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Pollen exposure in the district of Abidjan (Cote d'Ivoire, West Africa): A retrospective observational study

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Abstract
Pollens allergy is in constant increase in the world and significantly impairs patient's quality of life. In developing countries such as Cote d'Ivoire, there is no information on pollen exposure due to lack monitoring of aerobiologicals. The aim of this study was to appreciate the impact of plant pollens on the health of populations in the district of Abidjan (Cote d'Ivoire). A panel of eight plants was used for floristic study. Social and health survey combined to ethnobotanical investigations using a questionnaire was carried out in areas at risk. In Abidjan, four plants of the panel were found in six settings of the district of Abidjan (Abobo, Adjamé, Bingerville, Cocody, Port-Bouët, Yopougon), particularly *Cocos nucifera, Ceiba pentandra, Elaeis guineensis* and *Petersianthus macrocarpus*. The ethnobotanical uses were medicinal, food, decorative and shadiness. Of 322 people surveyed in six settings at risk, 129 had been affected by some multi allergic symptoms: ENT (76%), lungs (36%), eyes (54%), skin (32%) and cardiovascular system (16%). *Ceiba pentandra* was the most species incriminated in the allergic reactions, followed by *Petersianthus macrocarpus*. The most affected age was 11-20 years (39, 53%) and ENT symptoms were predominant. These study may open perspectives of floral geomatic such as development of monitoring tools in order to establish the exposure of people to plant pollens in Cote d'Ivoire.

Keywords: Pollens, Allergy, Ecology, district of Abidjan, Côte d'Ivoire

1. Introduction
The prevalence of allergic diseases and asthma is increasing worldwide, particularly in low and middle income countries (Panwakar 2014) [25]. These pathologies are becoming a major problem of public health in term of life quality, loss of work or schooldays, health cost, or mortality (Oussama 2009) [24]. According to Panwakar (2014) [25], the complexity and severity of allergic diseases, including asthma, continue to increase especially in children and young adults, who are bearing the greatest burden of these trends.
The respiratory allergies are the most frequent clinical symptoms impairing the quality of life of affected people (Masolie 2004) [19]. According to Beggs and Bambrick (2005) [4], the prevalence of the allergic rhinitis is increasing since 1960 worldwide. Allergic rhinitis causes itching, decrease in quality of life, reduced productivity and complications such as sleep apnoea and sinusitis (Walls *et al*., 2005) [34]. These symptoms can be triggered by indoor and outdoor allergens (Guilbert *et al*. 2016).
Pollens are among the most clinically important outdoor aeroallergen sources worldwide (Scala *et al*. 2010) [29] and responsible for exacerbating asthma. Subtropical grass pollens are more important allergen sources than temperate grass pollens for patients from a subtropical region (Davies *et al*. 2012; Nony *et al*. 2015) [10, 22]. Weeds and trees produce high pollens amounts that can induce allergies. An approximate 1 million to several millions pollens daily are produced by a plant (Néron 2004) [21]. The allergenic reactions depend mainly on the interrelationship between the beginning of the symptoms and seasons of pollination which vary according species and geographical areas.
Many pollen plants already have caused some health damages in several countries, such as India (Seema 2011) [31], Australia (Davies *et al*. 2014), France (Jacques *et al*. 2009) [14]. For example, in France, *Ambrosia artemisiifolia* (Asteraceae), commonly named ambrosia is an

Annual plant which allergic reactions are well documented and monitored at the scale of the whole country. Also, the pollen dispersion period is well established for the monitoring of symptoms. Seasonal dynamics of airborne pollens are important factors for reliable prevention of pollinosis. Data are available in many countries (Canuel and Bélanger 2010) [5] in order to follow the evolution of the pollens during the year and sensitize the populations. However, in West Africa countries such as Cote d'Ivoire, data are scarce. No study has investigated the link between pollens and allergic diseases. Only aeropalynological studies have been carried out in Nigeria and revealed the presence of *Elaeis guineensis* pollens in the atmosphere (Essien *et al.* 2014) [11]. In Côte d'Ivoire, most of studies on allergy focused on food (Yapo-Crézoit *et al.* 2011) [35], medicines (Kourouma *et al*. 2014) [17] and asthma in children (Koffi *et al*. 2000) [16]. This last decade, it is noticed an exacerbation of respiratory diseases like asthma with unknown etiology (Rancé 2010) [27]. In 2008, an epidemiological survey has reported that pollens may be incriminated among the allergens responsible for allergic rhinitis without specifying the plant species (Sankandé et *al*. 2008) [30]. Identification of provoking pollens may help customize programs for the diseases management.

The aim of this study was to assess for the first time in Cote d'Ivoire, the health impact of pollens of eight plants on population living the district of Abidjan.

2. Material and Methods

Settings

The study has been carried out in the District of Abidjan (Southern Cote d'Ivoire) influenced by four seasons (2 rainy and 2 dry). This setting is located between 5°10'- 5°38' N and 3°45'-4°21W. This urban area is composed of 10 municipalities representing approximately 5, 000, 00 inhabitants spread over 2119 km^2 (INS 2015).

Panel of plants

The selection of the eight allergenic pollens plants was based on literature (Yapo-Crézoit *et al.* 2015) [35]. These plant species were *Ceiba pentandra* (Malvaceae), *Cenchrus ciliaris* (Poaceae), *Cynodon dactylon* (Poaceae), *Cocos nucifera* (Arecaceae), *Elaeis guineensis* (Arecaceae), *Oryza sativa* (Poaceae), *Parthenium hysterophorus* (Asteraceae) and *Petersianthus macrocarpus* (Lecythidaceae).

