Research Article
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Evaluation of toxicological risks among screen printing workers: the case of the city of Yaoundé (Cameroon)

Summary

Manual screen printing is a growing printing market in Cameroon. This activity presents risks due to the substances that workers are exposed to. The low level of information on the toxicological risk to which screen-printing workers are exposed are hidden the hazards. We conducted this study to identifying products used (inks, thinners, additives), and related information: compositions, toxicological information, storage conditions, quantities used, usage frequency; which enabled us to calculate risk score relating to each product. This has been done via a descriptive cross-sectional study approved by the Institutional Committee of Ethics and Research of the Faculty of Medicine and Biomedical Sciences of the University of Yaoundé 1. To achieve this objective, the study was conducted in 91 screen printing workshops, where a total of 118 participants answered all the questions on the form. The survey phase consisted of questionnaire administered to each screen printer. Inks, thinners and additives used in screen printing were mainly made up of toxic even carcinogenic substances and highly volatile solvents. Approximately 80% of these products had a risk score of medium to very high risk. According to screen printers' statements, respiratory system seemed to be the most exposed and affected system, as a consequence of the practice of this profession.There is a huge need to implement prevention measures with, among other things, a health education program for screen printers and continuous research into the toxic effects associated with the practice of screen printing could reduce this risk to its lowest level, and protect public health amongst this population.

Keywords: screen printing, toxicological risks, screen printing products

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Introduction

Global Occupational Health Network (GOHNET) maintains that worldwide, deplorable occupational health and safety conditions result in two million workplace deaths, 271 million injuries and 160 million cases of occupational disease each year.[1] In addition, the main current printing processes use multiple inks and chemicals, some of which may be toxic or even carcinogenic.[2-5] However, health and safety risks in screen printing vary depending on the chemicals used, the type of press construction and the degree of automation of the various phases of the printing process.[6] In Cameroon, it should be noted that printing market is currently in full expansion.[7] Working in this field involves not only mastering the processes but also constant contact with various potentially hazardous substances. However, in Cameroon, many questions remain unexplored regarding toxicological risks these screen printers are exposed to. The aim of this work was to evaluate the toxicological risk of this sector. Our approach consisted in characterizing the risk related to the various products used by screen printers and then identifying various pathologies associated with the use of products used in this profession.

Materials and methods

Type and framework of the study

Our study took place in different screen-printing workshops in the city of Yaoundé in Cameroon department of Mfoundi, Center Region. The climate here is subequatorial with 2 dry seasons alternating with 2 rainy seasons. With an area of approximately 187 km^2, it has a population of approximately 4,100,000 inhabitants in 2019 according to the National Institute of Cartography (INC).[8] This city is characterized by a high concentration of youth, students and enterprising population.[9]

Study duration

The study ran from December 18, 2019 to August 13, 2020. The duration of the study which corresponds to the time period dedicated to data collection, was from January 31 to June 30, 2020.

Sampling

The target population consisted of employees of screen-printing units located in the city of Yaoundé and familiar with the use of inks, thinners and additives in their daily work. The database of actors working in the city of Yaoundé was obtained from the Ministry of Arts and Culture and the National Institute of Statistics, enabled us to locate their location. The localization of screen-printing workshops was possible via their identification plate.

Recruitment of screen-printing workers was done within the selected screen-printing structures. We presented our study and its objectives to the above targeted participants in order to obtain their consent. Only those who gave their consent were included in the study and were submitted to the questionnaire.

To this end, any screen printer meeting the criteria listed above was involved in the study. Consecutive and non-exhaustive non-probability sampling combined with network (snowball) sampling was carried out to select the people working in the screen-printing units. A total of 91 screen printing workshops were visited and 118 actors were interviewed.

Procedure

The questionnaire was administered to each participant in order to identify the products used (inks, thinners, additives). In addition, information was collected about the quantity and frequency of use of each product. After identifying the products used, we proceeded to

an inventory of their respective components. We also looked for the various aches and pains that seemed to be related to their use.

