Journal of Toxicology and Health
ISSN 2056-3779 | Volume 10 | Article 1

HOAJ
Herbert Open Access Journals

Original Research Open Access

Impact Of Obstructive Lung Diseases (Asthma and COPD) due to indoor air pollution and poor room ventilation quality in Medina (Senegal)

Salimata Thiam[1*], Mahammadou Lamine Daffe[1], Khady Thiam[2], Awa Ndong[3], Adama Faye[4], Mor Diaw[5], Mathilde Cabral Ndior[1], Fatoumata Bah[1], Nafissatou Omar Toure[2] and Mamadou Fall[1]

*Correspondence: limatath@gmail.com

CrossMark
Click for updates

[1]Laboratoire de Toxicologie et Hydrologie, Faculté de Médecine, de Pharmacie et d'Odontologie (FMPO), Université Cheikh Anta Diop, BP : 5005 Dakar-Fann, Sénégal.
[2]Service de Pneumologie, Centre Hospitalier Universitaire de Fann, Faculté de Médecine, de Pharmacie et d'Odontologie (FMPO), BP : 5035 Dakar-Fann, Sénégal.
[3]Department des sciences physico-chimiques, Unité d'Enseignement et Recherche, Université Iba Der Thiam, BP : A967 Grand Standing, Thiès, Sénégal.
[4]Institut de Santé et de Développement (ISED), Département de Médecine, Faculté de Médecine, de Pharmacie et d'Odontologie (FMPO), Université Cheikh Anta Diop, BP : 5005 Dakar-Fann, Sénégal.
[5]Laboratoire de Physiologie et d'Exploration Fonctionnelle, Département de Médecine, Faculté de Médecine, de Pharmacie et d'Odontologie (FMPO), Université Cheikh Anta Diop, BP : 5005 Dakar-Fann, Sénégal.

Abstract

Indoor air pollution is the underlying cause of 4 million deaths throughout the worldwide, of which 11% is directly caused by obstructive pulmonary disease. This study showed the possibilities of characterizing indoor air pollution in Medina neighbourhood (Dakar) and it also made it possible to estimate the impact of the main living room's ventilation on the occurrence of obstructive lung diseases (Asthma and COPD). This is a cross-sectional study based on a socio-demographic survey, air quality metrology (CO, PM10, NO, CO_2) and Functional Respiratory Assessment (spirometry). The impact measurement was carried out by logistic regression taking into account a certain number of confounding factors. Participants are distributed between 27 households which mainly use gas (55.56%) and charcoal (29.63%) as cooking fuel and in closed kitchens with window (66.67%). The prevalence of Obstructive pulmonary diseases is estimated at 33.06%. Regarding pollutants, levels are below WHO guidelines: CO (3.81 ppm), CO_2 (531.5 ppm), PM10 (0.27 µg/m^3) and NO (2.88 µg/m^3). In addition, study revealed an association between obstructive pulmonary diseases and living room's ventilation (chi-squared test's p-value = 0.02). Indeed, this lack of ventilation exposes residents to a higher risk of obstructive pulmonary disease: the Adjusted Odds Ratio (AOR [95%CI]) for medium and for poor levels are respectively estimated at 2.54 [1.27-5.08] and 2.06 [1.02-4.17]. These results therefore suggest that indoor air quality, particularly the renewal of air in the living rooms, as a determining factor of residents respiratory health condition.

Keywords: Indoor air, Respiratory lung disease, Senegal, Spirometry, West Africa

Introduction

Individuals spend an average rate of 80% of their time inside buildings (housing, public establishments, transport, etc.) [1]. The air components of these environments varies according to weather and activities that usually take place there. Most of the anthropogenic activities emitting pollutants inside buildings are known. For housing, these include combustion processes (biomass, smoking, etc.), cleaning products, waste incineration, road traffic and/or pollution caused by nearby industries [2]. These sources contaminate indoor air by emitting carbon monoxide, volatile organic compounds (benzene, toluene, ethylbenzene, xylene, formaldehyde, etc.), particulate matter, with harmful consequences for health and environment [3,4]. According to World Health Organization (WHO), indoor air pollution is the underlying cause of 4 million deaths thoughtout world, most of which occur in low- and middle- income countries [5]. In addition, 11% of these deaths are directly linked to obstructive pulmonary diseases [6]. Countries of Southeast Asia and sub-Saharan Africa are the most affected by these conditions. Among other obstructive respiratory diseases are asthma and Chronic Obstructive Pulmonary Disease (COPD) in first line. Prevalence of the latter varies respectively between 4