Environmental surveys on targeted plants distribution

A prospective survey was carried out in the district of Abidjan using the walk in the field method (Maillet 1981; Aké-Assi 1984; Chicouène 2000) [18, 1, 9] from August to November 2015. The data collected concerned the presence of the selected species in a site, number of individuals, phenology. A map of distribution of these species in the district of Abidjan was built.

Immuno allergological study in the surveyed area

Sampling

The sample size was calculated using the formula described by OMS (1991):

$$n = t^2 x\, p \frac{1-p}{m^2}$$

Where t = 1.96 at a trust level of 95%, m = standard error at 0.05%; p = approximate prevalence of allergic diseases in the surveyed zone (30%). This sample was distributed according the population of each study area in 2014 (INS 2015).

The prevalence of respiratory allergy was 30% at the margin of error **(**5%). This value was a mean of prevalence (27.5-35%) of allergic diseases such as asthma, rhinitis reported for Cote d'Ivoire according several investigations (Sakandé *et al.* 2008) [30]. A total number of 323 persons was obtained and subdivided into seven clusters (subgroup) of 46 people. Then these seven clusters were distributed in the district of Abidjan according the areas at risk identified after the environmental survey.

Respondents included in the survey were those living for at least one year in the surrounded area of targeted plants. The objectives of the survey were clearly explained to each person in order to obtain his consent. Only those having given their agreement were interrogated.

Observational retrospective study

The health impact of pollen grains was assessed using a questionnaire. In each cluster, the 46 people were randomly selected and interrogated from the questionnaire. A semi-structured interview was used for discussion with people. The data collected concerned socio-demographic characteristics, plant species, allergic symptoms and reactions, ethnobotanical usages.

Statistical analyses

The data were typewritten in duplicate using the software EpiData version 3.1. and proportions, frequencies and means were calculated with Excel. Statistical analyses were performed using a chi-square ($\chi 2$) test and Factorial Correspondence Analysis (FCA). The test of $\chi 2$ was used to compare socio-demographic characteristics and percentages of people having allergic reactions (eyes, ears and lungs) with the software XLSTAT, version 2014. When a difference between percentages of allergic people and factors exist at a threshold $\alpha = 5\%$, the $\chi 2$ test was completed with the procedure of Marascuilo. The FCA (factorial correspondence analysis) allowed to study the distribution of the symptoms and allergic signs of skin, nose, mouth, lungs and anaphylaxis.

3. Results

Distribution and phenology of plants studied

Environmental surveys on targeted plant distribution in the district of Abidjan indicated that four plants of the panel were among the most abundantly observed trees (Figure 1). These plants were found in the areas of Abobo, Adjamé, Bingerville, Cocody, Port-Bouet and Yopougon (Figure 2).

The plant species were *Ceiba pentandra* (Cp), *Cocos nucifera (*Cn), *Elaeis guineensis* (Eg) and *Petersianthus macrocarpus* (Pm). *Ceiba pentandra* was observed in Cocody (cité des arts and Zoo), in Yopougon (Adiopodoumé), Bingerville (Lycée Mami Houphouët Fêtai) and Adjamé (University Nangui Abrogoua). *P. macrocarpus* was inventoried in Yopougon (Adiopodoumé) and Adjamé (University Nangui Abrogoua). *Cocos nucifera* was found in Bingerville, Abobo (N'dotré) Port-Bouët (Warf) and Adjamé. *E. guineensis* was only present in Bingerville and Abobo.

Cocos nucifera (248 individuals) and *Elaeis guineensis* (113 individuals) were the most represented species in the district of Abidjan, including 200 individuals for Port-Bouët and 100 for Abobo. The phenology showed that leaves, flowers, pollens and fruits were present at the time of the study. For *Ceiba pentandra* and *Petersianthus macrocarpus,* leaves

were predominantly present but the presence of flowers, fruits and pollens varied according individuals. For some individuals of *Ceiba pentandra*, no leaves, flowers, pollens, fruits, notably in Yopougon, Bingerville and Cocody (Table1) was observed.

The ethnobotanical uses were medicinal, food, decorative, and shade.

Fig 1: Plant species selected, A: Kapok and trunk of *Ceiba pentandra*, B: *Cocos nucifera* with fruits and pollens, C: *Elaeis guineensis* with fruits and pollens, D: *Petersianthus macrocarpus* in flowering

