

Occupational Asthma among Car Painters in Parakou City in Benin, West Africa

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Abstract

Background and objective: Occupational asthma is responsible for 5 to 20% of adult asthma cases globally, and car painters are among the most at-risk workers. The objective of this study was to determine the prevalence and characteristics of car painters with probable occupational asthma in Parakou, Benin. **Materials and methods:** A prospective cross-sectional study was carried out between April and September 2023 in Parakou, the third most important city in Benin. **Results:** Overall, 116 workers in 22 car painting shops were included, 64 (55.17%) masters and 52 (44.83%) apprentices. Their mean age was 30.59 (± 11.30) years, and their male-female ratio was 28:1. A past history of asthma was reported in 3 (2.59%). There were 113 (97.41%) who used gun spray; 49 (42.24%) worked in a confined environment; 100 (86.21%) reported breathing discomfort during painting; and 2 (1.72%) used air-filtered masks. The overall prevalence of probable occupational asthma was 10.34% (12/116; 95% CI, 6.02 - 17.21), 12.50% (8/64) in masters and 7.69% (4/52) in apprentices ($p = 0.398$). Preceding occupational rhinitis occurred in 6 (50%). Asthma symptoms were partially controlled in 8 (66.67%) and uncontrolled in one (8.33%). Being a daily smoker (aOR = 4.59; 95%CI, 1.01 - 22.00; $p = 0.048$) was associated with probable occupational asthma, after adjustment for age and permanent residence. Following Peak Expiratory Flow monitoring, four painters provided interpretable records, of whom three were confirmed with occupational asthma based on the Oasys scoring system. Of the 12 with probable occupational asthma, none was followed-up at occupational health departments; 3 (25%) were prescribed a short-acting β -2-agonist, and no worker

was treated with inhaled corticosteroids. These workers considered the impact of the disease on their productivity at work to be moderate. **Conclusion:** occupational asthma was common among car painters in Parakou. This calls for raising awareness on this condition, and for actions to improve the prevention and management of the disease among professionals.

Keywords

Occupational Asthma, Painter, Oasys Scoring, Parakou City

1. Introduction

Asthma is a major public health condition with multiple phenotypes [1] [2], among which occupational asthma remains one of the most prevalent. It is estimated that 5 to 20% of all new adult asthma cases can be attributed to occupational exposure (3). Although remaining the commonest occupational respiratory disease, with more than 400 causative agents having been identified in the workplaces, occupational asthma remains an under-screened, underdiagnosed, underreported and poorly managed disease, especially in developing countries [3] [4].

From a semantic viewpoint, occupational asthma is characterized by the onset of the disease triggered by agents present in the work environment in a person with no asthma symptoms before the workstation. Occupational asthma needs to be distinguished from work aggravated asthma which occurs in a professional already known to be asthmatic before being assigned to the workstation, and whose symptoms are exacerbated at work. Both of these conditions occurring together constitute work-related asthma [5].

Car painting is one of the most-at-risk professions for respiratory complaints, including occupational asthma like symptoms. According to several reports in the literature, the prevalence of occupational asthma, using varying diagnostic tools, ranges between 9.6% and 33.6% [6]-[10]. In France, Ameille *et al.* reported an annual occupational asthma incidence rate of 326 per million employed people [11].

The painting shop environment is characterised by a mosaic of allergens and irritants, such as formaldehyde, acrylates, aziridines, chromium, cobalt, azo derivatives and isocyanates being the most incriminated in the onset of asthma symptoms [12]-[14]. In addition, other characteristics of this environment, such as frequent confinement, poor ventilation and high humidity levels, contribute to increase the risk of sensitisation to dust and asthma.

In sub-Saharan Africa, little is known about the burden and characteristics of occupational asthma among car painters. After a literature search, only three studies reporting on the burden of respiratory symptoms among car painters were found. In one study from South Africa, that analysed data from the Nationwide Surveillance of Work-Related and Occupational Respiratory Diseases programme in the country, isocyanate was the second most frequently reported agent

for occupational asthma [15]. Ndiaye *et al.* from Dakar published a clinical case of a professional who was exposed to isocyanates, with the diagnosis based on clinical investigation, spirometry and the specific bronchial provocation testing challenge results [16]. In another report from Nigeria, the prevalence ratio of respiratory symptoms was 21 times higher among car painters compared with electronic technicians [17]. To our knowledge, no studies have been carried out in Benin.