© 2023 Thiam et al; licensee Herbert Publications Ltd. This is an Open Access article distributed under the terms of Creative Commons Attribution License (http://creativecommons.org/licenses/by/3.0). This permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

and 14% and between 4 and 25% in sub-Saharan Africa [7]. These data are supported by few studies carried out in Africa with a significantly higher prevalence compared to developed countries [8-10]. In Burkina Faso and Senegal for example, respectively, a prevalence of 18.18% of asthma in women exposed to biomass smoke [9] and 43% of allergic rhinitis in street vendors exposed to road traffic has been documented [11]. These studies are an illustration of the negative impact of air pollution on respiratory health. This study supports existing literature on indoor air pollution and its health impact, particularly in Medina, a cosmopolitan city of Dakar.

Methods

Setting and study design

This is a cross-sectional study which based on socio-demographic survey, air quality metrology and Functional Respiratory Assessment. The study took place in the Medina, one of the most popular neighbourhood in Dakar with a density of 40,667 inhabitants/km^2 [12]. Several main and secondary roads pass through the neighbourhood Medina , hence the heavy traffic over there. In addition, Medina is characterized by the narrowness of its housing, most of which accommodates several families. These common housings seldom often have open kitchens (opening to another room), for, they have closed kitchens (not communicate with any other room) with no windows and very little green space.

Data Sampling and collection

Indoor air quality metrology

Measurement campaign included 27 dwellings, at the rate of two successive days of sampling by 7 hours a day . Measurements were carried out using air quality monitors: *AQ Pro version 1.05* is used to measure levels of nitrogen oxides (NO and NO_2) while *EVM-7 version 1.05* is used for carbon oxides (CO and CO_2) and Particulates Matter (PM_{10}) levels measurement.

Socio-demographic survey

In each home included in study, a questionnaire was administered to volunteers over 11 years old. In addition to certain housing characteristics (type of housing, cooking fuel, type of kitchen, burning incense, ventilation, etc.), this questionnaire is used to collect individual information (age, sex, smoking status, health status, etc.).

Functional Respiratory Assessment

It was carried out by spirometry and included participants in socio-demographic survey and others volunteers over 7 years old who had lived in Medina for at least five years and who had not had recent thoracic surgery. Moreover, parental consent had been obtained for children. *Spirobank II* and its accessories (scale, centimeter, recyclable tips, bronchodilator (*salbutamol*®) and inhalation chamber) were used to perform examination. This was done in a seated position and using a nose clip as recommended by the American Thoracic Society (ATS). A first phase without bronchodilator was implemented, then a second phase, 15 minutes after inhalation of the bronchodilator. Slow Vital Capacity and Second Maximum Expiratory Volume (FEV1) were obtained during this examination, as well as Forced Vital Capacity (CVF), estimates of Median Maximum Expiratory Flow (MED) at 75%, 50%, and 25% of CVF and Maximum Minute Ventilation (VMM).

Description of variables of interest

Obstructive lung disease

It is defined as a dependent variable and corresponds to being diagnosed with asthma and/or obstructive pulmonary disease. These disorders were diagnosed by spirometry according to the criteria of the Global Initiative for Asthma (GINA), and the Global Initiative for Chronic Obstructive Lung Disease (GOLD) [13]. Obstructive syndrome is first retained in face of a decrease in FEV1 more than 12%, a FEV1/FVC ratio less than 70% and a reduction of more than 20% in other ventilation flows. Differential diagnosis of asthma and COPD is made through a bronchial obstruction reversibility test using a β2 mimetic (*salbutamol*®) [13,14]. In addition, restrictive syndrome (restrictive ventilatory disorder, bronchospasm) is retained on basis to a decrease in slow vital capacity (CVL) and FEV1/FVC ratio greater than 95% in basal state [13].

