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Prevalence of asthma symptoms among bakery workers in Abidjan (Côte d'Ivoire)

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ABSTRACT

The objective of the present study was to determine the prevalence of occupational asthma symptoms among bakery workers. A cross-sectional study was done in the District of Abidjan from February to September 2019 among bakery workers. The study covered all workers aged 18 and over, employed and present in the bakery during interviews and lung tests. The socio-demographic and professional questionnaire of the American Thoracic Society was used, and the obtained qualitative and quantitative data obtained were analyzed with Stata 15.1 software. Out of the 599 workers included in our study, we had 405 bakers (67.6%, IC 95% [0.637–0.712]), 127 salespersons/cashiers (21.2%, IC 95% [0.181–0.247]), 38 cleaning persons (6.3%, IC 95% [0.046–0.086]) and 29 administrative staff (4.8%, IC 95% [0.034–0.069]). 85.8% (IC 95% [0.828–0.884]) of workers did not have the professional qualification in the bakery sector and 11.3% (IC 95% [0.090–0.142]) were illiterate. The prevalence of probable occupational asthma was 9.7%, 2.3%, 0.6% and 1.2%, respectively, among bakers, salespersons/cashiers, cleaning persons and administrative staff. Furthermore, logistic regression analysis revealed a relationship between probable occupational asthma and family history of asthma among the bakers. As a conclusion, the exposure of bakery workers to flour appeared to be one of the risk factors for probable occupational asthma and the work-related asthma. Also, bakers with a family history of asthma had high risk of developing probable occupational asthma.

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Introduction

Occupational asthma (OA) is the most common respiratory occupational disease in high-income, low-income, and middle-income countries **[1].** It is characterized by an inflammation of the airways, a variable bronchial obstruction, and a non-specific bronchial hyper reactivity, due to causes and situations attributable to the work environment **[2, 3].** OA is distinguished from work-exacerbated asthma which is defined as a pre-existing asthma whose manifestations are aggravated by exposure to occupational nuisances **[4].**

Occupational asthma and work-exacerbated asthma both fall into the category of work-related asthma. The World Health Organization (WHO) estimated at 339 million the number of people with asthma and at 417,918 the number of deaths from this disease in 2016 **[5]**. Attributable percentage of the occupational exposures in adulthood asthma causes is between 15 and 33% **[6].** It also affects young workers by causing absenteeism and incapacity at work and has some socioeconomic consequences **[4].** In France, the exposure of men to flour dust has been identified as one of the main causes of occupational asthma with a prevalence rate of 26.4% among bakers and pastry cooks **[7]**. In Poland, occupational asthma was diagnosed among 44.5% of bakers reporting respiratory symptoms in the workplace **[8]**. Despite the risk that flour dust causes to respiratory health among bakery workers, there is very little data on the prevalence of occupational asthma in Africa **[9].** Moreover, with the under-reporting of this disease due to the size of the informal sector and some technical and methodological difficulties, health professionals tend to under-estimate the prevalence of this disease in the workplace **[10]**.

In Côte d'Ivoire, the bakery sector has grown into a dynamic sector and employs twice as many people as the entire agro-food industry in the modern sector **[11].** Although this sector provides employment for the Ivorian youth, data on the work environment and on workers' health are almost non-existent. The only data available regarding the work environment in Côte d'Ivoire concerns the hairdressing industry **[12]** The existing data on asthma in Côte d'Ivoire largely concerns school environments and children under 5 **[12, 13, 14, ,15].**

Our study aimed at determining the prevalence of asthma symptoms in the workplace among bakery workers.

Materials. and methods

Study site

Our study was conducted in Abidjan, the economic capital of Côte d'Ivoire, in western Africa. Due to the similarity between bakeries, we randomly selected bakeries grouped together in seven municipalities, mostly in the working-class neighborhoods (Abobo, Adjamé, Koumassi, Port-Bouët, Treichville, and Yopougon) and the upscale neighborhoods of Cocody.