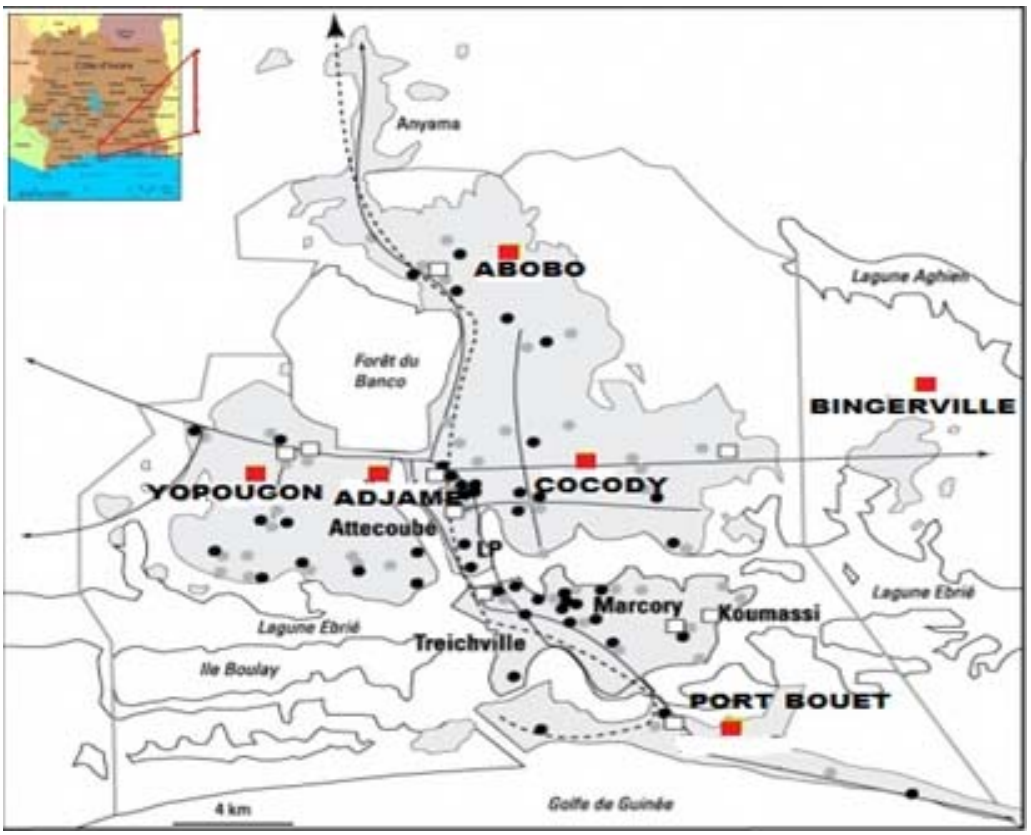


Fig 2: Areas at risk in the district of Abidjan
■ Study sites

Table 1: Local names, phenology and distribution of plant species in the district of Abidjan

Plant species		***Ceiba pentandra***						***Cocos nucifera***				***Elaeis guineensis***		***Petersianthus macrocarpus***	
Local names		**Akan (Egnien) ; Krou (Djo)**						**Akan (Kpako); Krou (kpako-tou)**				**Akan (Ayé) ; Mandé (Téhing)**		**Akan (Abalé)**	
Phenology and number of plants	A	0	0	0	0	0	0	18	19	200	11	13	100	0	0
	B	13	5	8	3	7	8	0	0	0	0	0	0	2	6
Settings		Yop (A)	Bing (G)	Coc (C)	Abo (N)	Adj (U)	Coc (Z)	Bing (LM)	Abo (N)	Port-B (D-W)	Adj (UNA)	Bing (G)	Abo (N)	Yop (A)	Adj (U)

A: Presence of leaves, flowers, pollens, fruits; B: Presence of leaves; absence of flowers, pollens, fruits, UNA :University Nangui Abrogoua ; LMFB : Lycée Mamie Houphouët Fêtai de Bingerville ; Adj (U) : Adjamé (UNA) ; Abo (N) : Abobo (N'dotré) ; Bing (G) : Bingerville (Gbagba) ; Bing (LM) : Lycée Mamie Houphouët Fêtai de Bingerville ; Coc (C) : Cocody (Cité des Arts) ; Coc (Z) : Cocody (Zoo) ; Port-B (D-W) : Port-Bouet (Derrière Warf) ; Yop (A) : Yopougon (Adiopodoumé)

Immuno allergological data

Socio-demographic characteristics

The people surveyed were students, civil servants, housewives and tradesmen. The mean of age ranged from 1 to 67 years. There were 158 men and 164 women (Table2).

Allergic reactions observed

Of the 323 people surveyed, 129 (40%) stated they had allergic reactions at some periods of the year, corresponding to the pollen dispersion periods of at least one of the four plants. Among these people, 43% were women and 37% men, however statistically, there was no difference between sex (Table 3).

The percentage of people presenting allergy in Yopougon (Adiopodoumé) was high compared to the other areas (Figure 3), but statistically there was no difference rate of affected people between the sites (Table 4).

The most quoted allergic reactions were sneezing, cough, itchiness of skin, eyes, throat, ears and feet, discharge, runny nose, nasal obstruction, shortness of breath, urticarial and chess tightness. The most incriminated plant species were *C. pentandra* and *P. macrocarpus.*

Symptoms and allergic reactions of skin

Dry of skin and cutaneous eruption were not found in the different sites visited. In Abobo, there were more people suffering from hives (3.88%). In Port-Bouet, all skin allergies were recorded for few people, except itching of skin that was the most frequent symptom in this zone (6.20%). In Yopougon, the problem of itchiness (9.30%) was the most important compared to the other sites (Figure 4).

ENT symptoms and reactions

In Port-Bouet, the persons interviewed had few symptoms and reactions (5.43%) at ENT level. Many of these persons (10.08-16.28%) had itching of throat, ears and nose followed by out-flow, breathing by mouth and sneezing (Figure 5).

Symptoms and allergic reactions of eyes

The number of people suffering from eyes allergies varied according to sites. Bingerville and Yopougon had the highest percentages for lacrimation (11.63%) and itching of eyes (15.5%). For the lacrimation, three groups were described:

Group 1: low percentage: Cocody zoo and Port-Bouet

Group 2: medium percentage: Abobo, Adjamé, Cocody (cite des arts) and Yopougon

Group 3: high percentage: Bingerville.