Living room's' ventilation

It is a variable with three levels (good, medium and bad). Good ventilation corresponds to the presence of at least one door and at least one window permanently open during the day. As for medium ventilation, it corresponds to the presence of at least one door permanently open during the day associated with the lack of a window. And finally, poor ventilation, corresponds to presence of at least one door not permanently open during the day associated with lack of window.

Statistical analysis

Analysis was carried out with R software after merging different databases (spirometry, survey and air quality), setting a significance threshold for estimates at 5%. Data were described in the form of frequencies (for qualitative variables), means and standard deviation (for quantitative variables). Factors associated with obstructive lung disease were determined using chi-squared test and impact measurement was caried out by logistic regression. The odds ratios (Crude Odds Ratios (COR) and Adjusted Odds Ratios (AOR)) were estimated along with their 95% confidence intervals (95% CI).

Ethical considerations

This study was approved by the ethics committee of Cheikh Anta Diop University under number (0335/2018 / CER / UCAD) issued on 25/May/2018. The process was explained to participants, who in turn signed an informed consent letter after reading and understanding study objectives. All participants were coated according to the standards of the Helsinki Declara-

doi: 10.7243/2056-3779-10-1

tion, respecting the criteria of anonymity, obtaining consent, confidentiality of results, risks and benefits of the study.

Results

Respondents' individual characteristics

A total of 27 households and 365 volunteers participated (N) in the study. The latter concerned all residents aged at least 7 years. Sample was mainly made up of adults (42.47%), with a strong participation of children (29.86%) and adolescents (21.1%) as well as a slight female predominance (52.05%). Less than half of respondents declared having an occupational activity (45.7%) and 3.91% of participants are current smokers versus 7.03% former smokers. Pulmonary diseases are noted in 37.16% of participants; these are distributed as follows: asthma (25.74%), COPD (61.03%), bronchospasm (10.29%), mixed ventilatory disorder (2.21%) and other (0.74%). Thus, prevalence of obstructive ventilatory diseases is estimated at 33.06% (**Table 1**).

Table 1. Respondents individual characteristics (in %)

Respondent characteristics	Frequency *N = 365*
Current age (in year)	
child= [7,15)	29.86
adolescent= [15,25)	21.1
adult= [25,65)	42.47
elderly person= [65,84]	6.58
Sex	
female	52.05
male	47.95
Lung disease	
Yes	37.16
No	62.84
	N= 135
Type of lung disease	
Asthma	25.74
COPD	61.03
Bronchospasm	10.29
Mixed ventilatory disorders	2.21
Other	0.74
	N= 365
Prevalence of obstructive lung disease[1]	33.06
	N= 256
Occupational activities	
yes	45.7
no	54.3
Tobacco-use status	
current smoker	3.91
ex-smoker	7.03
non-smoker	89.6

N=Sample size used for tabulation; 1obstructive lung disease included Asthma, Chronic Obstructive Pulmonary disease (BPCO) or having both.

Households selected characteristics

Table 2 records characteristics of surveyed households. Three types of households were identified with the majority having a

Table 2. Housing characteristics (in %) including indoor air parameters (in mean [+/- sd]).

Housing characteristics	Frequency *N = 27*
Household type	
larger household	44.44
apartment	37.04
wooden house	18.52
housing size (in m^2)	
150	74.07
300	22.22
200	3.7
Number of residents	
mean [+/- sd]	20.89 [+/- 13.13]
Number of living room	
mean [+/- sd]	12.96 [+/-8.88]
Housing ventilation	
good	59.26
medium	37.04
bad	3.7
Main living room's ventilation	
good	25.93
medium	33.33
bad	40.74
Kitchen type	
closed with window	66.67
open air	25.93
in bedroom	7.41
Type of cooking fuel	
gas	55.56
charcoal	29.63
both (gas and charcoal)	14.81
Average mean of cooking duration	
1 hour	37.04
2 hours	55.56
3 hours	7.41
Exposed to incense smoke	
yes	66.67
no	33.33
Exposed to deodorants	
yes	55.56
no	44.44
	mean [+/- sd]
Levels of indoor air pollutants	
CO (ppm)	3.81 [+/- 7.53]
CO_2 (ppm)	531.5 [+/- 121.46]
PM_{10} (ug/m^3)	0.27 [+/- 0.26]
NO (ug/m^3)	2.88 [+/- 14.96]

