choice of children under5-year-old was done for several reasons. Firstly, Côte d'Ivoire's population is young (44% of the population is below 15 years old and 6% above 60). Secondly, since the official year for kids to attend school is 5 years, children below 5 are still staying at home. After informed consent from approved by their parents or tutors, a questionnaire about child age, gender, cooking fuel and home location was filled.

In the two areas, indoor and outdoor $PM_{2.5}$ concentrations were measured with device 3M EVM-7.

Data Collection

Questionnaires were administered to the mother in order to assess the children asthma status and respiratory symptoms using standard questionnaire validated from the International Study of Asthma and Allergies in Childhood (ISAAC). In addition, Time-Activity Diary questionnaire was used to find the main location of children within the 24-hour time frame, characteristics of house and the fuel type used in the household. Daily indoor and outdoor concentrations of $PM_{2.5}$werealso measured. The key question used for assessing asthma symptom prevalence was: "Have you had wheezing or whistling in the chest in the last 12 months?".

Statistical Analysis

STATA software version 15.0. was used for this study. Descriptive statistics were performed andthe chi-square test was used to compare fuel consumption and mother's education level between the site Andokoi and Lubafrique. Therelationship between asthma and $PM_{2.5}$concentrationswere analyzed.

Results were presented as odds ratios (OR) with 95% confidence intervals (CI). p-value less than 0.05 was considered significance.

RESULTS

Demographics and Housing Characteristics of the two sites

In total, 104 children aged 0 to 5 were enrolled in the study. Table 1 shows that, 60 % of children were enrolled for site Andokoiand40 % for site Lubafrique. The sex ratio shows that 1.14 female were enrolled for site Andokoi while 1.44 male were enrolled for site Lubafrique.80 % households used butane gas alone on site Lubafrique while 52 persons used butane gas and biomass on site Andokoi. In term of mother's education level, the result shows that 58 % have less than high school level for the two sites. The high rate of illiteracy recorded at site Andokoi (40 %), followed by site Lubafrique (23 %).

Daily concentrations of indoor and outdoor show an average more than 153µg/m^3 which is higher than 25 µg/m^3 recommended by WHO at site Andokoi when households burnt biomass. Meanwhile, none of the household on site Lubafrique used biomass alone. Daily concentrations of indoor and outdoor carbon monoxide are lower in the two areas.

Table 1 Demographic profile of 104 children and characteristics of households reported at the two sites

	Site Andokoi (N, %)	Site Lubafrique (N, %)
Gender		
Male	28 (47)	26 (59)
Female	32 (53)	18 (41)
Fuel consumption †		
Butane gas	14 (23)	35 (80)
Butane gas and biomass *	31 (52)	9 (20)
Biomass	15 (25)	0 (0)
Mother's education level**		
Illiteracy	24 (40)	10 (23)
Less than high school	35 (58)	26 (59)
High school	1 (2)	8 (18)

Average daily indoor concentrations of $PM_{2.5}$ ($\mu g/m^3$)		
Butane gas	73 ± 9	30 ± 3
Butane gas and biomass	129 ± 14	40 ± 8
Biomass	164 ± 35	-
Average daily outdoor concentrations of $PM_{2.5}$ ($\mu g/m^3$)		
Butane gas	85 ± 9	35 ± 4
Butane gas and biomass	122 ± 14	68 ± 10
Biomass	153 ± 17	-
Average daily indoor concentrations of CO(ppm)		
Butane gas	0.9 ± 0.2	0.3 ± 0.1
Butane gas and biomass	2.4 ± 0.3	0.5 ± 0.2
Biomass	2.6 ± 0.5	-
Average daily outdoor concentrations of CO(ppm)		
Butane gas	2.3 ± 0.5	1.2 ±0.3
Butane gas and biomass	3.0 ± 0.3	1.2 ± 0.2
Biomass	3.2± 0.5	