In overall, no significant difference was observed between the areas. However, there was a difference for itching of eyes between the areas (Figure 6).

Symptoms and allergic reactions of lungs

In Port-Bouet, a few number of symptom expression at the level of lungs (3, 10%) was recorded. The high number was obtained for the sites of Abobo, Yopougon and Cocody (cité des arts), with more problems of cough (10.85%). In Adjamé, Bingerville and Cocody Zoo, few cases were recorded, but were lack of breath (7.75%), shortness of breath and screaming breathing (Figure 7).

Symptoms and allergic reactions of cardiovascular system

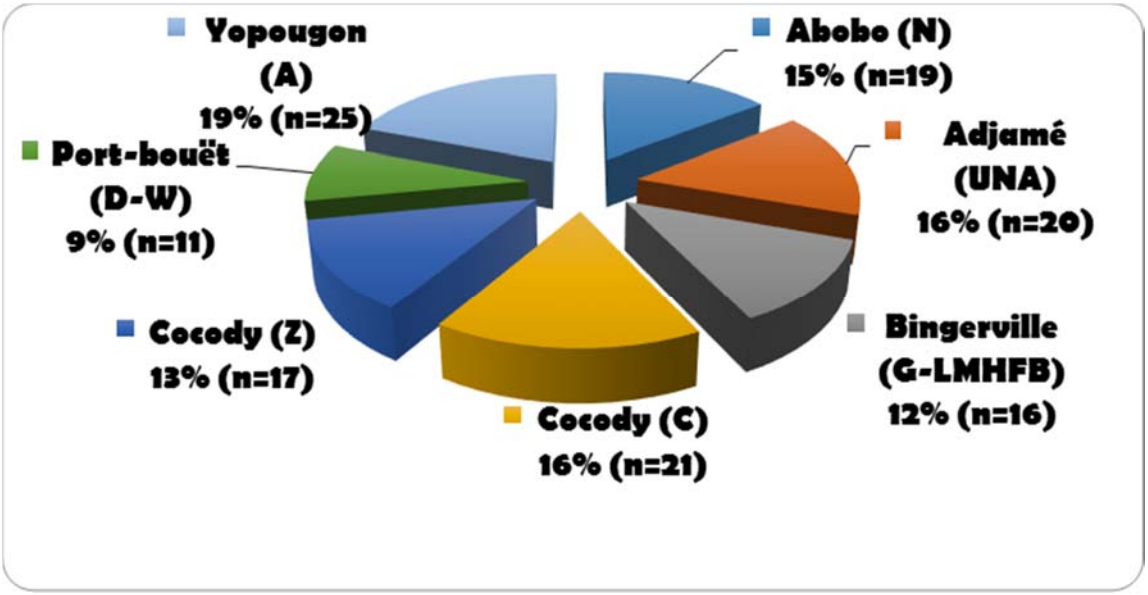
The percentage of clinical symptoms of cardiovascular system was very low. However, the number of people with allergy varied statistically between the zones with the highest percentage (4.65%) for Bingerville (Figure 8).

Symptoms and allergic reactions following anaphylaxis

The deterioration of health and reaction at the level of mouth followed by anaphylaxis were less encountered in the different sites (0.78%). The mouth tingling was recorded in Yopougon (4.65%) and Abobo (3.10%). The itching of mouth, feet and scalp were the most cited symptoms and allergic reactions (6.98%) in the different sites (Figure 9).

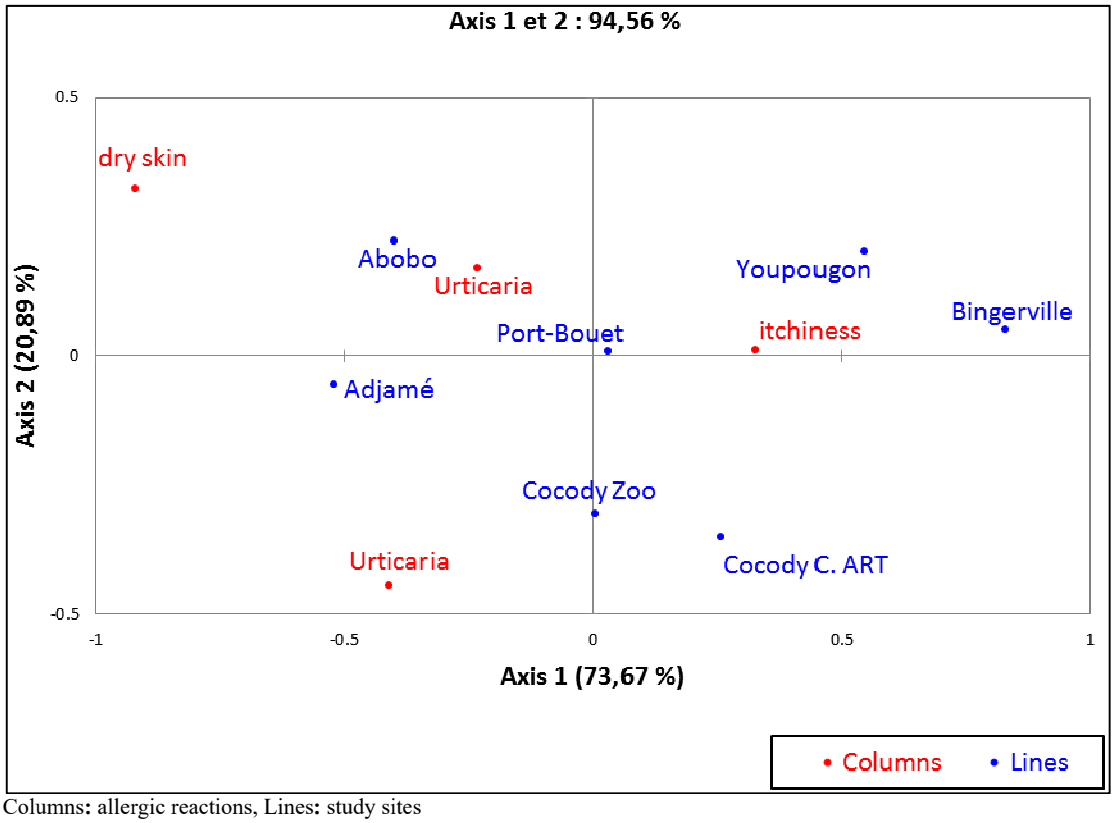
Symptoms and allergic reactions associated to age