Surveyed population

We calculated the sample size using Schwartz's formula. Eq. (A1)

$$\frac{Z^2 * p\,(1 - p)}{d^2} \tag{A1}$$

Where: Z represents the standard normal variance (at 5% type I of error) (1.96); P represents proportion expected in the population according to previous studies (15%) and d represents absolute error (0.03)

A sample size of 544 workers was obtained and rounded up to 600 to cope with any missing cases. The workers were selected from forty bakeries in the district of Abidjan, including the main bakers, the salespersons, the cleaning persons and the administrative staff.

Forty bakeries were selected using a random sampling technique in the district of Abidjan.

Data collection

Data collection took place in two stages. At the first stage, two questionnaires were used for data collection, filled by each worker. The first questionnaire from the French National Institute of Health and Medical Research (INSERM) **[16]** allowed us to collect information on the socio-demographic characteristics of the workers, namely: (1) Gender (2) Age (3) Vocational training (4) work position in the bakery (5) Number of working hours per day (6) Work seniority (7) Monthly income and (8) Tobacco status. The second questionnaire, the revised version of the American Thoracic Society (ATS) questionnaire, was used to determine respiratory symptoms **[17, 18]**. The symptoms of interest were asthma symptoms (dry cough and wheezing, dyspnea, and chest tightness in the past twelve months), a frequency of asthma attacks in the last twelve months, a history of asthma, the evolution of symptoms outside of the work environment, and rhinitis.

At the second stage of data collection, we measured lung volumes using a portable WinspiroPro 6.5 MIR (Medical International Research) spirometer. Personal data were entered according to the manufacturer's manual, and then the lung volumes FVC (Forced Vital Capacity), FEV1 (Forced Expiratory Volume in one second), FEV1/FVC and PEF (Peak Expiratory Flow), were measured. All spirometry was performed in the sitting position and repeated 3 times for each person. For those with lung function abnormality, the spirometry test was followed by reversibility testing after inhalation of salbutamol. The

test was performed by a well-trained medical professional (nurse) according to American Thoracic Society (ATS) and European Respiratory Society (ERS) guidelines **[19]**. Results were interpreted by an experienced physiologist and in line with ATS and ERS **[17]**.

Diagnostic Criteria:

(1) **Asthma Symptoms**: The symptoms considered in this study are the four cardinal asthma symptoms. These are dyspnea, wheezing, chest tightness and cough.
(2) **Reversible Obstructive Pulmonary Disorder**. This was defined by comparing the individual ratio of forced expiratory volume in one second (FEV1) and vital capacity (VC) to the lower limit of normal; and significant reversibility was diagnosed by an increase in FEV1$\geq$ 12% and 200 ml in absolute values. The extrapolations that have been proposed to derive African standards were used to determine the theoretical values **[17, 19, 20]**
(3) **Confirmed Asthma**. The diagnostic was made in a symptomatic worker with a reversible obstructive disorder. **[19]**
(4) **Probable Occupational Asthma**: A worker who (a) declared never having presented the symptoms of asthma before starting to work in a bakery; (b) started presenting the symptoms of asthma during working hours; and (c) whose symptoms improved while on vacation or outside the workplace **[20, 21].**
(5) **Probable Work-Aggravated Asthma:** A worker who has reported (a) a history of asthma before starting to work in a bakery; (b) a worsening of symptoms during working hours at a bakery; and (c) an improvement on the symptoms during holidays or outside the workplace **[17, 18]**
(6) **Probable Work-Related Asthma**: An association of the manifestations of occupational asthma and work-aggravated asthma **[17, 18]**
(7) **Probable Asthma in bakery**: An association of work-related asthma and non-work-related asthma.

Data analysis

Statistical analysis was performed with Stata version 15.1. Descriptive statistics were performed with four worker groups: (1) bakers, (2) salespersons, (3) cleaning persons and (4) administrative staff.

The first analysis was to find the means and standard deviations. The Chi-2 test was used for comparing the frequencies between two independent variables. Then, multiple linear regression models were used to assess a possible correlation between the dependent and independent variables. The multiple linear regression models were to show any relation between the asthma symptoms and the socio-demographic characteristics of the bakery workers. $p < 0.05$ was considered statistically significant.