†Fuel using was significantly associated with the sites ($p < 0.001$) using chi-square significant test
*Biomass (charcoal and wood)
**Mother's education level was significantly associated with the sites ($p < 0.001$) using chi-square significant test

Description of the child's time-activity diary (TAD)

Survey results indicated that most children in the two sites spent more time in the bedroom than in other indoor environments in on site Andokoior site Lubafrique (Figure 1, 2). The daily time spent by a child in the bedroom was about 44% by the living room (26%) and the kitchen (1%). Thereby, it can be assumed that children between 0 and 5 years old in the two sites spent about 71% of their daily time in the indoor environments of the house (bedroom, living room, closed kitchen). Concerning the outdoor, 19 % spent their time on the balcony, playground, transport, market with mothers on site Andokoi or Lubafrique.

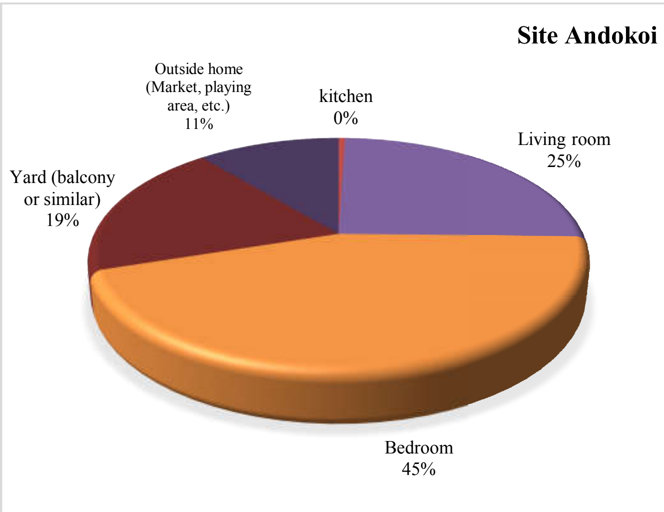


Figure 1 Daily average time of a 24-hours day spent by children under 5 years (n=60) in various area distribution in percentage (site Andokoi)

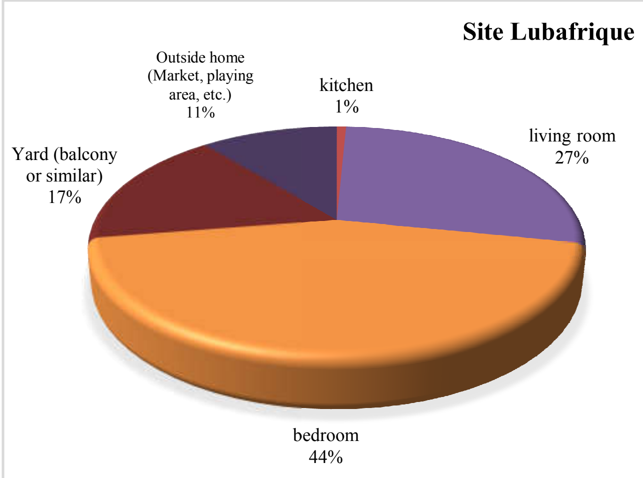
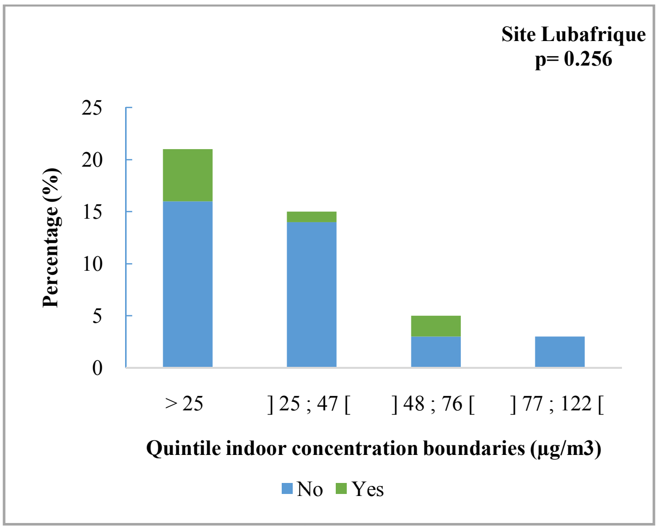


