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Exposure to Organic Solvent, Health Symptoms and Safety Practices Among Automobile Spray Painters in Johannesburg, South Africa

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Abstract

Automobile spray painters in small informal workshops in developing countries face high occupational exposure to organic solvents. Although health effects are well known, the influence of workers' knowledge, attitudes, and practices (KAP) on these effects is less well understood. This study examined spray painters' KAP regarding organic solvents and health symptoms and assessed workplace safety compliance. A cross-sectional study in Region F, Johannesburg, collected data among 152 spray painters across 47 workshops using a questionnaire and checklist. KAP scores were analysed with multivariable logistic regression to identify associations with eye, skin, respiratory, and CNS symptoms, while controlling for confounders. Workplace controls were inadequate: 64% of workshops conducted spray painting outdoors, while only 17% had a functioning spray booth. Although knowledge scores were high (45.29/50 $\pm$ 6.025), practice scores remained low (9.01/20 $\pm$ 5.275). After adjustment, higher knowledge was significantly associated with reduced odds of eye (AOR = 0.846), skin (AOR = 0.915), and respiratory symptoms (AOR = 0.890). Better practice scores also correlated with fewer skin symptoms (AOR = 0.891). No KAP construct was linked to CNS symptoms. In the absence of engineering controls, workers' knowledge is strongly linked to lower reporting of solvent-related symptoms affecting the eyes, skin, and respiratory system. However, knowledge does not appear to influence CNS symptoms, which are probably driven by ambient solvent concentrations that individual behavioural measures cannot effectively manage. Therefore, knowledge acts as a supplementary, rather than a substitute, safeguard where engineering controls are lacking. Interventions should include education and enforceable regulations to empower workers and ensure the use of engineering controls, especially in spray booths.

Keywords: occupational health; organic solvents; spray painters; knowledge-attitude-practice (KAP); South Africa; engineering controls

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1. Introduction

Occupational exposure to organic solvents is a significant global public health issue [1], especially in small-scale industries within low- and middle-income countries (LMICs) [2]. Additionally, about a million people die each year due to contact with hazardous substances globally [3]. Automobile spray painting is a common source of such exposure, involving solvents like toluene, xylene, and acetone [4], which are associated with both immediate

and long-term effects on the respiratory, integumentary, and central nervous systems (CNS) [5,6].

The South African automotive sector is a crucial part of the economy, contributing 6.9% to GDP [7], as evidenced by the 13.3 million vehicles on the road [8,9]. Furthermore, the automotive repair sector provides vital services and livelihoods, particularly in urban areas such as Johannesburg [10]. The automotive repair sector is valued at over R3.3 billion ($175.6 million). The sector further contributes to employment, with more than 115,000 workers employed in it. The City of Johannesburg's municipal by-laws, along with the national Occupational Health and Safety Act (No. 85 of 1993), establish specific regulations for automobile spray-painting activities, including the requirement for approved spray booths. However, enforcing these regulations in small-scale, often informal workshops is notoriously challenging in South Africa and worldwide [11,12]. This creates a paradox where comprehensive legislation exists on paper yet, in reality, there remains a high exposure risk, exposing a predominantly migrant and vulnerable workforce to danger.

Meanwhile, the hierarchy of controls emphasises elimination, substitution, and engineering measures (such as spray booths with local exhaust ventilation) over dependence on personal protective equipment (PPE) and administrative strategies [13]. Nonetheless, in informal or small-scale workshops typical of cities like Johannesburg, financial and regulatory constraints often make these advanced controls impractical, shifting the burden of risk management onto workers [14,15]. In addition, extensive research on exposure to organic solvents has predominantly focused on large-scale industrial settings, leaving little to no information on the impact of small-scale vehicle spray-painting enterprises [16].

In this context, understanding the role of workers' knowledge, attitudes, and practices (KAP) becomes essential. The KAP model suggests that knowledge influences risk perceptions and fosters positive attitudes, which, in turn, encourage the adoption of specific protective practices, such as the correct use of PPE, ultimately reducing exposure to hazards and improving health outcomes [17]. Although studies have documented generally poor safety practices among spray painters in LMICs [17–19], few have quantitatively examined how specific KAP dimensions relate to distinct health symptom profiles, while accounting for important workplace and demographic factors. Furthermore, there is a lack of such research in the South African context, where a large informal automotive repair sector exists alongside comprehensive, yet often unenforced, occupational health legislation [12].