Results

Characteristics of bakery workers surveyed in Abidjan in 2019

The main socio-demographic characteristics of workers are shown in Table A1.

As regards to the level of education of workers: 11.3% (IC 95% [0.090–0.142]) are illiterate, 17.5%, (IC 95% [0.146–0.208]) had a primary school level, 24.7% (IC 95% [0.214–0.283]) had a Middle School level, 30.4% (IC 95% [0.268–0.342]) had a High School level and 16.0% (IC 95% [0.132–0.208]) had a college level. In addition, 85, 8% (IC 95% [0.828–0.884]) of workers had no professional qualification in the field with an average work seniority of less than 5 years among the administrative staff and 3 years for the other positions.

Concerning the working hours, we noticed an uneven distribution. While on the one hand bakers and salespersons work more than 20 h a day, on the other hand the administrative staff and cleaning persons work an average of 12.8 h a day.

In addition, there is a different salary distribution for each position with 21% of workers, all positions combined, who have a salary lower than the minimum wage (91.53 €). Finally, concerning tobacco status, bakers have the highest proportion (25.2%) of smokers while that of sales employees is the lowest (zero).

Prevalence of asthma symptoms, asthma among bakery workers and spirometry results

Asthma symptoms reported from the revised questionnaire of the American Thoracic Society (ATS) during the working days are shown in Table A2. The Bakery workers exhibited symptoms such as wheezing, dyspnea, chest tightness and cough in the workplace. The highest probable work-related asthma prevalence is attributed to bakers and the lowest to cleaning staff (Table A3. The prevalence of confirmed asthma was 8.43% among employees with probable occupational asthma and 8.04% among all bakery workers with probable work-related asthma. Fifty percent (50%) of confirmed asthma cases were diagnosed among bakers without asthma symptoms in the past 12 months or history of asthma (Table A4).

Risk factors for probable occupational asthma

The multivariate analysis carried out with independent variables made it possible to determine some factors associated with probable occupational asthma. From these results, we observed that a history of asthma (OR = 5.67) increases the risk

Table A1
Characteristics of bakery workers surveyed in Abidjan in 2019.

Characteristics	Bakers	Salespersons/Cashiers	Cleaning Persons	Administrative Staff	p-value
Average Age (years)	30	26	29	32	< 0.0001*
Gender (n,%) **FemaleMale**	33 (8.2)378(91.8)	124 (97.6)3 (2.4)	20 (52.6)18 (47.4)	9 (31.0)20 (69.0)	< 0.0001*
Education Level (n,%)					
None	53 (13.1)	4 (3.1)	9 (23.7)	2 (6.9)	
Primary	85 (21.0)	11 (8.7)	8 (21.0)	1 (3.5)	< 0.0001*
Intermediate	101(24.9)	34 (26.8)	6 (15.8)	7 (24.1)	
Secondary	113(27.9)	47 (37.0)	13 (34.2)	9 (31.0)	
Higher	53 (13.1)	31 (24.4)	2 (5.3)	10 (34.5)	
Work Qualification (n,%)					
None	344(84.9)	111 (87.4)	35 (92.1)	24 (82.8)	0.5279
Secondary Vocational Training Certificate	47 (11.6)	14 (11.0)	2 (5.3)	1 (3.4)	
2-Year College Education Vocational Training Certificate	14 (3.5)	2 (1.6)	1 (2.6)	4 (13.8)	
Seniority (month)	29.7 ± 1.9	20.7 ± 3.4	29.0 ± 7.8	43.4 ± 10.6	< 0.0001*
Number of working days/month	17.6 ± 0.2	15.9 ± 0.3	24.5 ± 0.9	26.3 ± 0.8	< 0.0001*
Number of working hours/day	20.6 ± 0.3	21.0 ± 0.4	12.8 ± 0.9	12.8 ± 0.8	< 0.0001*
Nicotine Addiction					
Smokers	102 (25.2)	0 (0)	9 (23.7)	2 (6.9)	<
Non-smokers	302 (74.8)	127 (100)	29 (76.3)	27 (93.1)	0.0001*
Monthly Salary					
> 91.53 €< 91.53 €	73 (18.0)332 (82.0)	43 (33.9)84 (66.1)	10 (26.3)28 (73.7)	5 (17.2)24 (82.8)	0.0018*

* Significant result.