Figure 2 Daily average time of a 24-hours day spent by children under 5 years (n=44) in various area distribution in percentage (site Lubafrique)

Prevalence of Asthma Related Symptoms by $PM_{2.5}$ Concentrations

Figures 3 and 4 show the proportion of asthma symptoms and $PM_{2.5}$ concentrations in indoor and outdoor by quintile. The prevalence of wheezing was almost similar at site Andokoi and Lubafrique (18.3 % [95% CI (0.08 – 0.30)] and 18.2% [95% CI (0.06 – 0.28)]. The study found that 11.4 % of children living in less polluted indoor housing (< 25 $\mu g/m^3$) had wheezing and none suffer from wheezing in the most indoor polluted housing between 77 $\mu g/m^3$ and 122 $\mu g/m^3$at site Lubafrique. Nonetheless, this observation showed a different trend with outdoor $PM_{2.5}$ concentrations wherewheezing was observed in all the proportion of $PM_{2.5}$ concentrations in indoor and outdoor quintile.

The asthma related symptoms at site Andokoi, increased with quintile of $PM_{2.5}$. Indeed, the children exposure to high indoor and outdoor concentration of $PM_{2.5}$ had the highest proportion of wheezing or whistling in the chest (15.4 %). In addition, the highest proportion of a dry cough at night (23.3%; 25 %), was found among children exposed to high indoor and outdoor $PM_{2.5}$ concentrations.



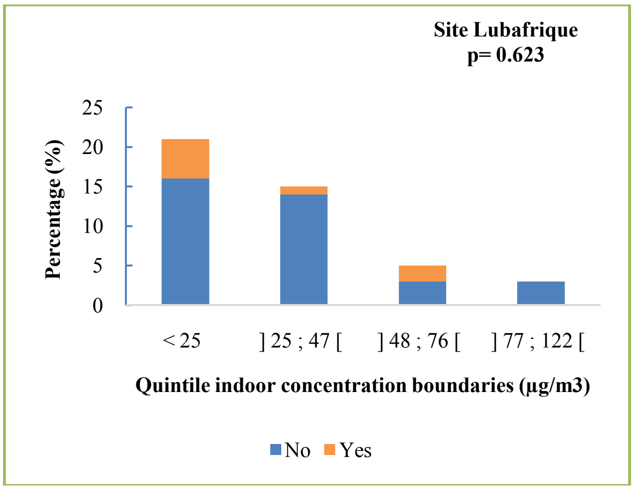


Figure 3 Proportion of child wheezing or whistling in the chest in the last 12 months by indoor and outdoor $PM_{2.5}$ concentrations at site Lubafrique