This study, therefore, aimed to: (1) describe the workplace factors and compliance with safety regulations in automobile spray-painting workshops in Johannesburg; and (2) assess the relationship between workers' KAP scores and the prevalence of self-reported health symptoms (ocular, dermatological, respiratory, and CNS). We hypothesised that higher KAP scores would be associated with a lower prevalence of self-reported symptoms, even in the context of suboptimal engineering controls.

2. Materials and Methods

2.1. Study Design and Setting

A descriptive, cross-sectional study was conducted between July and August 2025 in Region F of the Johannesburg Metropolitan Municipality, South Africa. This design was selected to provide a quantitative "snapshot" of the prevailing workplace conditions, KAP levels, and health symptom prevalence at a single point in time. The municipality covers an area of 1645 km^2 and has an estimated population of 4.4 million [20]. Region F is one of seven regions within the Johannesburg municipality and was selected because it had a high concentration of vehicle spray-painting workshops; as a result, the study could access a large number of vehicle spray-paintings. The map of the study area is displayed in Figure 1.

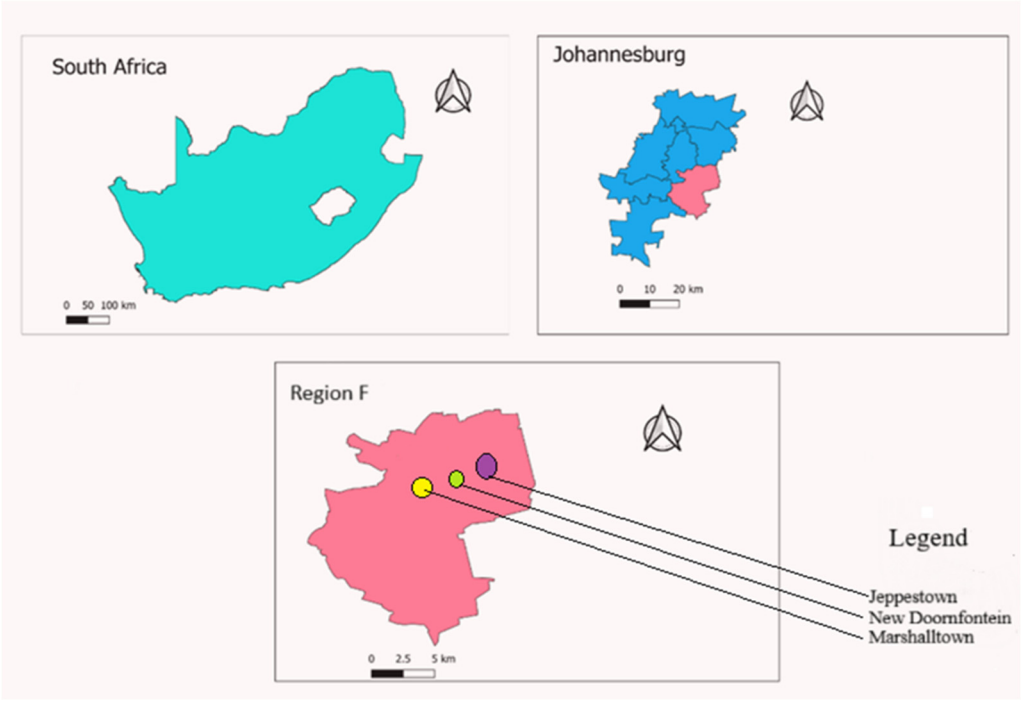


Figure 1. Study area Region F.