sd= standard deviation

doi: 10.7243/2056-3779-10-1

surface of 150 m2 (74.07%): larger household (44.44%), apartment (37.04%) and wooden house (18.52%). Average number of residents per household is 20.89 (+/- 13.13) and more than half of the households have a good ventilation overall (59.26%). However, concerning main living room, less than half of households (25.95%) have a good level of ventilation. Regarding polluting activities related to cooking, households mainly use closed with window: 66.67% versus 25.93% of open-air kitchen. In addition, 55.56% of households use gas as cooking fuel versus 29.63% of charcoal users. Cooking takes an average 2 hours for the majority of households (55.56%). In addition, exposure to tobacco smoke and perfume sprays are respectively estimated at 66.67% and 55.56%. However, residents' exposure levels to pollutants such as CO (3.81 ppm), CO_2 (531.5 ppm), PM_{10} (0.27 µg/m^3) and NO (2.88 µg/m^3) are below WHO reference values for short-term exposure (**Table 2**).

Occurrence of obstructive lung disease by selected characteristics and chi-squared test

Regarding the results of bivariate analysis, living room's ventilation is significantly associated with the occurrence of obstructive lung disease (p=0.02 <5%). Indeed, 16.16% of participants with an obstructive lung disease lived in households where living room's ventilation is bad while 12.60% and 3.84% of them respectively lived in households with a medium and good ventilation for this room (**Table 3**).

Impact measurement by logistic regression

Both in univariate and multivariate logistic regression, living room's ventilation is associated with an excess risk of obstructive lung disease occurence. Results reveal Crude Odds Ratios of 2.55 [1.08-4.23] and 2.14 [1.31-4.96] for respectively medium and poor levels of ventilation. After adjusting for age, sex, smoking status, occupational activities and exposure to perfume sprays , Adjusted Odds Ratios (AOR) were estimated at 2.54 [1.27-5.08] (medium ventilation) and 2.06 [1.02-4.17] (bad ventilation) (**Table 4**).

Table 3. Distribution of obstructive lung disease (in %) according to selected characteristics.

Selected characteristics	Obstructive lung disease	Chi-2 test's p-value
Individual characteristics		
Current age (in year)		0.91
child= [7,15)	9.59	
adolescent= [15,25)	6.58	
adult= [25,65)	14.79	
elderly person= [65,84]	1.92	
Sex		
female	18.63	0.22
male	14.25	
Housing characteristics		
Household type		
larger household	15.62	0.48
apartment	11.51	
wooden house	5.75	
housing size (in m^2)		
150	27.67	0.12
300	3.84	
200	1.37	
Housing ventilation		
good	21.64	0.10
medium	9.59	
bad	1.64	
Main living room's ventilation		
good	3.84	**0.02****
medium	12.88	
bad	16.16	
Kitchen type		
closed with window	18.90	0.41
open air kitchen	12.60	
in bedroom	1.37	
Type of cooking fuel		
gas	12.88	0.95
charcoal	13.15	
both (gas and charcoal)	6.85	
Average mean of cooking duration		
1 hour	13.97	0.56
2 hours	18.08	
3 hours	0.82	
Exposed to incense smoke		
yes	21.92	0.10
no	10.96	
Exposed to deodorants		
yes	21.37	0.05*
no	11.51	

