

## Change in peak expiratory flow over time among workers exposed to polyvinyl chloride dust

H. Lawin,\* P. Ayelo,\* V. Hinson,\* J. Kagima,† B. Fayomi\*

\*Unit of Teaching and Research in Occupational and Environmental Health, Department of Public Health, Faculty of Health Sciences, University of Abomey-Calavi, Abomey-Calavi, Benin; †Department of Internal Medicine, Egerton University, Kenya

### SUMMARY

**OBJECTIVE:** To evaluate the variation of peak expiratory flow (PEF) over a working week among non-smoking workers without previous asthma who have been exposed to polyvinyl chloride (PVC) dust.

**DESIGN:** We conducted a cross-sectional study among 42 operators with exposure to PVC dust (filling hoppers to feed extrusion machines) and 23 employees without exposure to PVC dust in a plant producing PVC pipes in West Africa. A pre-tested questionnaire was administered and PEF was measured using a portable peak flow meter after a day off (day 1), on day 3 and at the end of the week (day 6).

**RESULTS:** The two groups did not differ by age or body mass index. Dyspnoea was more prevalent in exposed

workers than controls (52% vs. 13%,  $P = 0.002$ ). PEF decreased more significantly in exposed workers than controls (–8% vs. –3% on day 3 and –10% vs. –5% on day 6, both  $P = 0.004$ ). The duration of exposure did not affect PEF variability in the exposed groups.

**CONCLUSION:** The decrease of PEF over the working week in workers exposed to PVC dust is consistent with occupational asthma, although standard measures to diagnose occupational asthma were not used. This result reinforces the need to prevent excessive exposure to PVC dust.

**KEY WORDS:** PVC dust; occupational exposure; asthma; PEF; Africa

THE DUST PRODUCED during the manufacture of polyvinylchloride (PVC) objects includes a large proportion of small particles. The administration of PVC dust to animals has been reported to cause inflammatory changes of the bronchioles and alveoli, including a proliferation of histiocytes and granulomatous lesions.<sup>1,2</sup> In 1989, Lee et al. described a case of reported occupational asthma caused by exposure to PVC dust.<sup>3</sup> Other authors have also reported lung impairment in workers exposed to PVC dust,<sup>4–7</sup> specifically on variations in peak expiratory flow (PEF).<sup>8–10</sup> However, Chivers et al. concluded from their epidemiological study of 509 workers that PVC dust did not affect ventilatory function.<sup>11</sup> Findings of these studies have therefore been contradictory, and very few recent studies seem to have addressed the issue in the context of increased incidence of asthma caused by occupational and environmental exposure as well as genetic factors.<sup>12–15</sup>

We conducted a cross-sectional study among non-smoking workers exposed to PVC dust using repeated measures of PEF over a 1-week period of activity and among a control group without exposure to PVC dust. The workers were exposed to a mixture of PVC-

based materials. Briefly, the work process consisted of pouring PVC powder into hoppers; the PVC was then extruded in machines for the manufacture of drain-pipes. Exposure to PVC dust may cause respiratory problems other than asthma, but the main objective of the present study was to evaluate PEF variation over a working week.

### MATERIAL AND METHODS

#### *Study setting*

The project was conducted in a plant that employs about 150 individuals. The plant manufactures drains and pressure pipes of different diameters. Employees do not usually wear personal protective equipment and the work environment is polluted by aerosols of PVC-based materials. Apart from the administrative officers, employees are involved in 8-h/day shift work, with about 2 days off per week.

#### *Study design and participants*

We conducted a cross-sectional study of 44 non-smoking employees exposed to PVC dust in this plant. These employees usually pour materials that

**Table 1** Sociodemographic and professional characteristics of study participants

	Exposed group (n = 42) Mean $\pm$ SD	Control group (n = 23) Mean $\pm$ SD	P value
Age, years	30.4 $\pm$ 9.3	32.7 $\pm$ 9.3	0.27
Weight, kg	65.0 $\pm$ 7.9	67.0 $\pm$ 8.5	0.34
Height, cm	171.6 $\pm$ 6.1	171.2 $\pm$ 7.8	0.87
Body mass index	22.9 $\pm$ 2.8	22.0 $\pm$ 1.9	0.16
Length of employment in the plant, months, median (25–75 <sup>th</sup> percentiles)	32 (17–51)	10 (5–53)	0.06
Duration in current position, months, median (25–75 <sup>th</sup> percentiles)	16 (8–39)	10 (5–53)	0.52

SD = standard deviation.

have already been mixed into a hopper; the material then passes into the extruder, where it is heated to 160–200°C. These materials comprise more than 90% of their weight of PVC resin powder with additives such as stabiliser, lubricant and colouring. The workplace was poorly ventilated and the workers generally did not wear protective personal devices. All workers were male. We excluded two employees with pre-existing asthma; only 42 workers were therefore recruited. We also recruited a control group, which comprised administrative officers (two drivers, two liaison officers) and 20 handlers who load trucks for customers. These 24 employees were therefore unexposed to PVC dust. We excluded one of the handlers as he had a history of smoking.