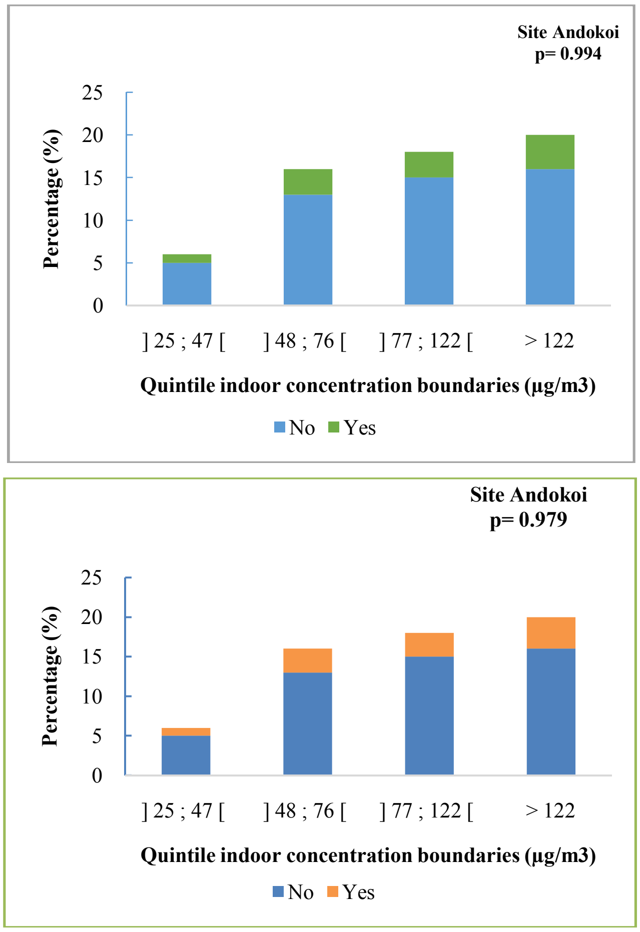


Figure 4 Proportion of child wheezing or whistling in the chest in the last 12 months by indoor and outdoor $PM_{2.5}$ concentrations at site Andokoi

Multivariate Analysis

In this study, positive correlation is found between dry cough at night and outdoor (r=0.38) concentration of $PM_{2.5}$on the one hand and the another hand between dry cough at night and outdoor concentration of carbon monoxide (r= 0.33) at site Andokoithrough Pearson correlation. Also, the multivariate analysis is used in order to examine the influence of covariates (gender, age, education) over the first correlation. Adjusted with the co-variables, the outdoor concentration of $PM_{2.5}$ in the model 1 was significantly associated with dry cough at night only at site Andokoi (OR= 1.01[95% CI (1.001 – 1.020)]). Outdoor concentration of $PM_{2.5}$atsite Andokoi increased the risk in children under five to get the dry cough at night.

The second analysis in the model 2 gave tree significant association between wheezing and study variables. Indeed, positive correlation is found between wheezing and indoor concentration of $PM_{2.5}$ (r=0.48), wheezing and outdoor concentration of $PM_{2.5}$ (r=0.43) and wheezing and indoor carbon monoxide (r=0,28) at site Andokoi. Adjusted with the co-variables, the indoor concentration of $PM_{2.5}$ was significantly associated with dry cough at night only at site Andokoi (OR= 1.02 [95% CI (1.002 – 1.04)]).

At the site Lubafrique, no significant correlation was found between dry cough at night either indoor or outdoor concentration of $PM_{2.5}$.

DISCUSSION

Children under 5 year-olds at the two sites stay long hours (71 % of daily time) inside the house. Indoor and outdoor concentrationsof $PM_{2.5}$ werehigher than WHO air quality value recommended (25 µg/m^3) and may raise the risk of asthma related symptoms invulnerable population to air pollutants.

The daily time spent by the children in the bedroom was about 44%, followed by the living room (26%), the other area (balcony) (11 %) and the kitchen (less than 1%). This finding was similar in the two sites and did not dependent on the site (p=0.16). In high income countries (HICs), children spent 70-90% of the daily time in indoor environment[24,25]. In our study, children under 5in the Yopougon municipality spent 70 % of the daily time in indoor which is similar to the HICs.To the best of our knowledge, no specific study in children under 5 concerning specific TAD has not been conducted.

Biomass burning in traditional stoves and kitchen poorly ventilated arethe most indoor air pollutionin LMCS[26,27,28]. Indeed, important concentrations of PM_{10} (611.3 µg/m^3 to 2656 µg/m^3) wererecord in kitchens in Tanzania[26]. Moreover, high concentration of other pollutants such as CO, NO_2, VOC found in this microenvironment are an additional risk of exposure for women and children[27,28]. Although these studies revealed that kitchens were highly polluted by gases and particles during the biomass combustion, the results in Yopougon indicated that kitchens were less visited by children (0.5-0.7% of child time/day). Children exposure to indoor air pollution could be more frequent inother indoor environments. Result showed that children's bedroom was already identified as the greatest contribution to daily exposure to pollutants[27]. Also, the study found that the little time spent by children in kitchen and suggested that, mothers in urban area could be aware of risk of physical injuries and air pollution exposure to children.