Regarding age, the allergic symptoms and reactions were similar except itching of skin. The different percentages obtained for skin itching were 6.33% for 31-50 years and 18.6% for 11-20 years (table 5). There was a difference between the age classes concerning the allergic reactions. When considering age, different profiles appeared, the 11-20 years group was the most sensitive and the most predominant allergies were sneezing followed by itching of eyes (Figures 10 et 11).



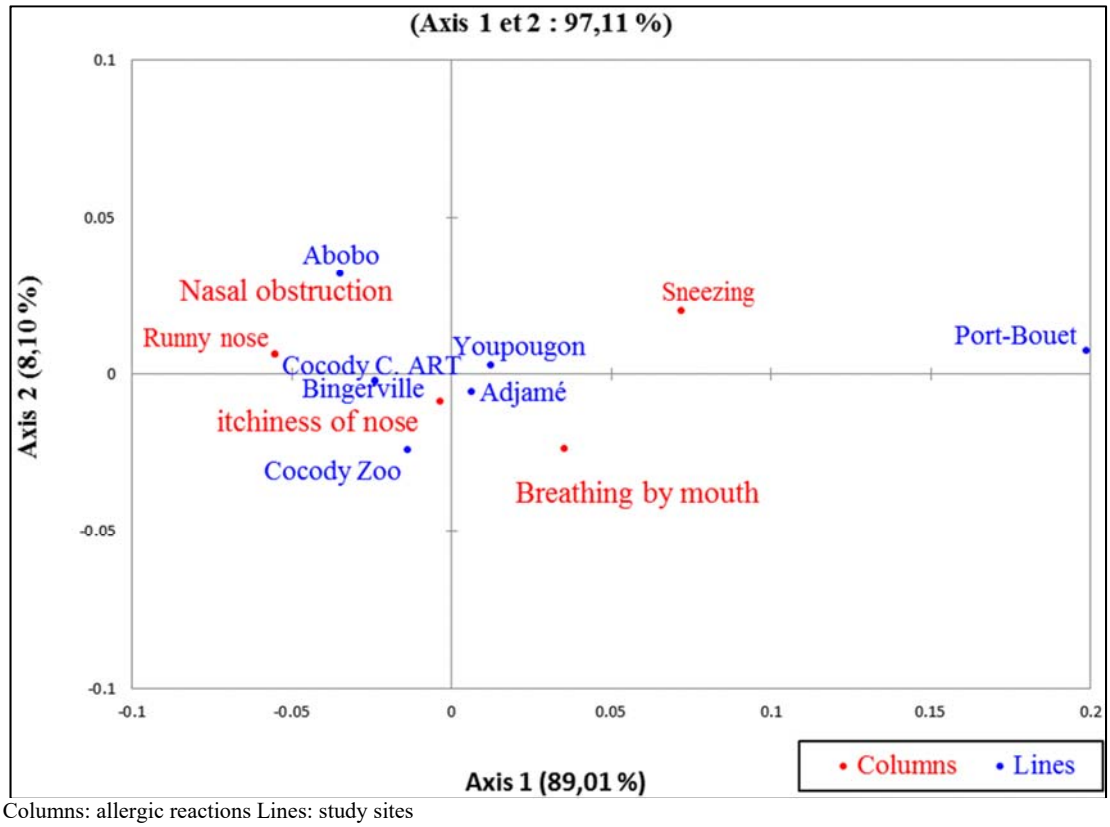
(A): Adiopodoumé ; (C) : Cité des Arts) ; (D-W) : (Derrière Warf) ; (G-LMHB) : (Gbagba - Lycée Mamie Houphouët Fêtai de Bingerville) ; (N) : (N'dotré) ; (UNA) : University Nangui Abrogoua ; (Z) : (Zoo).