#### Variables and measurement

As primary outcome, using a portable peak flow meter (Pikolys®, Eolys, Montélimar, France), we measured the PEF (l/min) immediately after the rest day (day 1), after 2 working days (day 3) and at the end of the working week (day 6). The measures were taken in the company health centre and recorded in a spreadsheet for analysis. On each occasion three manoeuvres were done and the best one was recorded. All manoeuvres were performed between 10:00 am and 1:00 pm.

A pre-tested questionnaire was administered to all the participants to assess asthma-related respiratory symptoms (cough, dyspnoea, wheezing) at initial screening. Sociodemographic characteristics, duration of employment and duration in current position at the plant were assessed. Duration in current position among those who were exposed was the length of exposure to PVC dust. No measurements of exposure to PVC dust were made.

#### Data analysis

Group differences for continuous variables were evaluated using Student's *t*-test or Mann-Whitney *U*-test, respectively, for normally and non-normally distributed variables. Categorical variables were assessed using the  $\chi^2$  test. A multivariate linear regression analysis of significant changes in PEF, including age, body mass index (BMI) and duration

of exposure to PVC dust in the exposed group, was carried out.  $P < 0.05$  was considered significant.

#### Ethics

All study participants provided written informed consent. The ethics committee of the University of Abomey-Calavi in Benin approved the study.

## RESULTS

#### Sociodemographics and professional characteristics

The sociodemographic characteristics of the study participants did not differ significantly between the groups despite duration of employment and time in current position in the plant (Table 1).

#### Respiratory symptoms

As shown in Table 2, dyspnoea was more prevalent among the employees exposed to PVC dust than among those with no exposure, and this difference was statistically significant ( $P = 0.002$ ). Cough as a symptom was more common in the exposed group than in controls (43% vs. 26%), although the difference was not statistically significant. Wheezing was not reported.

#### PEF measurement

Decrease in PEF was 2–3 times greater in the exposed group than in the controls (Table 3). A multivariate model on PEF variations on day 3 and day 6 compared to baseline measures showed that significant variations of the PEF on day 3 and day 6 were not significantly related to age, BMI and duration of current (exposed) employment (Table 4).

## DISCUSSION

Our study of two groups of non-smoking workers without pre-existing asthma who did not differ in

**Table 2** Prevalence of respiratory symptoms

	Exposed group (n = 42) %	Control group (n = 23) %	P value
Cough	43	26	0.28
Dyspnoea	53	13	0.002

**Table 3** Repeated PEF measurement

	Exposed group ( <i>n</i> = 42)	Control group ( <i>n</i> = 23)	<i>P</i> value
Predicted PEF, l/min	600	546	0.002*
% of predicted PEF day 1	82	91	0.003*
% of predicted PEF day 3	74	88	<0.001*
% of predicted PEF day 6	71	86	<0.001*
Predicted PEF difference 1 (day 1–day 3)	8*	3*	0.004*
Predicted PEF difference 2 (day 1–day 6)	10*	5*	0.004*
Predicted PEF difference 3 (day 3–day 6)	3 (–2–5)*	2 (–3–8) <sup>†</sup>	0.493 <sup>‡</sup>

\* Student's *t*-test.<sup>†</sup> Expressed in median (25<sup>th</sup>–75<sup>th</sup> percentiles).<sup>‡</sup> Mann-Whitney *U*-test.

PEF = peak expiratory flow.

terms of age and BMI showed that exposure to PVC dust was associated with decreased PEF in the exposed workers. These results are consistent with occupational asthma due to exposure to PVC dust, although standard measures to diagnose occupational asthma were not used in this paper. As individual exposure to the PVC dust was not measured, we could not assess the level of exposure that may have led to PEF reduction. Furthermore, although PVC resin accounted for >90% of the weight of the materials used, the exposure was to a mixed material. To avoid selection bias, we did not recruit administrative staff, such as management or accounting officers, as controls as they may have had higher socio-economic status.

PEF decreased significantly more in exposed workers than in controls over the course of the working week: –8% vs. –3% on day 3 and –10% vs. –5% on day 6. Lee et al. demonstrated that the diurnal variation of PEF in workers exposed to PVC dust was 6.5% vs. 4.3% in the control group and that the concentration of inhaled PVC dust was respectively 1.6 mg/m<sup>3</sup> and 0.4 mg/m<sup>3</sup>.<sup>9</sup> This variation is lower than the one we found in our study. The reason for this difference may have been due to the fact that our study assessed PEF changes after several days of work, and cumulative exposure may not have been equal.