The different levels of indoor and outdoor concentration of $PM_{2.5}$ at the two sites were not significantly associated with the presence of wheezing in the last 12 months, only with the dry cough at nightat site Andokoi. The difference between the dry cough at night at site Andokoi and L may explain by the biomass fuel consumption and the low quality of housing at the site Andokoi. The previous study found that household characteristics (number of windows, kitchen location) increased only indoor concentration of $PM_{2.5}$ and biomass combustion increased both indoor and outdoor concentration of

$PM_{2.5}$ at both sites[23]. Consequently, biomass combustion and household characteristics were the risk factors that increased indoor and outdoor concentration of $PM_{2.5}$ and asthma related symptoms. Studies have already found the association between home quality in urban area and asthma symptoms. Insufficient ventilation in housing raised the level of indoor pollution which can trigger or exacerbate asthma[29,30]. In addition, the study done in Ouagadougou, capital of Burkina Faso, showed similar proportion of biomass using (60 % of households) and the significant association between air pollution and the prevalence of acute respiratory infection (OR=14.703; CI 95%:1.156 - 186.887) among children under five[31].

Although the study did not show an association between asthma and $PM_{2,5}$concentrations of, as shown as the results of studies in Sri Lanka[19] and Quebec[15], children living in the household with higher indoor $PM_{2.5}$ concentrations were more likely to have respiratory infections.

This survey result is consistent with previous studies which reported that children were vulnerable to air pollutants[1], on the other hand the highest risk to develop respiratory diseases[3,32,33]. The strength of the study was to examine the health effects of exposure to indoor and outdoor concentration of $PM_{2.5}$ measured in two sites of house where children spent most of their time.

One limitation of the study was the diagnosis of asthma in the children under 5 which was not done due to the variability of the wheezy illnesses. Other limitation was the highest level of illiteracy which could have introduce the bias during the questionnaire administration which was minimize by the physician staff.

CONCLUSION

The present study assessed the asthma related symptoms using the questionnaire validated from the International Study of Asthma and Allergies in Childhood and examined the relationship between exposure to indoor and outdoor concentration of $PM_{2.5}$ resulting to fuel combustion. The assessment was done in 104 households located in two residential sites, one was closer to an industrial area (*Andokoi*) and the other was far from the industrial area (*Lubrafrique*) in Yopougon (Côte d'Ivoire). The questionnaire and measurement data used to evaluate asthma related symptoms in children under 5 exposed to various levels of indoor and outdoor concentration of $PM_{2.5}$ at the two sites. In this study, biomass burning was significantly associated with the poor ventilation and increased the indoor and outdoor concentration of $PM_{2.5}$ which had already been polluted (WHO 25 $\mu g/m^3$ per day). Consequently, asthma related symptoms at site Andokoi, increased with indoor and outdoor concentration of $PM_{2.5}$. However, the study did not find any relationship between wheezing or whistling in the chest in the last 12 months and indoor and outdoor concentration of $PM_{2.5}$ at the two sites. Nevertheless, the asthma related symptoms increased with indoor and outdoor concentration of $PM_{2.5}$. From this study, we can suggest that using the butane gas reduced indoor and outdoor concentration of $PM_{2.5}$ and the risk of asthma related symptoms. The future work is going to be a longitudinal study. The diagnostic methodology of asthma will be the validated questionnaire ISAAC and spirometry to minimize misclassification.

Acknowledgements

This study was supported by the grant N° 107347-001 of Ecohealth Chair "Urban Air Pollution and Noncommunicable Diseases (ChairePol) and International Development Research Center (IDRC).We would like to thank the field-workers and Eco-Health staff for their technical support.