Fig 3: Percentage of people with allergy according to the setting



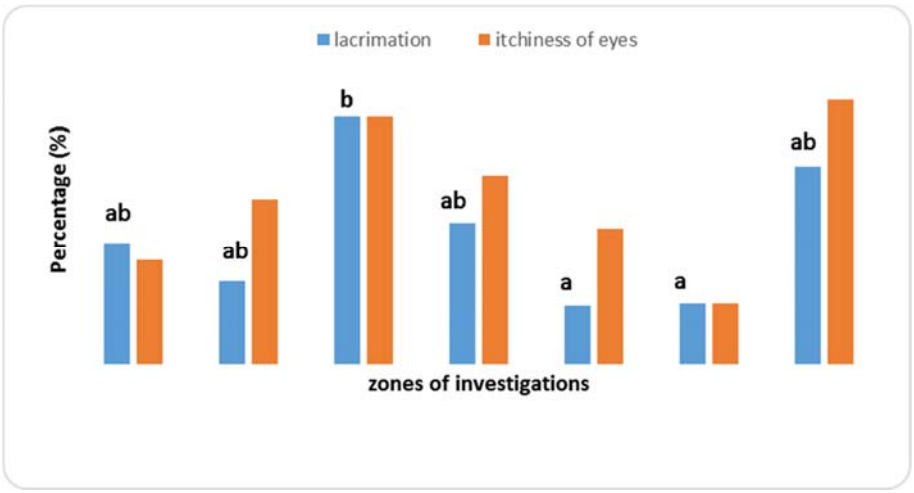
Columns**:** allergic reactions, Lines**:** study sites

Fig 4: Distribution of allergic symptoms and reactions of skin according to the sites



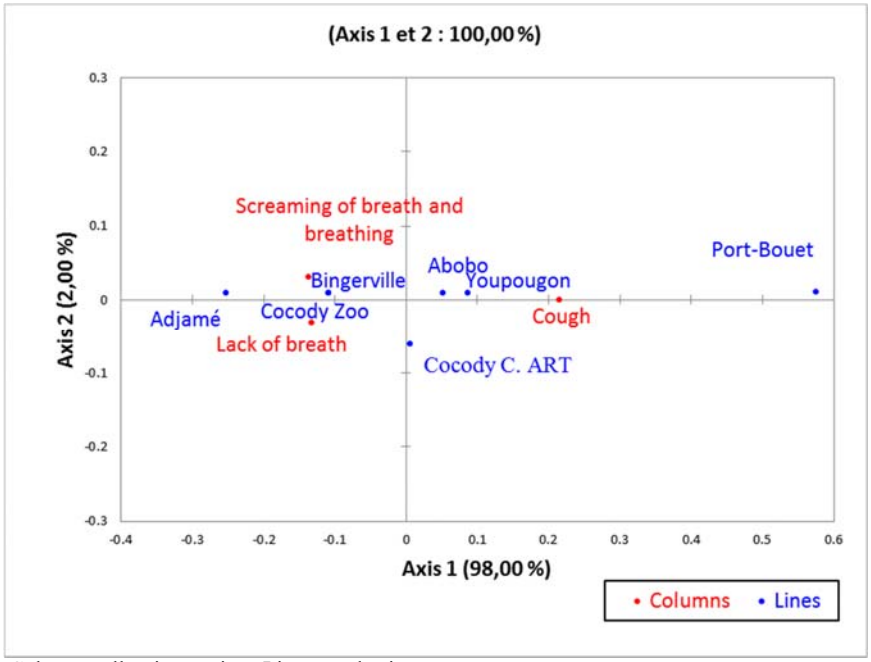
Columns: allergic reactions Lines: study sites

Fig 5: Distribution of the ENT symptoms and reactions



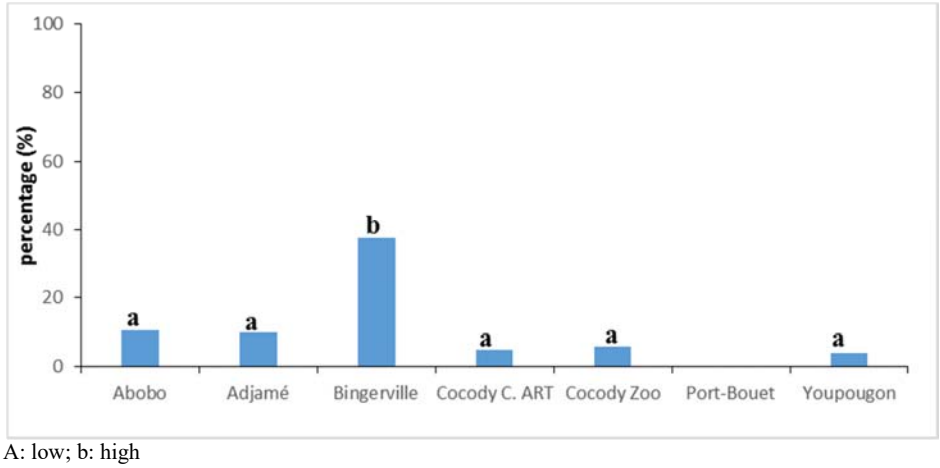
A: low; ab: high; b: very high

Fig 6: Histogram of the allergic symptoms and reactions of eyes according to the study areas



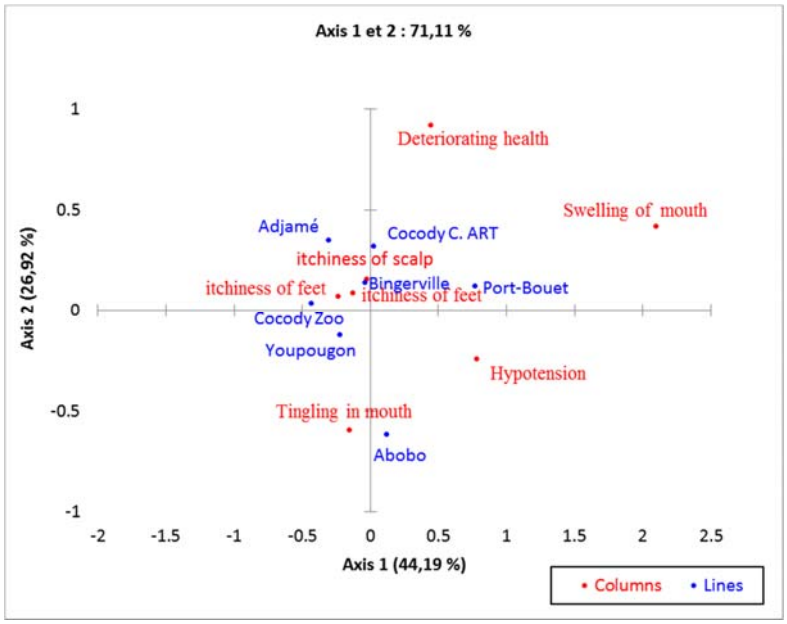
Columns: allergic reactions Lines: study sites