More specifically:

a) After validation of the data sheet by our supervisors, we contacted the Ministry of Arts and Culture and the National Institute of Statistics to obtain their databases on screen printers in Yaoundé.

b) We proceeded to identify the different districts of the Mfoundi department in order to be able to cover all the screen-printing units.

c) The study was carried out among screen printers in the city of Yaoundé according to a certain number of criteria, including mainly the production of printed materials using the screen-printing process and the use of inks, thinners and additives.

d) Identification of screen-printing workshops was done by the presence of an identification plate.

e) After having identified the screen-printing workshops, we proceeded to the selection of the screen-printing structures; this one depended essentially on the agreement of the person in charge of the structure; thus, all the screen printing structures of the city of Yaoundé were likely to be retained for the recruitment of the screen printing workers.

f) The recruitment of screen printers was done within the selected screen-printing structures. After making contact, during which we introduced ourselves and clearly defined the reason for our presence. We presented our study and its objectives to potential participants in order to obtain their consent. Only subjects who gave their consent (see Appendix 2: Informed Consent Form) were included in the study and submitted to the questionnaire.

g) The questionnaire was administered to each participant to identify the products used (inks, thinners, additives). In addition, information was collected on the amount and frequency of use of each product.

h) After identifying the products used, we proceeded to inventory their respective components.

i) We also researched the various medical issues that seemed to be related to their use.

Data analysis

After entering the collected data into the CSPro version 7.3 software, a data processing phase was carried out. The analysis of the data was done using the IBM SPSS statistics software version 23.0. First of all, the descriptive analysis of the data was carried out. For variables with a normal distribution, the mean and standard deviation were the two parameters calculated. In the opposite case, the median and the interquartile range were calculated.

Calculation of risk score for each product according to the method defined by the INRS was carried out and the products were classified according to their risk score in a decreasing order.

Description of the risk score calculation method for prioritizing potential risks[10]

Purpose of the method

Purpose of this method is to classify chemical agents according to their potential risks.

Required data

Several pieces of information are necessary to carry out this method: name of chemical agent or its reference, labeling, quantity used, frequency of use.

Hazard classes

Hazard class is determined primarily from informations given in Safety Data Sheet (SDS) or, if not available, on the label. Assignment of a hazard class to a preparation is based on the risk phrases mentioned in section 15 "regulatory information" and phrases beginning with "R" in the SDS. If several risk phrases are present, the highest hazard class shall be selected.

Quantity used

It is characterized using five classes (Table 1). In order to establish the quantity classes, it is essential to determine, first of all, the appropriate temporal reference of consumption: daily, weekly, monthly, yearly... Determination of quantity classes is carried out by taking the quantity consumed (Qi) of the chemical agent considered in relation to the quantity of the most consumed agent (QMax).

Table 1 Quantity class of products

Class	Quantity used
I	Negligible (< 1%)
II	Low Between (1% and 5%)
III	Medium Between (5% and 12%)
IV	Significant Between (12% and 33%)
V	Very important Between (33% and 100%)

Frequency of use

Frequency of use is structured into four classes (Table 2). "Frequency" parameter makes it possible to differentiate products used occasionally from those used continuously. To determine the frequency of use classes, the time frame must be identical to that used to determine the quantity classes: daily, weekly, monthly, annual, etc.

Table 2 Frequency class of the products

Frequency class	Frequency of use
I	Occasional: a few days a year
II	Occasional: a few days a month or a few weeks a year
III	Discontinuous: a few days a week or a few months a year
IV	Continuous: every day, all year round

Potential exposure classes

For a chemical agent, potential exposure results from combination of quantity and frequency of use classes. Overall, higher the quantity and frequency of use of a chemical agent, greater is the probability of employee exposure. The potential exposure classes are determined using the grid proposed in Table 3 below.