References

1. World Health Organization. Air Pollution and Child Health: Prescribing clean air [Internet]. 2018 [cité 9 nov 2018]. Available from: http://www.who.int/ceh/publications/Advance-copy-Oct24_18150_Air-Pollution-and-Child-Health-merged-compressed.pdf?ua=1.
2. Ahmed R, Robinson R, Mortimer K. The epidemiology of noncommunicable respiratory disease in sub-Saharan Africa, the Middle East, and North Africa. Malawi Med J Malawi2017; 29(292):203‑211.
3. Patelarou E, Tzanakis N, Kelly FJ. Exposure to indoor pollutants and wheeze and asthma development during early childhood. *International Journal of Environmental Research and Public Health* 2015;12(4):3993‑4017.
4. Apte K, Salvi S. Household air pollution and its effects on health. F1000Research 2016;5:2593.
5. Noubiap JJN, Essouma M, Bigna JJR. Targeting household air pollution for curbing the cardiovascular disease burden: A health priority in Sub-Saharan Africa. J*ournal of Clinical Hypertension* 2015; 17(10):825-829.
6. Jafta N, Barregard L, Jeena PM, Naidoo RN. Indoor air quality of low and middle income urban households in Durban, South Africa. Environ Research 2017;156:47‑56. DOI 10.1016/j.envres.2017.03.008.
7. Balakrishnan K, Sambandam S, Ghosh S *et al*. Household air pollution exposures of pregnant women receiving advanced combustion cookstoves in India: Implications for intervention. Ann Glob Heal 2015;81(3):375‑85.
8. Ekouevi K, Tuntivate V. Household Energy Access for Cooking and Heating: Lessons Learned and the Way Forward. 2012 [cité 9 juin 2018];96. Disponible sur: http://siteresources.worldbank.org/extenergy2/Resources/HouseHold_Energy_Access_DP_23.pdf.
9. Li Q, Jiang J, Wang S *et al*. Impacts of household coal and biomass combustion on indoor and ambient air quality in China: Current status and implication. Sci Total Environ 2017;576:347‑61.
10. Shen G. Quantification of emission reduction potentials of primary air pollutants from residential solid fuel combustion by adopting cleaner fuels in China. J Environ Sci (China) 2015;37:1‑7.
11. Du W, Li X, Chen Y, Shen G. Household air pollution and personal exposure to air pollutants in rural China –A review. Environmental Pollution 2018;237:625-638.
12. Thacher JD, Emmelin A, Madaki AJK, Thacher TD. Biomass fuel use and the risk of asthma in Nigerian children. Respir Med 2013;107(12):1845‑51.
13. Gordon SB, Bruce NG, Grigg J *et al*. Respiratory risks from household air pollution in low and middle income countries. The Lancet Respiratory Medicine 2014;2(10):823-860.