Table A2
Evolution of asthma symptoms in the workplace among bakery workers in Abidjan in 2019.

Symptoms	**Number**	**%**
Wheezing		
Absent	487	81.3
Present	112	18.7
Exacerbation in the workplace	88	14.7
No exacerbation in the workplace	24	4
Dyspnea		
Absent	498	83.1
Present	101	16.9
Exacerbation in the workplace	80	13.4
No exacerbation in the workplace	21	3.5
Thoracic tightness		
Absent	497	83.0
Present	102	17.0
Exacerbation in the workplace	75	12.5
No exacerbation in the workplace	27	4.5
Cough		
Absent	527	88.0
Present	72	12.0
Exacerbation in the workplace	57	9.5
No exacerbation in the workplace	15	2.5

Table A3
Prevalence of asthma among bakery workers in Abidjan in 2019.

	Bakers	**Salespersons /Cashiers**	**Cleaning Persons**	**Administrative Staff**
Asthma phenotypes	Nb (%)	Nb (%)	Nb (%)	Nb (%)
Reported Asthma /Asthma History	6 (1.0)	9 (1.5)	1 (0.2)	1 (0.2)
Probable Asthma	73 (12.2)	23 (3.8)	8 (1.3)	8 (1.3)
Probable Work-Related Asthma	61 (10.2)	19 (3.2)	5 (0.8)	7 (1.2)
Probable Occupational Asthma	58 (9.7)	14 (2.3)	4 (0.6)	7 (1.2)
Probable Work-Aggravated Asthma	3 (0.5)	5 (0.8)	1 (0.2)	0 (0.0)
Probable Non Work-Related Asthma	12 (2.0)	4 (0.7)	3 (0.5)	1 (0.1)

Table A4
Spirometry results of bakery workers in Abidjan, 2019.

	Total	Spirometry done	OVD reversible (%)
Bakers with asthma symptoms or history of asthma	112	112	9(8.04)
Probable work-related asthma	92	92	8(8.69)
Probable occupational asthma	83	83	7 (8.43)
Probable work-aggravated asthma	9	9	1(11.11)
Probable non-work-related asthma	20	20	1(5.00)
Bakers without asthma symptoms or history of asthma	487	487	9(1.84)

OVD= Obstructive vVentilatory dDisorder / Denominator= number of spirometry tests performed.

of developing probable occupational asthma (Table A5). However, our analysis did not reveal any other relation between probable occupational asthma and the other independent variables.

Discussion

Our objective was to determine the prevalence of asthma symptoms and the risk factors for probable occupational asthma among bakery workers.

Compared to several studies which focused on bakers/pastry chefs and apprentices **[4, 20, 22],** our study considered all bakery staff which could be exposed to flour dust.

The gender ratio (male/female) in bakeries is on average 2.2. It is 11.2 for bakers and 0.02 for salespersons/cashiers. This difference could be explained on one hand by the arduous nature of the work and on the other hand by managerial dispositions. In fact, bakers' tasks in the production line are sometimes manual and physically labor-demanding with an average of 20 working hours. Those bakers generally work from night till early morning (10 p.m. to 6 a.m.) to supply the demand for bread in the morning and are most often exposed to the heat of the baking ovens. These labor constraints could justify the preference of men, but also of young people (31.6 ± 0.4). Studies in bakeries have shown similar results with young workers, less than 40 years old **[20, 23]** and a high ratio of men in this category **[20]**.

Table A5
Factors associated with probable occupational asthma among bakery workers in Abidjan in 2019.