Fig 7: Distribution of allergic symptoms and reactions of lungs



A: low; b: high

Fig 8: Histogram of people suffering from allergies at cardiovascular level in each study areas



Columns: allergic reactions Lines: sites of investigations

Fig 9: Distribution of allergic symptoms and reactions following an anaphylaxis according to the study sites

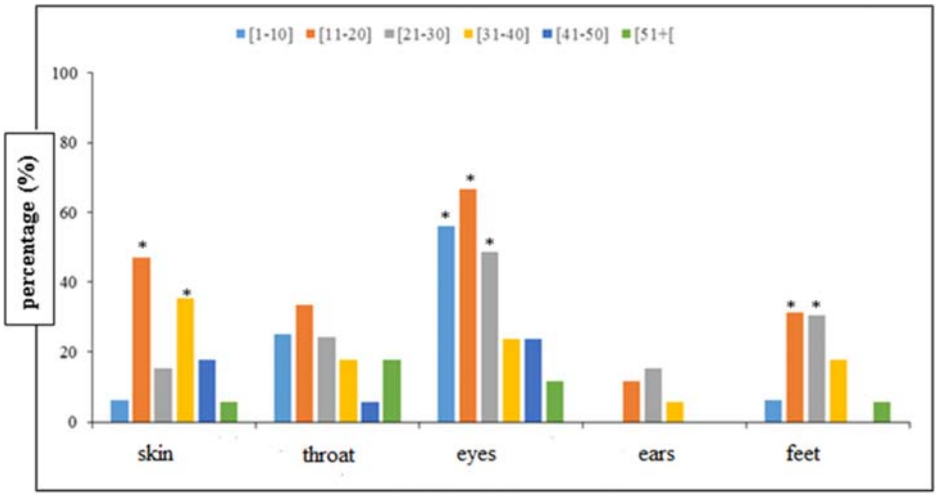


Fig 10: Histogram of itchiness of skin, throat, eyes, ears and feet according to age

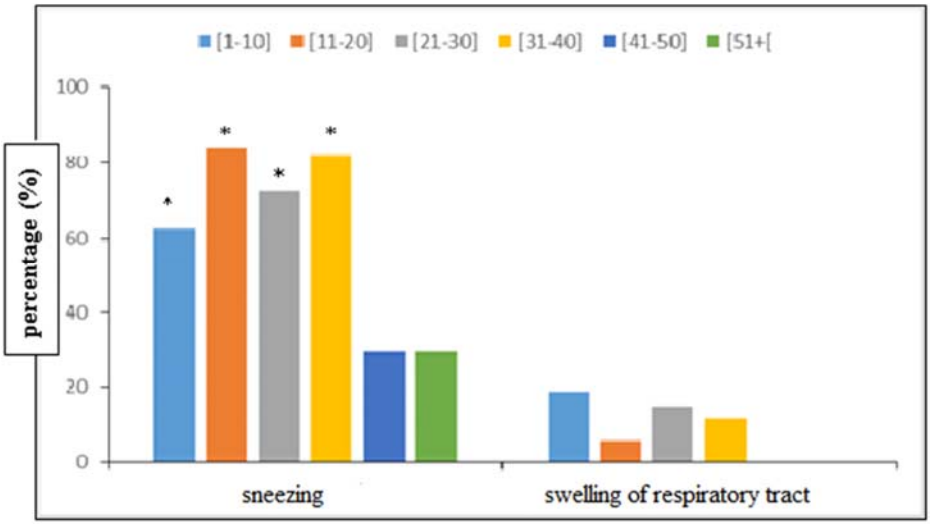


Fig 11: Percentages of people suffering from sneezing and swelling of respiratory tract according to age

Table 2: Sociodemographic characteristics of people surveyed

Areas		Adj	Abo	Coc1	Coc2	PoB	Yop	Bing	Total	Mean
Age	1-10	0	10	4	9	12	2	6	43	6
	11-20	5	11	21	13	15	20	8	93	13
	21-30	37	15	12	11	7	7	12	101	14
	31-40	4	10	6	8	6	8	13	55	7
	41-50	0	0	2	2	4	6	4	18	2
	51-60	0	0	1	3	2	3	2	11	1
	61-70	0	0	0	0	0	0	1	1	0
	Total	46	46	46	46	46	46	46	322	
Sex	Man	25	20	22	21	20	28	22	158	22
	Woman	21	26	24	25	26	18	24	164	24
	Total	46	46	46	46	46	46	46	322	
Profession	Civil servants	0	0	2	0	2	11	3		3
	Liberal Profession	0	11	7	14	10	9	9		9
	students	46	6	24	9	7	21	7		17
	Total	46	46	46	46	46	46	46		
	traders	0	16	6	11	8	3	13		8
	house wife	0	6	4	5	10	2	5		5
	No job	0	7	3	7	9	0	9		5
	Total	46	46	46	46	46	46	46		46
Places of survey	home	0	46	14	28	40	16	24		24
	work	46	0	32	18	6	20	22		21
	Total	46	46	46	46	46	36	46		
Allergic reaction	Yes	20	19	21	17	11	25	16	129	18
	No	26	27	25	29	35	21	30	193	28
	Total	46	46	46	46	46	46	46	322	