Apart from dyspnoea, respiratory symptoms did not differ significantly in the two study groups. This may have been due to the exposure level of the

workers and/or the exclusion of smokers and workers with pre-existing asthma. Finally, we found that the duration of exposure to PVC dust (duration in current position) did not affect PEF changes in the exposed group. Chivers et al. also reported that the length of service had a negligible effect on ventilatory function in the exposed group;<sup>11</sup> however, Süyür et al. concluded that a median of 36 months of exposure affected PEF variability.<sup>8</sup>

## CONCLUSION

PEF decreased more significantly in workers exposed to PVC dust than in controls, and duration of exposure did not affect PEF changes over time in the exposed groups. This decrease in PEF is consistent with occupational asthma due to exposure to PVC dust, although standard measures for diagnosing occupational asthma were not used in this study. These findings reinforce the need for appropriate preventive measures in this plant, such as the use of personnel protective equipment and better medical surveillance for workers, to mitigate the high incidence of asthma, especially in low- and middle-income countries with unfavourable working environments.

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**Table 4** Model of variation of PEF integrating age, BMI and time in current position of the exposed group

	Exposed group	
	<i>P</i> value	Adjusted <i>R</i> <sup>2</sup>
Predicted PEF difference 1 (day 1–day 3)		
Age	–0.04	0.76
BMI	0.01	0.95
Time in current position	0.15	0.30
Predicted PEF difference 2 (day 1–day 6)		
Age	0.05	0.80
BMI	0.09	0.61
Time in current position	0.08	0.64

PEF = peak expiratory flow; BMI = body mass index.

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Conflicts of interest: none declared.

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**R E S U M E**

**OBJECTIF :** Evaluer la variation du débit expiratoire de pointe (PEF) sur 1 semaine de travail chez les travailleurs non-fumeurs et sans antécédent d'asthme exposés à la poussière de polychlorure de vinyle (PVC).

**MÉTHODE :** Nous avons mené une étude transversale chez 42 opérateurs exposés (exposition élevée, mais non-mesurée) à la poussière de PVC (par remplissage des trémies pour alimenter des machines d'extrusion) et 23 employés sans exposition à la poussière de PVC (témoins) dans une usine de production de tuyaux en PVC. Un questionnaire prétesté a été administré et le PEF a été mesurée à l'aide d'un débitmètre de pointe portable après un jour de repos (jour 1), 3 jours après et à la fin de la semaine (jour 6).

**RÉSULTATS :** Les deux groupes ne différaient pas selon

l'âge ou l'indice de masse corporelle. La dyspnée était plus fréquente chez les travailleurs exposés (52%) que chez les témoins (13%) ( $P = 0,002$ ). Le PEF a diminué significativement plus chez les travailleurs exposés que chez les témoins ( $-8\%$  vs.  $-3\%$  le jour 3 et  $-10\%$  vs.  $-5\%$  le jour 6 ;  $P = 0,004$  pour les deux). Il n'y a aucun effet de la durée de l'exposition sur la variabilité du PEF dans le groupe exposé.

**CONCLUSION :** La diminution du PEF au cours de la semaine de travail chez les travailleurs exposés à la poussière de PVC fait penser à l'asthme professionnel, bien que les méthodes standardisées de diagnostic n'aient pas été utilisées. Cette étude renforce la nécessité de prendre des mesures d'hygiène appropriées pour éviter une exposition excessive à la poussière PVC.

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**R E S U M E N**

**OBJETIVO:** Evaluar la variación del flujo espiratorio máximo (PEF) durante 1 semana laboral en personas no fumadoras sin antecedente de asma y expuestas a polvos de policloruro de vinilo (PVC).

**MÉTODO:** Se llevó a cabo un estudio cruzado de 42 operadores expuestos al polvo de PVC (manipuladores de tolvas de alimentación de máquinas de extrusión) y 23 empleados sin exposición a este polvo en una planta de fabricación de tubos de PVC en África occidental. Se administró un cuestionario puesto a prueba previamente y se midió el PEF con un dispositivo portátil después del día de reposo (día 1), luego de 3 días de trabajo y al final de una semana laboral (día 6).

**RESULTADOS:** La edad y el índice de masa corporal no diferían entre los grupos. La disnea fue más frecuente en

los trabajadores expuestos (52%) que en los testigos (13%) ( $P = 0,002$ ). La disminución del PEF fue más significativa en el grupo de trabajadores expuestos al polvo de PVC que en los testigos ( $-8\%$  contra  $-3\%$  en el tercer día y  $-10\%$  contra  $-5\%$  en el sexto día;  $P = 0,004$  en ambos casos). La duración de la exposición no afectó la variabilidad del PEF en los grupos expuestos.

**CONCLUSION:** La disminución del PEF durante la semana laboral en los trabajadores expuestos al polvo de PVC es indicativa de asma ocupacional, aunque no se hayan utilizado los medios diagnósticos corrientes de este trastorno. Los resultados obtenidos respaldan la necesidad de prevenir la exposición excesiva al polvo de PVC.

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