*Close to significance; **significant

Discussion

In Médina, the average number of residents per household is estimated at 20, therefore higher than national average (6 residents) and those found in Ouagadougou (7 residents) and Durban (14 residents) [**15-17**]. This situation reflects a promiscuity, partly explained by the history of the neighbourhood . It happens to be a traditional residential area where of most of the houses are legacies [**15**] hence the polynuclear structure of families. Moreover, for its proximity to the town, Medina is a place where civil servants and informal sector' workers converge [**18**]. 3.91% of respondents (children excluded) declared to be current tobacco smokers, a proportion below the national average estimated at 6% in 2015 [**19**]. This low proportion is linked to the massive presence of women whose consumption is lower compared to men, but also to religion and culture. However, the study revealed a high proportion of exposure to passive smoking (66.67%), i.e., twice the 25% recorded in India [**20**]. The same is observed for exposure to perfume sprays (estimated at 55.56%). This could be the result

doi: 10.7243/2056-3779-10-1

Table 4. Univariable and adjusted logistic regression models between obstructive lung disease and level of living room ventilation.

Variables	Univariable model			Adjusted model		
	COR	95% CI	p-value	AOR	95% CI	p-value
Main living room's ventilation						
good[ref]						
medium	2.55	[1.08 - 4.23]	<0.01**	2.54	[1.27 - 5.08]	<0.01**
bad	2.14	[1.31 - 4.96]	0.03**	2.06	[1.02 - 4.17]	0.04**
Exposed to deodorants						
yes[ref]	--	--	--	--	--	--
no	--	--	-	1.59	[0.99 - 2.57]	0.05*
Current age (in year)						
adult= [25,65)[ref]	--	--	--	--	--	--
child= [7,15)	--	--	--	0.9	[0.46 - 1.75]	0.75
adolescent= [15,25)	--	--	--	0.85	[0.43 - 1.70]	0.65
elderly person= [65,84]	--	--	--	0.85	[0.30 - 2.40]	0.76
Sex						
male[ref]	--	--	--	--	--	--
female	--	--	--	1.13	[0.69 - 1.86]	0.63
Occupational activities						
yes[ref]	--	--	--	--	--	--
no	--	--	--	1.03	[0.55 - 1.92]	0.92
Tobacco-use status						
non-smoker[ref]	--	--	--	--	--	--
ex-smoker	--	--	--	0.49	[0.13 - 1.88]	0.30
current smoker	--	--	--	2.13	[0.52 - 8.66]	0.29

ref =Reference category; *close to significance; **significant;

of increased promiscuity in urban areas and high demography (about 5% per year) [21]. Indeed, Dakar concentrates about 23% of Senegalese population and nearly 61% of urban population [21]. Participants in this study are from 27 households which mainly use liquefied petroleum gas (55.56%) as cooking fuel versus 29.63% of charcoal users. Liquefied petroleum gas is indeed of very widespread usage in Senegal, particularly in urban areas where it is estimated at 49.5% versus 24.1% of charcoal use [22]. Compared to other West African countries, Liquefied petroleum gas is used much lower: 60% (Burkina Faso), 98% (Mali) and 47% (Ivory Coast) [17,23,24] use charcoal as their main energy source. Indeed, in most of these countries, access to clean energy is often more difficult for households [9]. In addition, certain ancestral culinary practices are still very widespread in these countries, unlike Dakar where the modernity of life and lack of space no longer allow certain cooking methods. Biomass fuel is involved in deterioration of indoor air quality due to the significant emission of several harmful components such as carbon monoxide, Volatile Organic Compounds (VOCs) and suspended particles [17,25,26]. It is often used in closed kitchens with window, in open air or inside bedrooms. In the urban area of Dakar, 66.67% of households have closed kitchens window compared to 40.46% in Burkina and 31.3% in Mali [24,27]. Many of these kitchens are often poorly ventilated reflecting a high level of pollution. In these kitchens, woman also stay cooking for hours, everyday . The study reveals an average cooking duration of 1-3 hours. This is similar to that noted in India (2 hours) but relatively low compared to that average cooking-time found in Zimbabwe (1.5-9 hours) [20,28]. Concerning air quality metrology, study reveals concentrations below WHO regulatory values for short-term exposition: CO (4,36 mg/m^3), CO_2 (531.5 ppm), PM_{10} (0.27 µg/m^3) and NO (2.88 µg/m^3). Higher levels of pollution have been documented by other studies. Indeed, much higher concentrations of NO (19 µg/m^3) and PM_{10} (19 µg/m^3) are found in Durban [16], and in Zimbabwe, a level of CO (23.0 mg/m^3) 8 times higher was observed [28]. These levels are the result of biomass combustion inside households, the lack of air renewal, a poor hygienic condition and a set of domestic practices emitting pollutants in air [25,29]. Air quality is a determinant of respiratory health, particularly, obstructive pathologies such as asthma and COPD. 37.16% of participants (365) presented pulmonary involvement, which corresponds to asthma and COPD in 25.74% and 61.03% respectively. A