Adj = Adjame; Abo = Abobo; Coc 1 = Cocody (Cité des arts); Coc 2= Cocody (Zoo) ; PoB = Port-Bouet ; Yop = Yopougon ; Bing = Bingerville

Table 3: Allergic percentages according sex

Sexe	Yes (%)	No (%)	Statistical parameter of Khi 2		
Men	37,34	62,66	dl	X^2	*P*
Women	42,68	57,32	1	0,956	0,328

Table 4: Percentage of people presenting an allergy in each study area

Sites	Presence of allergies		Statistical parameter of Khi 2		
	Yes	No	dl	X^2	*P*
Cocody Cité des arts	45,65	54,35	6	10,48	0,106
Cocody Zoo	36,96	63,04			
Bingerville	34,78	65,22			
Abobo	41,30	58,70			
Adjamé	43,48	56,52			
Port-Bouet	23,91	76,09			
Yopougon	54,35	45,65			

Table 5: Comparison of groups using the procedure of Marascuilo

Samples	Proportions	Groups	
[1-10]	0,063	a	
[21-30]	0,152	a	
[51+]	0,200	a	b
[31-40]	0,353	a	b
[41-50]	0,429	a	b
[11-20]	0,471		b

4. Discussion

This study was carried out to study the allergic reactions due to pollens in the district of Abidjan. Environmental survey showed that seven settings in this district were at risk due to abundance of four plants with known allergen potential. These plants were *Ceiba pentandra, Petersianthus macrocarpus, Cocos nucifera* and *Elaeis guineensis*

The observational retrospective immuno allergological study showed that symptoms and allergic reactions were commonly observed by people living close to these plant species. The pollens of *Cocos nucifera* and *Elaeis guineensis* have already caused respiratory allergies in Asia (Jaggi *et al.* 1989) [15]. Of 323 people surveyed, 129 (40%) suffered from allergic reactions at some periods of the year corresponding to the dispersion period of pollens of at least one of the four plants. The percentage of people having allergy was twofold superior to that obtained in France (20%) in 2010 (RNSA 2010). This may be explained by lack of surveillance of aeroallergens and tools for prevention in Cote d'Ivoire. Also people are not aware of the

implication of pollens in allergic reaction. The main symptoms commonly observed were ENT symptoms (cough), itching of skin and eyes. These symptoms are similar to those observed with *Ambrosia artemisiifolia* in many regions in the world (Chauvel 2013) [7].

When considering the overall studied population, risks were significantly increased in the presence of *Ceiba pentandra* and *Petersianthus macrocarpus*. However, the symptoms expressions with these two plants were more recurrent in Yopougon (Adiopodoumé). The counts of pollens of *C. pentandra* was reported in Nigeria (Essien 2014) [11] and the allergenicity of its fibers mentioned by the European agency for work security and health (Anonymous 2003). This present study led credence to the allergenic property of *C. pentandra* and confirmed the capacity of its pollen to cause allergic reaction in people. This study showed that *Ceiba pentandra* was the species mainly involved in allergic reactions observed by people surveyed. This could be explained by its relative large distribution in the district of Abidjan. However, in term of abundance, the plant species was not the most predominant compared to *Cocos nucifera*. According to Demers (2013) [13], some species have strong ability to provoke allergenic reaction than others. This is the case of *Ambrosia artemisiifolia* (Jacques *et al*. 2009) [14]. For Cote d'Ivoire, these types of plants may be identified and dispersion of their pollen studied.

For *P. macrocarpus*, this is to our knowledge the first report of its allergenic potential. Many people living in Yopougon and Adjame have incriminated this plant in allergic reactions they had. High percentages of itchiness in these two settings, in presence of *P. macrocarpus* alone demonstrated the strong implication of this plant species in symptoms observed. The immuno allergological reactions following an anaphylaxis was scarce in the settings surveyed. This result is consistent with previous reports on the epidemiology of anaphylaxis in Canada (Simons *et al*. 2002) [32].

In the present study, different profiles appeared according to gender and age. There was no significant difference between women and men affected. Similar result was obtained in Quebec where prevalence of symptoms and diagnosis of allergic rhinitis were the same for the both sex (Canuel and Bélanger 2010) [5]. However, for the age, the most sensitive age group was 11- 20 years group, followed by 1-10 and 21-30 years groups. According to Aubier *et al*. (2005) [3] young people are more sensitive to allergies.

This study highlighted the crucial role of plant pollens in allergic reactions morbidity in the district of Abidjan and posed a significant ongoing health burden. Many allergic reactions were reported by people surveyed living close to *Ceiba pentandra, Cocos nucifera, Elaeis guineensis* and *Petersianthus macrocarpus*. Risk varied according to age but not gender.

This study which is the first report of allergenic effect of plant pollens in Cote d'Ivoire, opens several research perspectives. A cross-study in different settings of Cote d'Ivoire is ongoing in order to determine the seasonal dynamics of airborne pollens. Also, sensitization to pollen extracts of identified plants will be measured by skin prick in subjects surveyed.

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