This study aimed therefore to determine the prevalence and characteristics of car painters with occupational asthma like symptoms in Parakou City, Benin.

2. Materials and Methods

2.1. Study Type

This was a cross-sectional study with data prospectively collected between April 1 and September 30, 2023.

2.2. Setting

The study was carried out in Parakou, the third most important city in Benin, located in the northern-central part of Benin, West Africa.

Car painting profession in Parakou: Overall, at least three to four years of training, including theoretical and practical notions, are required to become a master car painter, and after having successfully passed a national final examination. There were some variations regarding the place where the paint was sprayed. At best, the cars were painted in a “paint room” to prevent the new paintwork from being marred by dust or other weather conditions. Painters who were unable to afford a “paint room” erected tents where, apart from the entrance, all the three other sides were made of thick materials such as tarpaulins, in order to provide a quite fairly enclosed area. Some directly painted outside, in the open air, in the garage. There is no systematic assessment at the opening of the workshop to ensure worker safety, and there is no planned preventive check-up by an occupational health specialist.

2.3. Participants

All master and apprentice car painters who were met on the day of the survey and gave their formal consent were included in the study. Painters who, for various reasons, were unable to attend the appointment or to respond to the questions were not included.

2.4. Data Collection and Variables

An individual face-to-face interview was conducted anonymously. Data were collected on demographic characteristics, lifestyles, and comorbidities, with an emphasis on any history of asthma and other stigmas associated with atopy. Occupational-related characteristics, the presence of symptoms suggestive of asthma and rhinitis and their link with any exposure to the occupational agents present at workplace were searched for.

Additionally, for those with occupational asthma symptoms, other information was sought, including the management of the disease, the level of control of symptoms in the last four weeks using the Global Initiative for Asthma criteria [2], and the impact of these symptoms on productivity at work based on the painters' self-judgement. Following the questions, the painters underwent an examination of the upper and lower respiratory systems. They were then invited to perform a Peak Expiratory Flow (PEF) monitoring over the next four weeks. During this period, they were asked to measure their PEF four times daily on working days for three weeks, and on an equivalent of one week on days-off [18] [19]. At each PEF measurement, three attempts were made from which only the highest value was considered and documented. Given that the car painters were in the private sector and were self-employed, they did not consent to leave their gainful activity for a whole week without any compensation. Therefore, their days-off represented their period without exposure. The measures were performed in the morning before arriving at work, at the middle of the shift, at the end of the shift and 2 to 3 hours after the end of the shift [20]. During the days-off, the measures in the middle and at the end of the shift were taken at the same time as during work days. All the data were recorded on the Oasys website (<http://www.occupationalasthma.com/oasys.aspx>). Following automated readings, a report was generated on the data quality as well as the Oasys score.

2.5. Diagnostic Criteria

The diagnostic criteria were based on the European Respiratory Society recommendations and the screening of occupational asthma questionnaire items developed by Pralong *et al.* [3] [21] [22].

Asthma symptoms: these included dyspnoea, wheezing, chest tightness and cough [2].

Probable occupational asthma: A worker without a previous history of asthma before starting the profession, and who reported a reproducible triggering of asthma symptoms during painting with an improvement during days without professional activity [3] [21] [22].

Confirmed occupational asthma: A worker with probable occupational asthma and for whom the Oasys score was >2.5 [19] [23] [24].

Occupational rhinitis: A worker declared having had at least two of the following symptoms such as rhinorrhoea, nasal pruritus, sneezing or nasal obstruction that occurred during painting and improved during periods of inactivity [25].