proportion of asthmatics twice as high (45%) as that noted in present study is noted among bus drivers in Dakar, unlike COPD (40%) [30] which is significantly underrated [30]. Lower proportions of asthma and COPD are documented by other studies in East Africa. Indeed, asthma and COPD are noted with respective proportions of 9.8% (Uganda) and 4.5% (Rwanda), i.e., 9 and 12 times the values recorded in Medina [31,32]. Moreover, the prevalence of obstructive ventilatory disease (asthma and COPD) is estimated at 33.06%. This prevalence is multiplied by 3 compared to a Nepalese study (8.1%) among adults exposed to biomass smoke [33]. Other non-obstructive pathologies were also diagnosed in Medina, these are restrictive ventilatory disorders (2.21%) and bronchospasm (10.29%). Living room's ventilation has been identified as a determining factor in the occurrence of obstructive ventilatory disease in the Medina. Indeed, adjusted risk (AOR [95%CI]) through age, sex, smoking status, occupational status and exposure to perfume sprays , is respectively estimated at 2.54 [1.27-5.08] and 2.06 [1.02-4.17] for medium and poor levels of ventilation in a room.

Conclusion

The study revealed a high prevalence of obstructive respiratory diseases among residents of the Medina. Lack of ventilation in living room is a determining factor in the occurrence of these disorders. This result suggests broadening and deepening studies on indoor air quality in housing and its health impact in order to have enough evidence to support advocacy for regulating indoor air level in Senegal particularly, but also generally in sub-Saharan Africa.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

Authors' contributions	ST	MLD	KT	ANB	AF	MD	MCN	FB	NOT	MF
Research concept and design	√	--	--	--	--	--	--	--	--	√
Collection and/or assembly of data	√	--	√	--	--	--	--	--	--	--
Data analysis and interpretation	√	√	--	--	--	--	--	--	--	--
Writing the article	√	√	--	--	--	--	--	--	--	--
Critical revision of the article	√	--	--	√	--	--	--	--	--	--
Final approval of article	√	√	--	--	√	√	√	√	√	√
Statistical analysis	--	√	--	--	--	--	--	--	--	--

Acknowledgements

We thank the ChairPol project for the technical support to this work. We would like also to thank the Medina People for their time and valuable information that they provided for this study.

Publication history

Editor: David Han, University of Texas at San Antonio, USA.
Received: 01-Nov-2022 Final Revised: 07-Jan-2023
Accepted: 11-Jan-2023 Published: 09-Feb-2023