Variables	OR	IC 95%	P-value
Age	1.02	0.90 – 1.09	0.59
Chemical additives	1.12	0.11 – 11.46	0.92
Enzymes	4.63	0.78 – 27.38	0.09
Flour	0.22	0.03 – 1.38	0.11
Work Seniority	0.99	0.89 – 1.00	0.33
Skin dermatoses	9.25	0.80 – 106.58	0.07
Number of working hours/day	1.05	0.97 – 1.15	0.23
Family History of Asthma	5.67	1.50 – 21.05	0.010*

*Significant result.

Also, the results of our study showed that 80% of workers are unskilled in the bakery industry. Most of them do not come from a vocational school curriculum or are dropouts (3% to 13%) with an average work experience of 2.5 years. These results are particularly observed in low- and middle-income countries **[10, 24].** The number of working hours per day in all groups, particularly for bakers and salespersons/cashiers is greater than the working time set by the national labor regulation authority, which is 8 h/day or 40 h/week (Law No.2015–532 related to the labor code in Côte d'Ivoire). Furthermore, workers in bakeries (17.2% to 33.9%) have wages below the guaranteed minimum inter-professional wage which is 91.23€ per month. Thus, the regulatory working time is not respected, and the remuneration offered by bakery owners is below the inter-professional minimum wage. This situation could reflect the precariousness of labor in bakeries in Côte d'Ivoire. Despite this observation, the bakery sector is positioned as a job-offering sector for the young population aged from 15 to 34 in a national environment where the unemployment rate was estimated at 12.7% among the young people **[11, 25].**

Our study also looked at the respiratory health conditions of bakery workers by analyzing the symptoms of asthma, a common occupational disease in bakeries. Thus, we have determined a prevalence of probable occupational asthma of 9.7%, 2.3%, 0.6% and 1.2% respectively among bakers, salespersons/cashiers, cleaning persons and staff administrative.

These different rates appear to be associated to the duration and/or the intensity of exposure of each category of workers to allergenic agents present in bakeries.

In fact, bakers are the only workers who handle the flour and other chemicals in the production line. But, the other workers: salespersons/cashiers, cleaning persons and the administrative staff could also be exposed by the flour dust. Their exposure to dust could be due to the absence of impenetrable barriers between the bread production area and the selling area in most bakeries. Thus, the layout of the bakeries could favor the circulation of the flour dust from the production area to other workplaces.

Within dusty working environments, we recorded a high probable asthma prevalence (18.7%) among bakery workers. This probable asthma prevalence is similar to that found by Gillet (17%) in 2015 in France **[26]** but higher than that of Ade in 2018 in bakeries of Parakou in Benin which was estimated at 13.68% **[18]**. According to the literature **[27]** the variations in the prevalence of probable asthma could be due to the operational definition of asthma adopted in each study, which in our case are the same as that of the study in Benin **[20].**

Studies have shown that work seniority is an important factor influencing the prevalence of respiratory symptoms among bakers **[28, 29].** In Sudan exposure to the flour dust in bakeries for 3 years or more is associated with an increase in respiratory symptoms**.** In our study this factor does not seem to be the most determining one since we have a large professional population of less than 3 years in bakeries. In addition, our study showed that the highest prevalence of probable occupational asthma (9.7%) and work-related asthma (10.2%) is among bakers compared to administrative staff who record more years of work. The prevalence rate obtained among bakers is similar to that of the study in Benin **[20].** Therefore, we can suppose that the exposure of bakers to flour is one of the risk factors of probable occupational asthma and work-related asthma.

Moreover, none of the managers of the visited bakeries had carried out some health checks on their workers **[10].** Studies pointed out that the occupational diseases in Senegal and other African countries were not reported properly and under-diagnosed. The situation could be due to the weakness of authorities and the lack of willingness of professional bakery association's lack of willingness to perform their duty. Some bakery workers, fearing losing the loss of their job, may not declare their symptoms, thus contributing to underestimation of the disease. Another factor possibly contributing to underestimating the prevalence of occupational asthma is the lack of recognition of asthma symptoms by bakery workers **[20].** In our study fifty percent (50%) of confirmed asthma is diagnosed among workers without previous asthma symptoms or history of asthma.