Table 3 Potential exposure class

Quantity class						
5	0	4	5	5	5	
4	0	3	4	4	5	
3	0	3	3	3	4	
2	0	2	2	2	2	
1	0	1	1	1	1	
	0	1	2	3	4	Frequency class

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Determining the potential risk score

Potential risk results from the combination of hazard classes and potential exposure. It reflects the probability of observing a risk, given the general conditions of use (quantity, frequency) of a hazardous chemical agent. Determination of potential risk is carried out using grid in Table 4. Scores can be added together to allow prioritization of different entities. The priority of consideration of a product is determined from the decision grid presented in the table below.

Table 4 Potential risk score of products

Potential exposure class						
5	100	1000	10000	100000	1000000	
4	30	300	3000	30000	300000	
3	10	100	1000	10000	100000	
2	3	30	300	3000	30000	
1	1	10	100	1000	10000	
	1	2	3	4	5	Hazard class

Prioritization of potential risk

Prioritization is used to rank the hazardous chemical agents. This step makes it possible to defer the examination of chemical agents with low potential risks (Table 5).

Table 5 Risk prioritization

Score HRP/ Produit	Priority
≥ 10000	High
100 – 10000	Medium
< 100	Low

Results

Characteristics of the study population

A total of 91 screen printing shops were visited. The majority (%) of these shops were one-man businesses. All these screen printing units were mainly located in four districts of Yaoundé 1, 2, 4 and 6. One hundred and twenty-nine (129) screen printers were surveyed, but only 118 screen printers (91.47%) were included in the statistical analyses. Men represented 95.76% (111/118) of our sample and women 4.24%, for a sex ratio of 22.60. The average age of a screen printer in the city of Yaoundé was 35.33 years (with a minimum of 21, a maximum of 64 and a standard deviation of 10.13).

Several products were identified as being used in screen printing. Below are the band diagrams of thinners, additives and inks used in screen printing that we have listed and identified during our study (Figure 1).

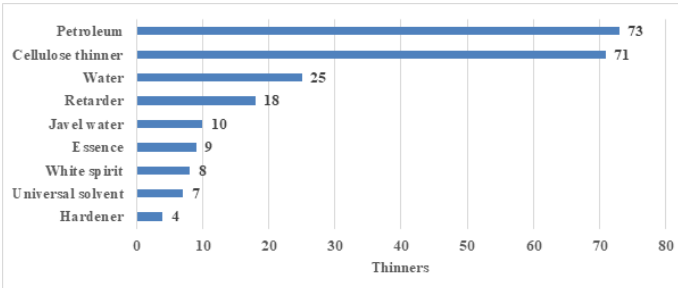

Figure 1 Thinners recorded during the study.

From this figure, it appears that petroleum is the most used thinner 73 (61.3%), followed by cellulosic thinner 71 (60.2%).

The graph below illustrates the different additives used by screen printers (Figure 2).

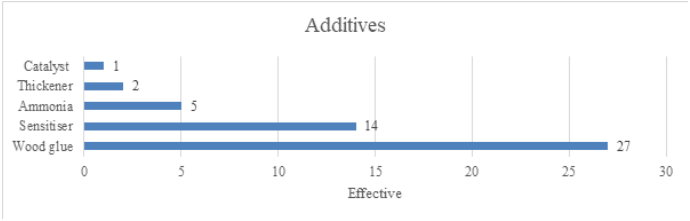

Figure 2 Additives listed during the study.

Among the most used additives, we have white glues 27 (22.9 %) followed by sensitizers 14 (11.6 %).

Regarding inks, the diagram below lists the products used by screen printers (Figure 3).

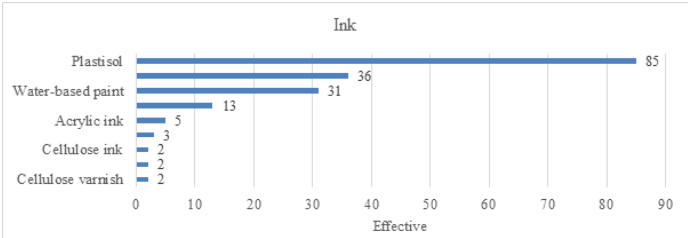

Figure 3 Inks listed during the study.