2.6. Data Analysis

Data were double-entered into the EpiData EntryClient (v4.6.0.0) software. They were then analyzed using R software (v4.3.1). Quantitative variables were described using means (with the standard deviation), or medians (with their interquartile range). Qualitative data were described by frequencies and percentages. Factors associated with symptoms suggestive of occupational asthma among painters

were determined by bivariate and then multivariate analysis using logistic regression. Factors such as demographic and occupational characteristics, as well as atopy and smoking habits, that may be linked with asthma were included in this analysis. All factors with a p value <0.200 on bivariate analysis were included in the multivariate analysis model [26]. The Odds Ratios (OR), their 95% confidence interval and the p values were determined. The Pearson and Fischer chi-square tests (if one of the theoretical numbers was less than 5) were used. The level of significance was set at <5%.

2.7. Ethical Approval

This study was carried out with the agreement of the Local Ethics Committee for Biomedical Research of the University of Parakou, reference number CLERB-UP054/2023. Informed consent from participants was previously obtained. Data confidentiality was respected.

3. Results

Characteristics of the study participants: Twenty-two car painting shops were visited throughout Parakou city during which 131 master and apprentice painters were met. Of these, 15 declined to participate in the survey.

Overall, 116 (88.55%) painters were included. There were 64 (55.17%) masters and 52 (44.83%) apprentice painters. Their mean age was 30.59 (± 11.30) years, ranging from 16 to 56 years and their male female ratio was 28:1. A personal history of asthma before starting painting was present in 3 (2.59%) painters (**Table 1**).

Table 1. Demographic characteristics and comorbidities of car painters included in the study, Parakou, April-September 2023.

Characteristics		n (%)
Age group (years)	< 40	86 (74.14)
	≥ 40	30 (25.86)
Gender	Female	4 (3.45)
	Male	112 (96.55)
History of atopic disease	Family asthma	17 (14.66)
	Personal atopy	34 (29.31)
	Asthma	3 (2.59)
	Allergic rhinitis	29 (25.00)
Smoking status	Non-smoker	73 (62.93)
	Smoker	40 (34.49)
	Ex-smoker	3 (2.59)
Total evaluated		116

There were 55 (47.41%) painters who practiced for at least ten years, and 113 (97.41%) who used gun spray for painting. There were 49 (42.24%) painters who declared working in an insufficiently ventilated environment, 100 (86.21%) who reported breathing discomfort during painting, 96 (82.76%) who admitted wearing more or less frequently a mask (a surgical or fabric mask in 94 (81.03%) and an

effective air-filtering mask in 2 (1.72%) (**Table 2**).

Table 2. Occupational-related characteristics of car painters included in the study, Parakou, April-September 2023.

Characteristics		n (%)
Duration in painting job (years)	< 10	86 (74.14)
	≥ 10	30 (25.86)
Type of paint used	Solvent-based paint	116 (100)
	Water-based paint	3 (2.59)
	Powder paint	0 (0)
Application painting tools	Brush	65 (56.03)
	Spray gun	113 (97.41)
	Roll	4 (3.45)
Working environment	Ventilated	67 (57.76)
	Confined	49 (42.24)
Need for respiratory protection equipment	No	16 (13.79)
	Yes	100 (86.21)
Use of any mask to protect the respiratory tract	Never	20 (17.24)
	Rarely	46 (39.66)
	Most of time	32 (27.59)
	Always	18 (15.52)
Use of air filtered mask	No	114 (98.28)
	Yes	2 (1.72)
Total evaluated		116

Prevalence and characteristics of painters with probable occupational asthma: The cascade of selection of the participants, in relation to their status with regard to asthma symptoms and their link with the occupational environment are shown in **Figure 1**.