From our study, after multiple logistic regression, it has emerged that a family history of asthma (OR = 3.439; $p < 0.001$) could be the factor associated with the risk of probable occupational asthma. This result differs from the study in Benin **[20]** in which rhino-conjunctivitis was associated with occupational asthma. In our study, following our objectives, we focused on the exposure to allergens (flour dust, chemical additives, enzymes, etc.) which could favor probable occupational asthma in bakeries and a family history of asthma as a confounding factor. This is especially true since the risk of asthma is multifactorial **[18].** However, our results have not clearly established a relationship between these allergens and proba-

ble occupational asthma. Several studies have reported high rates of sensitivity to flour allergens and prevalence of airways disease among workers exposed to flour dust [30, 31]. In addition, in our study, we did not find a relationship between probable asthma and smoking status. Indeed, there is no consensus on the link between exposure to tobacco and incidence of asthma in adults [32]. Some studies have suggested that passive and active exposure to tobacco smoke may be a risk for asthma in adulthood [32, 33].

However, the same studies have showed that a family history of asthma coupled with an unfavorable work environment would increase the risk of developing asthma symptoms. There seems to be little difference in the work environment of the surveyed bakeries. Their work environment is characterized by the presence of flour dust and the absence of appropriate personal protective equipment (PPE) for the workers. So, our study has determined the main characteristics of bakery workers and contributes to the determination of the prevalence of asthma symptoms and occupational asthma in bakeries for low- and middle-income countries.

As previously mentioned, the data collection was carried out with the aid of a questionnaire. To minimize the handicap for highly illiterate workers, the questionnaire was translated into easy-to-understand French language and coupled with gestures to explain the manifestations of certain symptoms.

Conclusion

Our study has allowed us to identify the socio-demographic characteristics and to determine the prevalence of asthma symptoms and occupational asthma in the bakeries of the municipalities of Abidjan. The revised American Thoracic Society (ATS) socio-demographic questionnaires, and spirometry, were used to characterize and determine the prevalence of symptoms of asthma and occupational asthma. In our study, the bakery workers were grouped into four categories, namely the bakers, salespersons/cashiers, cleaning persons and the administrative staff. Most of the workers are young (the average age varies between 26 and 32) and the majority (80%) of the workers are without any professional qualification in the bakery sector.

The bakery sector is an employment sector for young people from non-vocational training schools (pupils and students) who, despite being without basic skills in the bakery sector, are able to successfully fit into the economic fabric and acquire some work experience (2.5 and 5 years). This survey has revealed some risks of exposure of workers to flour dust as well as the precariousness of work in the production and sales line (lack of PPE, lower-than-legal salary, long working hours, etc.)

In addition to the factors associated with probable occupational asthma is the family history of asthma. Clearly, this study has revealed the risk of developing symptoms of asthma or occupational asthma in the present work environment of the bakers in Abidjan. As far as probable occupational asthma is concerned, we found that there are more results showing that inhalation of flour dust is associated with the exacerbation or the increased prevalence of asthma.

Our next study will focus on the correlation between the exposure of bakers to the flour dust and the development of probable occupational asthma in Abidjan.

Declarations

Ethical approval and consent to participate

This study is part of the large study of the Eco-health chair which included the protocols of doctoral students of the Inter-University Doctoral Program (IDP) submitted and approved by the national ethics committee under the No.026–18/MSHP/CNER-KP.

Carried out in the city of Abidjan, the study was approved by the Bakery Owners Union of Côte d'Ivoire and the Ivorian Anti-Pollution Center (CIAPOL).

Written consent was obtained from the participants and they were made aware that their participation was voluntary and they could opt out of the study at any given time without any explanation.

Authors' contributions

Loukou Léandre KONAN, PhD. Candidate. Conceptualized and analyzed the results of the study Ahua Kouassi René KOUAO, PhD. Conceptualized and analyzed the results of the study Michel BROU, MD, article reader Guillaume ZAMINA, Ph.D. article reader Issiaka TIEMBRE and Brama KONE had contributed in conceptualization and preparation of the manuscript. YOBOUE Veronique, article reader

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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