The main product used was plastisol 85 (60.2 %), followed by matt ink 36 (30.4 %) and paints 31 (26.3 %).

Regarding organic solvents, several types were found among different screen printing products, we have mentioned some of them in the table 6 below.

Table 6 Organic solvents contained in screen printing products

Name of the substance	Name of the product	Organic solvent types
Vinyl chloride (Chloroethylene)	Plastisol	Chlorinated solvent
Toluene/ Benzene, ethybenzene, nitrobenzene/ xylene/ naphtha/ n-hexane/ n-alkanes/ hexamethylene diisocyanate/ cylohexane	Matt ink, cellulose thinner, gasoline, cellulose varnish, glue, retardant, white spirit, gasoline, glue	Petroleum solvents
Butan.1.ol/ propan.2-ol/ Isobutanol/2-Methylpropan-1-ol/ methanol/ benzyl alcohol	Cellulose thinner, cellulose ink, plastic ink, retardant, universal solvent	Oxygenated solvents (alcohol)
Acetone/cyclohexanone/ butanone	Matt ink, acrylic ink, universal solvent, white spirit	Oxygenated solvents (ketone)

In short, several types of organic solvents were found in screen printing products.

Risk score of screen-printing products

The risk score was calculated for each product. Thus, we distinguished products with probably very high risk (risk score ≥1000) requiring immediate corrective measures during handling, products with moderate risk requiring corrective measures and a thorough evaluation (risk score between 100-1000), and finally products with low risk (risk score <100), not requiring special measures during handling.

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We decided to study the high risk and medium risk products, as defined in the table 7 below.

Table 7 List of products used with high and medium risk scores

Products with high risk score	Medium risk score products
Cellulose thinner	Universal Solvent
Petroleum	Gasoline/Fuel
Matt ink	Retarder
Plastisol	Plastic ink
Neutral ink	Wood glue
Water based paint	White spirit

Factors associated with the occurrence of pathologies

We investigated association between the occurrence of some reported subjective symptoms and products with high and medium risk scores.

Cellulose thinner (OR: 6.04 and P = 0.003), plastisol (OR = 6.8 and P = 0.046), plastic ink (OR = 6.7 and P = 0.007), and white spirit (OR = 8.09 and P = 0.025) were products which had significant association with possibility occurrence of respiratory problems by their p-value (Table 8).

Table 8 Association between the products used and the occurrence of respiratory problems

Variables	Respiratory problems		OR (IC à 95 %)	P Value
	Yes % (n)	No % (n)		
Products				
Cellulosic Thinner	82.4 (14)	17.6 (3)	6.045 (1.635-22.35)	0.003
Petroleum	60 (6)	40 (4)	1.615 (0.431-6.049)	0.473
Matt Ink	62.5 (5)	37.5 (3)	1.792 (0.408-7.869)	0.434
Plastisol	85.7 (6)	14.3 (1)	6.80 (0.793-58.418)	0.046
Neutral ink	53.5 (38)	46.5 (33)	1.555 (0.74-3.268)	0.243
Water based paint	52.1 (38)	47.9 (35)	1.357 (0.644-2.862)	0.422
Universal solvent	57.1 (4)	42.9 (3)	1.4 (0.3-6.38)	0.663
Gasoline/ Fuel	33.3 (3)	66.7 (6)	0.49 (0.11-2.06)	0.323
Retarder	61.1 (11)	38.9 (7)	1.77 (0.63-4.94)	0.27
Plastic ink	84.6 (11)	15.4 (2)	6.78 (1.43-32.13)	0.007
White glue	51.9 (14)	48.1 (3)	1.15 (0.48-2.71)	0.749
White spirit	87.5 (7)	12.5 (1)	8.09 (0.96-68.04)	0.025

OR, odd ratio; CI, confidence interval

Regarding skin problems, products with a strong association were cellulose thinner (OR = 3.2 and P = 0.023) and wood glue (OR = 2.9 and P = 0.017) (Table 9).