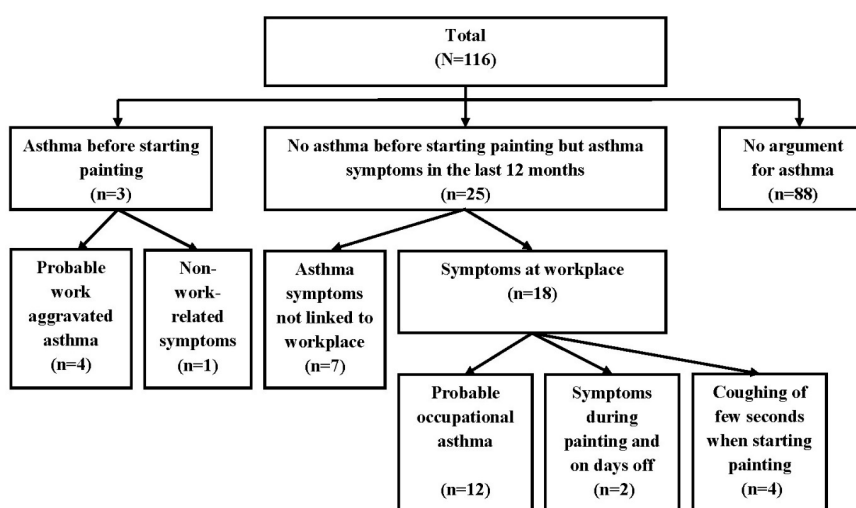


Figure 1. Occupational related characteristics of car painters included in the study, Parakou, April-September 2023

Overall, 12 painters met the diagnostic criteria for probable occupational asthma, giving an overall prevalence of 10.34% (95%CI, 6.02 - 17.21). The prevalence was 12.50% (8/64) and 7.69% (4/52) among master and apprentice painters respectively ($p = 0.398$). The overall median duration of symptoms was 5 years (IQR = 3 - 6) years; this was 5.75, and ranging between 3 and 6 years, for master painters and was 2 years ranging from 6 months to 2 years for apprentices. Among the 12 painters with probable occupational asthma, dyspnoea and violent coughing that occurred during painting and improved in periods of days off were reported by 100% ($n = 12$) and 75% ($n = 9$) respectively. Occupational rhinitis symptoms preceded that of asthma in 6 (50%) painters. On the survey day, one painter complained of dyspnoea and had audible wheezing at lung auscultation. Based on the GINA criteria, 8 (66.67%) painters were partially controlled and one (8.33) was uncontrolled (**Table 3**).

Table 3. clinical characteristics of painters with probable occupational asthma, Parakou, April-September 2023.

Characteristics		n (%)
Symptoms	Attacks of breathlessness	12 (100)
	Coughing	9 (75)
	Persistent chest tightness	6 (50)
	Wheezing	0 (0)
Occupational rhinitis	Absent	6 (50)
	Present	6 (50)
Symptoms on the day of the survey	Dyspnoea	1 (8.33)
	Wheezing at lung auscultation	1 (8.33)
	Rhinorrhoea	4 (33.33)
	Nasal congestion	1 (8.33)
Level of control of asthma symptoms	Controlled symptoms	3 (25)
	Partially controlled symptoms	8 (66.67)
	Uncontrolled symptoms	1 (8.33)
Total evaluated		12

After bivariate and multivariate analysis, the factor associated with probable occupational asthma was being a daily smoker (aOR = 4.59; 95%CI = 1.01 - 22.00; $p = 0.048$), after adjustment for age and permanent residence (**Table 4**).

Table 4. Factors associated with probable occupational asthma disease among car painters, Parakou, April-September 2023.

Characteristics	n/N (%)	Bivariate analysis		Multivariate analysis		
		cOR	Pvalue	aOR	95%CI	Pvalue
Age		1.04	0.119	1.02	0.96 - 1.08	0.464
Gender	Female	0/4 (0)	1	-	-	
	Male	12/112 (10.71)	1.96e ⁻⁷			
Personal atopy	No	8/82 (9.76)	1	-	-	
	Yes	4/34 (11.76)	1.23			