References

1. ADEME. Les chiffres en air intérieur [Internet]. ADEME. 2015 [cité 2 févr 2022]. Disponible sur : https://www.ademe.fr/expertises/air-bruit/chiffres-cles-observations/chiffres-air-interieur.
2. Cachon FBA. Étude de pollution atmosphérique en Afrique Sub-Saharienne : Cas de Cotonou (Bénin) : Caractérisation physicochimique des matières particulaires d'origine urbaine et impact toxicologique sur des cellules épithéliales bronchiques humaines (BEAS-2B) cultivées in vitro. [Benin] : Université du Littoral Côte d'Opale ; Université Cheikh Anta Diop de Dakar ; 2013.
3. Dieme D, Cabral-Ndior M, Garçon G, Verdin A, Billet S, Cazier F, et al. Relationship between physicochemical characterization and toxicity of fine particulate matter ($PM_{2.5}$) collected in Dakar city (Senegal). Environ Res. févr 2012 ; 113 : 1-13.
4. Ndong A. Pollution de l'air extérieur et intérieur à Dakar (Sénégal) : caractérisation de la pollution, impact toxicologique et évaluation épidémiologique des effets sanitaires. : 197.
5. OMS. Pollution de l'air à l'intérieur des habitations et santé [Internet]. 2021 [cité 2 févr 2022]. Disponible sur : https://www.who.int/fr/news-room/fact-sheets/detail/household-air-pollution-and-health.
6. OMS. The top 10 causes of death [Internet]. 2020 [cité 2 févr 2022]. Disponible sur : https://www.who.int/news-room/fact-sheets/detail/the-top-10-causes-of-death.
7. Ku GM, Silveira VCD, Kegels G. MALADIES RESPIRATOIRES CHRONIQUES (MRC) EN AFRIQUE. 2018 ; 62.
8. Ramírez-Venegas A, Velázquez-Uncal M, Pérez-Hernández R, Guzmán-Bouilloud NE, Falfán-Valencia R, Mayar-Maya ME, et al. Prevalence of COPD and respiratory symptoms associated with biomass smoke exposure in a suburban area. Int J Chron Obstruct Pulmon Dis. 25 mai 2018 ; 13 : 1727-34.
9. Sana A, Kafando B, Dramaix M, Meda N, Bouland C. Household energy choice for domestic cooking : distribution and factors influencing cooking fuel preference in Ouagadougou. Environ Sci Pollut Res. Mai 2020 ; 27(15) : 18902-10.
10. Taylor ET, Nakai S. Prevalence of Acute Respiratory Infections in Women and Children in Western Sierra Leone due to Smoke from Wood and Charcoal Stoves. Int J Environ Res Public Health. June 2012 ; 9(6) : 2252-65.
11. Sylla FK, Faye A, Fall M, Lo M, Diokhané A, Touré NO, et al. Near-Road Exposure to Air Pollution and Allergic Rhinitis : A Cross-Sectional Study among Vendors in Dakar, Senegal. Occup Dis Environ Med. 2017 ; 05(04)

: 106-20.