Table 9 Association between the products used and the occurrence of skin problems

Variables	Skin problems		OR (IC à 95 %)	P Value
	Yes % (n)	No % (n)		
Products				
Cellulosic Thinner	52.9 (9)	47.1 (8)	3.245 (1.134-9.289)	0.023
Petroleum	50 (5)	50 (5)	2.6 (0.702-9.628)	0.141
Matt Ink	12.5 (1)	87.5 (7)	0.319 (0.038-2.698)	0.271
Plastisol	42.9 (3)	57.1 (4)	1.852 (0.392-8.743)	0.431
Neutral ink	29.6 (21)	70.4 (50)	0.99 (0.442-2.218)	0.981
Water based paint	24.7 (18)	75.3 (55)	0.539 (0.241-1.204)	0.13
Universal solvent	28.6 (2)	71.4 (5)	0.94(0.17-5.12)	0.948
Gasoline/Fuel	22.2 (2)	77.8 (7)	0.65(0.13-3.33)	0.611
Retarder	22.2 (4)	77.8 (14)	0.63(0.19-2.08)	0.453
Plastic ink	38.5 (5)	61.5 (8)	1.56(0.47-5.16)	0.461
Wood glue	48.1 (13)	51.9 (14)	2.91(1.19-7.12)	0.017
White spirit	12.5 (1)	87.5 (7)	0.31(0.03-2.69)	0.271

OR, odd ratio; CI, confidence interval

Job-related health problems

In our study population, 79 (66.9%) screen printers reported having a job-related health problem. Various symptoms by system were as defined by the following Table 10.

Table 10 Summary of symptoms by system identified during the study

Systems	Health problems
Respiratory	Respiratory infection, sore throat, rhinitis, cough, asthma, shortness of breath
Skin	Dry skin, scaling, itching, rash, skin irritation
Ocular	Visual disturbances, itching,
Nervous Systems	Headache, dizziness, fatigue, dizziness
Articular	Neck pain, back pain, knee pain, shoulder pain
Digestive	Abdominal pain, vomiting, nausea

These different subjective symptoms cited were grouped by system and we were able to construct the graph defining subjective health problems and percentages (Figure 4).

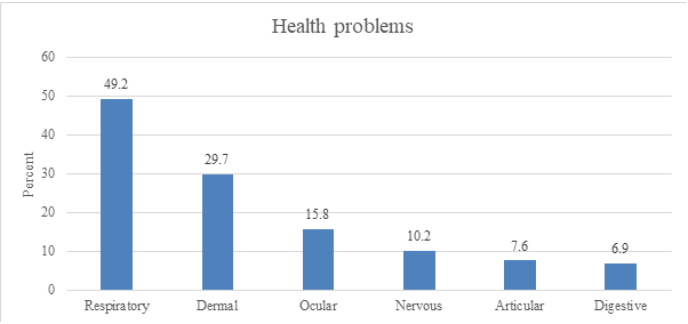

Figure 4 Percentage of different health problems identified by system.

Source: Tchouakeu NJ. Risques toxicologiques chez les travailleurs de sérigraphie dans la ville de Yaoundé. Thèse Doctorat en Pharmacie, FMSB/ Université de Yaoundé 1, Cameroun ; 2020.

Our study revealed that the respiratory system was the most affected system according to the screen printers. Indeed, 49.2% of screen printers reported having respiratory problems related to their job, followed by conditions of the integumentary, ocular, nervous, articular, and digestive systems with respective frequencies of 29.7%, 15.8%, 10.2%, 7.6%, and 6.9%.

The occurrence of health problems in screen printers was most increased after 16 and 30 years of practice.

Discussion

Manual screen printing is a growing printing market in Cameroon. However, many questions remain unexplored regardingvtoxicological risks to which screen printers are exposed. Lack of information is a problem that motivated this study.

During our study, we did not find any data similar to ours. However, research on exposure to organic solvents in screen printing has been conducted by other researchers as, (Vouriot et al.[11], Hostrman et al.[12], Hussain et al.[13], Yu et al[14]).