Continued

Smoking status	No smoker	5/73 (6.85)	1		1		
	Daily smoker	5/27 (18.52)	3.09		4.59	1.01 - 22.00	0.048
	Occasional smoker	2/13 (15.38)	2.47	0.133	2.28	0.28 - 12.97	0.374
	Ex smoker	0/3 (0)	8.69e ⁻⁷		3.86	NA - 9.78e ⁺¹¹³	0.995
Permanent residence	Rural	3/56 (5.36)	3.12		1		
	Urban	9/60 (15.00)	1	0.102	4.32	1.01 - 23.98	0.063
Seniority in painting	-	-	1.00	0.212			
Spray gun use	No	0/3 (0)	1				
	Yes	12/113 (10.62)	1.86e ⁶	0.992			
Painting environment	Ventilated	5/67 (7.46)	1				
	Confined	7/49 (14.29)	2.07	0.241			

cOR = Crude Odds Ratio; aOR: Adjusted Odds Ratio; 95%CI: 95% confidence interval

Confirmation of the diagnosis: Of the 12 painters with probable occupational asthma, five refused to perform the PEF monitoring testing. Of those who accepted it, three reported inaccurate or insufficient measures and were then excluded from analysis. For the remaining 4 painters with interpretable data, the Oasys score was equal to 3 in two and 3.75 in one, and they were therefore confirmed with occupational asthma.

Management of the disease and self-reported impact on work performance: Of the 12 painters with probable occupational asthma, none had a follow-up at an occupational health department; three (25%) declared having a clinical follow-up and were prescribed a short-acting β -2-agonist, and none had inhaled corticosteroids. The impact of the disease on work performance was judged to be moderate by 5 (41.67%) painters (Table 5).

Table 5. Management and self-reported impact on work performance in painters with probable occupational asthma, Parakou, April-September 2023.

	Characteristics	n (%)
Management of the disease	Occupational health follow-up	0 (0)
	Clinical follow-up	3 (25.00)
	Prescription of short-acting β -2-agonist	3 (25.00)
	Prescription of inhaled corticosteroids	0 (0)
Impact on performance at work	None	2 (16.67)
	Low impact	5 (41.67)
	Moderate impact	5 (41.67)
	High impact	0 (0)
Total evaluated		12

4. Discussion

The findings from this study provide a better idea on the burden of occupational asthma in the car painting profession in Parakou city, Benin, a virtually all-male profession, with a male female ratio of 28:1. The characteristics of the study

population reported in this study, especially the marked disparity according to the gender, reflect the situation of the painter's profession in Parakou city and also in the whole country. The rare females who were met during the survey were included. The conclusions can be generalized to all painters. Overall, the prevalence of probable occupational asthma among painters was 10.34%. More specifically, this was 12.50% among masters and 7.69% in apprentices. On average, symptoms lasted five and three years respectively for masters and apprentices.

The prevalence of occupational asthma in this study was consistent with that published in other reports in the literature. For instance, our prevalence was close to that found among males in France at 12% [10]. In another study from Türkiye, the prevalence of occupational asthma among car and furniture painters, based on questionnaires, pulmonary function tests, one-month PEF monitoring and non-specific histamine bronchial provocation tests was 9.6% [6]. However, there may be variations according to the setting. For instance, a much higher prevalence of 19.6% was reported by Cullen *et al.* from New Haven, USA, after the use of a self-administered questionnaire [7]. In another study from Denizli, Türkiye, the prevalence of occupational asthma based on symptoms only among car painters was 22.1% [8]. There may also be an age-related susceptibility, since in one study from Ankara, that included apprentice car painters who were adolescents, an occupational asthma prevalence of 50% was reported based on symptoms [27]. Reasons for these variations are not known and will probably require further research. Overall, however, our findings corroborate with those of other researchers who also found a high proportion of occupational asthma in this group of workers based on clinical assessment, due to their specific environment composed of allergens and irritants.

If, as stated in other reports [7] [14] there is no association between atopy and probable occupational asthma, there has been a significant link with current smoking, and our study findings corroborate this [7]. Painters who are smokers are subject to a greater insult to the bronchial mucosa, with consequently a high degree of inflammation and the gradual development of asthma. The lack of association in this study, between the use of a spray gun that increases the risk of aerosolization, contrary to that reported elsewhere is not surprising since almost all of the painters (>97%) used this tool in our setting. Other reported associated factors have been isocyanates, the main causative agent, and solvents, which may increase the risk of irritation of the bronchial mucous, and working in a confined environment [10]. The frequency of association with occupational rhinitis (50% in our study), is comparable to that reported by Krüll *et al.* with low molecular weight substances such as isocyanates [18]. It is much lower than that observed with high molecular weights, which predominantly induce an immediate hypersensitivity mechanism [18].