14. Adeloye D, Chan KY, Rudan I, Campbell H. An estimate of asthma prevalence in Africa: a systematic analysis. Croat Med J 2013;54(6):519‑31.
15. Zhang YX, Liu Y, Xue Y *et al*. Correlational study on atmospheric concentrations of fine particulate matter and children cough variant asthma. Eur Rev Med Pharmacol Sci 2016;20(12):2650‑2654.
16. Tétreault L-F, Doucet M, Gamache P *et al*. Childhood Exposure to Ambient Air Pollutants and the Onset of Asthma: An Administrative Cohort Study in Québec. Environ Health Perspect 2016;124(8):1276‑1282.
17. Yamazaki S, Shima M, Yoda Y*et al*. Association between PM2.5and primary care visits due to asthma attack in Japan: Relation to Beijing's air pollution episode in January 2013. Environ Health Prev Med 2014;19(2):172‑6.
18. Potter PC. Current guidelines for the management of asthma in young children. Allergy, Asthma and Immunology Research 2010;2(1):1-13.
19. Yamazaki S, Shima M, Yoda Y *et al*. Association between PM2.5and primary care visits due to asthma attack in Japan: Relation to Beijing's air pollution episode in January 2013. Environ Health Prev Med 2014;19(2):172‑6.
20. Phillips MJ, Smith EA, Mosquin PL *et al*. Sri lanka pilot study to examine respiratory health effects and personal $PM_{2.5}$ exposures from cooking indoors. Int J Environ Res Public Health 2016;13(8):651-663.
21. Arthur M. Institute for Health Metrics and Evaluation. Nurs Stand [Internet]. 2014 [cité 12 juin 2018];28 (42):32‑32. Disponible sur: http://www.healthdata.org/cote-divoire
22. United Nations Development Programme. Nama study for a sustainable charcoal value chain in Côte d'ivoire [Internet]. 2016 [cité 6 févr 2019]. Available from: www.mdgcarbon.org.
23. Institut National de la Statistique. Enquete sur le niveau de vie des menages en Côte d'Ivoire (ENV 2015) [Internet]. 2015 [cité 12 mai 2018]. Available from: http://www.ins.ci/n/templates/docss/env2015.pdf (Frenc)
24. Kouao AKR, N'datchoh ET, Yoboue V *et al*. Exposure to indoor and outdoor air pollution among children under five years old in urban area. Glob J Environ Sci Manag 2019;DOI: 10.22034/gjesm.2019.02.00.
25. Matz CJ, Stieb DM, Davis K *et al*. Effects of age, season, gender and urban-rural status on time-activity: Canadian human activity pattern survey 2 (CHAPS 2). Int J Environ Res Public Health 2014;11(2):2108‑24.
26. Leech JA, Nelson WC, Burnett RT, Aaron S, Raizenne ME. It's about time: A comparison of Canadian and American time-activity patterns. J Expo Anal Environ Epidemiol 2002;12(6):427‑32.
27. Kilabuko JH, Matsuki H, Nakai S. Air quality and acute respiratory illness in biomass fuel using homes in Bagamoyo, Tanzania. Int J Environ Res Public Health 2007;4(1):39‑44.
28. Saksena S, Singh PB, Prasad RK *et al*. Exposure of infants to outdoor and indoor air pollution in low-income urban areas - A case study of Delhi. J Expo Anal Environ Epidemiol 2003;13(3):219‑30.
29. Dionisio KL, Howie S, Fornace KM *et al*. Measuring the exposure of infants and children to indoor air pollution from biomass fuels in The Gambia. Indoor Air 2008;18(4):317‑27.
30. Heinrich J. Influence of indoor factors in dwellings on the development of childhood asthma. Int J Hyg Environ Health 2010;214:1‑25.
31. Northridge J, Ramirez OF, Stingone JA, Claudio L. The Role of Housing Type and Housing Quality in Urban Children with Asthma. J Urban Heal Bull New York Acad Med 2010;87(2). DOI:10.1007/s11524-009-94041.
32. Kafando B, Millogo T, Windinpsidi Savadogo P *et al*. Pollution de l'air intérieur et prévalence des infections respiratoires aiguës chez les enfants à Ouagadougou. Sante Publique (Paris) 2018;30(4):575. (French)
33. Oliveira M, Slezakova K, Delerue-Matos C, Pereira MC, Morais S. Children environmental exposure to particulate matter and polycyclic aromatic hydrocarbons and biomonitoring in school environments: A review on indoor and outdoor exposure levels, major sources and health impacts. Environment International. 2019;124:180‑204.

How to cite this article:

Kouao Ahua Kouassi René., 2019, Prevalence of Asthma in Children Under 5 Years old Exposed to air Pollution in Abidjan, (Côte D'ivoire). *Int J Recent Sci Res.* 10(07), pp. 33353-33358. DOI: http://dx.doi.org/10.24327/ijrsr.2019.1007.3655

****