12. Thioune A, Mbengue S. COMITE DE LECTURE ET DE VALIDATION DES SES. 2019 ; 347.
13. Miller MR. Standardisation of spirometry. Eur Respir J. 1 août 2005 ; 26(2) : 319-38.
14. FitzGerald JM, Sadatsafavi M. The importance of measuring asthma control in emerging economies [Editorial]. Int J Tuberc Lung Dis. 1 mars 2014 ; 18(3) : 254-254.
15. ANSD. Etude Monographique sur les Services Immobiliers du Logement à Dakar (EMSILD) – Août 2012 [Internet]. Dakar ; 2012 [cité 2 févr 2022] p. 95. Disponible sur : http://www.ansd.sn/ressources/rapports/RAPPORT_EMSILD_2010.pdf.
16. Jafta N, Barregard L, Jeena PM, Naidoo RN. Indoor air quality of low and middle income urban households in Durban, South Africa. Environ Res. juill 2017 ; 156 : 47-56.
17. Kafando B, Windinpsidi Savadogo P, Millogo T, Sana A, Kouanda S, Sondo B. Pollution de l'air intérieur et prévalence des infections respiratoires aiguës chez les enfants à Ouagadougou. Santé Publique. 2018 ; 30(4) : 575.
18. Ndour CT. La rue, espace prépondérant de loisir à la Médina, Dakar [Internet] [masters]. [Trois-Rivières] : Université du Québec à Trois-Rivières ; 2006 [cité 27 avr 2022]. Disponible sur : https://depot-e.uqtr.ca/id/eprint/1595/.
19. ANDS. Rapports Enquête sur le tabagisme [Internet]. http://www.ansd.sn/index.php?option=com_ansd&view=titrepublication&id=32. 2015 [cité 2 févr 2022]. Disponible sur : http://www.ansd.sn/index.php?option=com_ansd&view=titrepublication&id=32&Itemid=290
20. Johnson P, Balakrishnan K, Ramaswamy P, Ghosh S, Sadhasivam M, Abirami O, et al. Prevalence of chronic obstructive pulmonary disease in rural women of Tamilnadu: implications for refining disease burden assessments attributable to household biomass combustion. Glob Health Action. Déc 2011 ; 4(1) : 7226.
21. Ndir B. Situation économique et sociale du Sénégal 2017-2018. 2020 ; 11.
22. Sene S, Diop O, Diouf AF, Bah M, Malou JR, Gueye EHM, et al. COMITE DE LECTURE ET DE CORRECTION. 2014 ; 10.
23. Juhé-Beaulaton D. Bois de chauffe et charbon de bois dans le Sud du Bénin : évolution de la production au cours du XXe siècle. 2006 ; 8.
24. FONABES. FONABES_UCC__MALI_SDAFC_Sido_mai2017.pdf [Internet]. http://fonabes.org/AdminS/ajax/pdf/FONABES_UCC__MALI_SDAFC_Sido_mai2017.pdf. 2017 [cité 2 Févr 2022]. Disponible sur : https://fonabes.org/AdminS/ajax/pdf/FONABES_UCC__MALI_SDAFC_Sido_mai2017.pdf.
25. Dionisio KL, Howie SRC, Dominici F, Fornace KM, Spengler JD, Adegbola RA, et al. Household Concentrations and Exposure of Children to Particulate Matter from Biomass Fuels in The Gambia. Environ Sci Technol. 20 mars 2012 ; 46(6) : 3519-27.
26. Sana A. Choix énergétiques dans les ménages et pollution de l'air domestique à Ouagadougou, Burkina Faso : caractérisation de l'exposition et de l'effet sur la santé respiratoire des femmes. 14 oct 2020 [cité 2 févr 2022] ; Disponible sur : http://hdl.handle.net/2013/
27. Kafando B, Savadogo PW, Sana A, Bagnoa V, SANON S, KOUANDA S, et al. Pollution intérieure par les $PM_{2,5}$ issues des combustibles utilisés pour la cuisson des repas et risques sanitaires dans la ville de Ouagadougou. Env Risque Sante–Vol 18 No 3 Mai-Juin 2019. 2020.
28. Rumchev K, Spickett JT, Brown HL, Mkhweli B. Indoor air pollution from biomass combustion and respiratory symptoms of women and children in a Zimbabwean village. Indoor Air. 5 Nov 2007 ; 0(0) : 071105095528002.
29. Ezzati M, Kammen DM. The health impacts of exposure to indoor air pollution from solid fuels in developing countries : knowledge, gaps, and data needs. Environ Health Perspect. nov 2002 ; 110(11) : 1057-68.
30. Sylla FK, Faye A, Diaw M, Fall M, Tal-Dia A. Traffic Air Pollution and Respiratory Health : A Cross-Sectional Study among Bus Drivers in Dakar (Senegal). Open J Epidemiol. 11 Janv 2018 ; 08(01) : 1.
31. Morgan BW, Siddharthan T, Grigsby MR, Pollard SL, Kalyesubula R, Wise RA, et al. Asthma and Allergic Disorders in Uganda : A Population-Based Study across Urban and Rural Settings. J Allergy Clin Immunol Pract. 2018 ; 6(5) : 1580-7.
32. Mustapha BA, Blangiardo M, Briggs DJ, Hansell AL. Traffic Air Pollution and Other Risk Factors for Respiratory Illness in Schoolchildren in the Niger-Delta Region of Nigeria. Environ Health Perspect. oct 2011 ; 119(10) : 1478-82.
33. Kurmi OP, Devereux GS, Smith WCS, Semple S, Steiner MFC, Simkhada P, et al. Reduced lung function due to biomass smoke exposure in young adults in rural Nepal. Eur Respir J. 1 Janv 2013 ; 41(1) : 25-30.

Citation:
Thiam S, Daffe ML, Thiam K, Ndong A, Faye A, Diaw M, Ndior MC, Bah F, Toure NO and Fall M. **Impact Of Obstructive Lung Diseases (Asthma and COPD) due to indoor air pollution and poor room ventilation quality in Medina (Senegal)**. *J Toxicol Health*. 2023; **10**:1. http://dx.doi.org/10.7243/2056-3779-10-1