There were a number of challenges encountered during the implementation of the study, especially for the PEF monitoring follow-up. For example, some painters refused to carry out PEF monitoring. Others, although agreeing to take the

test, ultimately failed to honour their commitment or did not perform the minimum of four daily measurements and/or the four weeks of PEF monitoring. Some reported identical measures of the PEF on both working days and days-off. These challenges, however, are not unique. For instance, in one study only 55% of patients reported reliable values, due to poor technique in using the peak flow meter [28]. Other limitations included the lack of being able to identify causative agents of symptoms at the workplace using objective methods, such as specific IgE antibody dosages or bronchial challenge testing. These tests require logistics that are not yet available in our setting. On the other hand, the prospective nature of the study, the use of recommended diagnostic criteria to identify symptoms suggestive of occupational asthma, and attempts to assess their level of control represent some of the strengths of the study [2] [3] [21] [22]. PEF monitoring is the best validated method for confirming the occupational nature of asthma; and it is recommended in all guidelines [3]. Additionally, the use of the Oasys system allowed an automatic analysis of the PEF recording and prevented any bias due to subjective interpretation. This freely available automatic reading system is the most widely used in the literature and has a sensitivity of 75% with a specificity of 94%, according to previous reports [23] [24].

The study raises a number of concerns regarding the prevention and management of health disorders among these professionals, who are exclusively self-employed and without health insurance in the private sector. These challenges are quite common in other developing settings in sub-Saharan Africa. More than 80% of the car painters reported breathing discomfort during painting and almost all of them declared not using an effective air-filtering mask, due to its high cost. None of the 12 painters with probable occupational asthma has so far been consulted by an occupational health specialist, in order to reduce exposure to the risk and avoid complications. When symptoms became severe, they temporarily left the workstation until improvement or subcontracted the assigned work to another painter. The systematic replacement of the suspected paint by a more tolerated type of paint is challenging due to economic issues and the need to respect the client's requirements and his/her financial capabilities. Regarding medical treatment, only 3 of the car painters consulted a medical practitioner and were prescribed a short-acting bronchodilator: none were prescribed an inhaled corticosteroid. Based on our discussions, painters do not access hospital care because the symptoms are most of time moderately severe and traditional medicines are preferred, thanks to their low cost.

As for the influence of asthma symptoms on loss of work productivity, based on both time off and productivity at work, this was considered to be moderate by four out of ten painters at the time of the survey. However, this is likely to get worse if appropriate measures are not taken to remove themselves or reduce their exposure to the risk. In a multinational study conducted in 2019 in Brazil, Canada, Germany, Japan, Spain and the United Kingdom, the average work productivity loss was quite comparable to that found in this study and was estimated at 36% [29].

The findings from this study have some implications. They underline the need to raise awareness on the potential risk of developing asthma along with possible complications, targeting both master and apprentice car painters, to incorporate a continuing education program on protective measures and to advocate for providing personal protective equipment including affordable effective respiratory masks such as N90 and P100 respiratory masks. Means should be found to reduce paint aerosol exposure through, for instance the use of high volume, low pressure spray guns, adoption of controlled spraying techniques and adequate ventilation. We also advocate for the affordability of materials with low-toxicity such as water-based paints or isocyanate-free products. Periodic check-ups are also important and should be instituted, with a focus on lung function, to detect as early as possible the first symptoms of the disease; and painters with a history of asthma should always carry their short-acting bronchodilator. All these improvements will probably require support from the government, their local association, and from health practitioners such as occupational specialists.

5. Conclusion

In conclusion, one car painter in ten working at Parakou City probably had occupational asthma. However, very few completed accurate PEF monitoring for the confirmation of the diagnosis. A significant association was found with current smoking in this setting. The impact of these symptoms on work productivity was considered to be moderate. There is a need to improve technical and medical preventive measures, as well as the management of this disease.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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