Previous work dealing with harmful exposure in screen printing has focused on the use of organic solvents rather than other compounds that may be equally toxic. Regarding organic solvents, several types have been found in different screen printing products. Our results are similar to those of Horstman et al.,[12] in 2001 in USA, Yu et al.,[14] in 2004 in China, Hussain et al.,[13] in 2014 in Pakistan who had studied the presence of several organic solvents in screen printing shops. Thus, we had by authors the research of exposure to some solvents: Yu et al (n-hexane, isopropanol, toluene and benzene), Hostrman et al (methyl alcohol, acetone, isopropyl alcohol, methyl ethyl ketone, methyl isobutyl ketone, toluene, xylene, glycol ether and n-hexane), and Hussain et al (acetone, glycol ethers, methanol, toluene and xylene).

The solvents used for cleaning the limbs and surfaces were, in descending order: petroleum, cellulose thinner, water, soap, bleach, gasoline. The toxic substances contained in these products that could affect the health of screen printers were mainly: toluene; n-hexane; benzene; our results are in agreement with those of Horstman et al.,[12] in 2001 in the USA, Yu et al.,[14] in 2004 in China, Hussain et al.,[13] in 2014 in Pakistan who found the same substances in their respective studies on toxic organic solvents in screen printing.

All the products incriminated in the development of health problems according to the associations of variables carried out, had a high or medium risk score. The determination of the risk score could serve as an indicator of the characterization of the toxic risk associated with exposure to a product.

Cellulose thinner (OR: 6.04 and P = 0.003), plastisol (OR = 6.8 and P = 0.046), plastic ink (OR = 6.7 and P = 0.007) and white spirit (OR = 8.09 and P = 0.025) were the three products that had significant association with the possibility of respiratory problems. This is explained by the fact that these products are composed of toxic substances for the respiratory tract, among others: titanium dioxide, Morpholine-4-carbaldehyde, 2-methoxypropanol. Indeed, Andujar et al.,[16] in a study on the respiratory effects of manufactured nanoparticles in France, obtained similar results.

For skin problems, the products strongly associated with the development of this type of pathology were cellulose thinner (OR = 3.2 and P = 0.023) and wood glue (OR = 2.9 and P = 0.017). Together, these products doubled the risk of skin problems. The presence of toluene in the cellulose thinner, and compounds such as butanone, cyclohexane, petroleum naphtha and ethyl acetate in the wood glue could, because of their chemical toxicity, be incriminated in the occurrence of irritant dermatitis.

Respiratory system was the most affected system according to screen printers' statements. Indeed, 58 (49.2%) screen printers stated that they had experienced respiratory problems related to their work, followed by disorders of the integumentary, ocular, nervous, articular and digestive systems with respective numbers of 35 (29.7%), 18 (15.8%), 12 (10.2%), 9 (7.6%), and 7 (6.9%). Our results were closed to those obtained by Decharat[15] in 2014 in Thailand who obtained a decreasing order by symptom, the percentages were as follows: eye irritation 79 (52. 7%), rhinitis 75 (50%), allergic skin reactions 57 (38%), dizziness 45 (30%), visual disturbances 35 (23.3%), drowsiness 32 (21.3%), asthma exacerbation 26 (17.3%), cough 24 (16%), nausea/vomiting 23 (15.3%). Moreover, in terms of frequency, and occurrence of symptoms, our results differ from those obtained by Hussain et al.,[13] in 2014 in Pakistan. Indeed, memory loss was the main threat found with a percentage up to 72%. Other common disorders were: hypertension, depression, dizziness, dry skin, headache, work fatigue, sore throat, and vision disorders with percentages of 47%, 53%, 56%, 55%, 49%, 56%, 30%, and 38% respectively. This difference showed that the symptoms found in this study were not subjective to participants, but rather were researched in these participants.

Conclusion

In sum, the objective of our study was to evaluate the degree of toxicological risk to which screen printers are exposed. It was found that various inks, thinners and additives are used by screen printers in the city of Yaoundé and are for the most part composed of highly toxic or even carcinogenic substances.

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Conflicts of interest

No conflicts of interest were recorded during our work.

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