The latest available data from the City of Johannesburg Environmental Health directorate, Region F, indicate 97 vehicle spray-painting workshops, representing 35% of all workshops in the municipality [21]. Furthermore, an estimated 4 people are employed in each workshop. Therefore, using 97 workshops with 4 people employed, an estimated population of 388 is obtained for Region F. Therefore, a sample size of 193 was calculated using Epi Info™ v7.2.6.0 at a 95% confidence level, expected frequency at 50%, margin of error 5%, cluster sampling set at 1, and a total of 193 sampling population was reached [22]. A purposive sampling technique was employed, whereby researchers systematically visited all accessible workshops from the official City of Johannesburg registry within Region F. This non-probability method was chosen for its practical feasibility in a geographically dispersed, informal sector, as it allowed direct engagement with owners and maximised recruitment within the study's timeframe. The researcher visited 71 workshops; 47 agreed to participate, and 24 declined, resulting in a workshop response rate of 66%. Of these, 152 vehicle spray painters completed the questionnaire, yielding an individual response rate of 79%. The primary reason for nonparticipation was that owners were unavailable; therefore, workers were uncomfortable proceeding without their employers' approval. Although a lack of participation may be attributed to fear of inspection or regulatory concerns, particularly among non-compliant workshops, the results may underestimate the true prevalence of symptoms and the extent of the absence of safety controls in the region. Inclusion criteria: (1) age 18 years and above, (2) both females and males were considered, (3) permanently employed in vehicle spray painting within Region F, and (4) provided written informed consent. Those excluded were (1) learners, (2) apprentices, (3) casual and part-time workers, and (4) individuals who did not perform spray painting. The questionnaire was administered in English; given the high proportion of non-South Africans (76%) and the linguistic diversity of South Africa, translation to other languages was not required, as all participants understood English. Any discrepancies in wording were clarified during the pilot study, which included 15 participants who were subsequently excluded from the main study.

Ethical approval was granted by the University of Johannesburg Faculty of Health Sciences Research Ethics Committee, with ethics clearance number REC-3522-2025. Gatekeeper permission was obtained from the City of Johannesburg. Written informed consent was secured from all participants prior to the interview. Anonymity and confidentiality were preserved by using coded questionnaires.

2.2. Data Collection

Two instruments were used:

- Observational Checklist: A walk-through survey evaluated workshop compliance with the City of Johannesburg Public Health Bylaws and the Occupational Health and Safety Act (No. 85 of 1993). It recorded the presence of a spray booth, type of ventilation, hygiene facilities, and availability of PPE.
- Structured Questionnaire: Administered face-to-face, it covered:
    - Section A: Socio-demographics (age, gender, education, work experience, smoking).
    - Section B–D: KAP constructs. Knowledge (10 items) and Attitude (7 items) used a 5-point Likert scale from (Strongly Disagree = 1, Disagree = 2, Neutral = 3, Agree = 4, Strongly Agree = 5). Practice (4 items) assessed frequency of safety behaviours (Never = 1, Rarely = 2, Sometimes = 3, Often = 4, Always = 5). Additional questions detailed the types and frequency of specific PPE use.
    - Section E: Self-reported health symptoms experienced in the past 12 months, covering eye (e.g., reduced vision, itching), dermatological (rash, itching), respiratory (cough, wheeze), and CNS (headache, dizziness) domains.

The questionnaire was piloted among 15 participants and refined. The health symptom questions were adapted from the Medical Research Council respiratory symptoms questionnaire, which has been used in other similar studies [23–25].

2.3. Data Management and Statistical Analysis

Data were analysed using Epi Info™ (version 7.2.6.0) and MS Excel (version 2024). Descriptive statistics summarised demographics, workplace factors, and KAP scores. Composite scores were calculated for Knowledge (range 10–50), Attitude (range 7–35), and Practice (range 4–20). Composite scores for each KAP domain were derived by averaging the individual item scores. Knowledge included 10 items scored on a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree), with higher scores indicating greater agreement with accurate safety knowledge. Attitude consisted of 7 items on the same 5-point Likert scale, with higher scores denoting more positive safety-oriented beliefs. Practice involved 4 items measured on a 5-point frequency scale (1 = Never to 5 = Always), with higher scores reflecting more consistent safe work behaviours. Negatively worded statements across all domains were reverse-coded before analysis to maintain consistent directionality. The mean scores for each domain retained the original 1–5 scale and were analysed as continuous variables in all regression models.

To evaluate the relationship between KAP and health symptoms, four separate multivariable logistic regression models were created. The dependent variable in each model was the presence or absence of symptoms within a specific domain (eye, dermatological, respiratory, CNS). The independent variables included the continuous Knowledge, Attitude, and Practice scores. All models were adjusted for the a priori confounders of age, smoking status, working hours per day, and years of work experience. Results are presented as Adjusted Odds Ratios (AOR) with 95% Confidence Intervals (CI).

While the initial sample size calculation required 193 participants, the final sample size obtained was 152. To ensure the stability of the multivariable logistic regression models,

we evaluated the Events Per Variable (EPV) ratio. For the ocular and CNS models, the EPV exceeded 8.0, providing relatively stable estimates. However, in the respiratory and dermatological models, the lower frequency of reported symptoms resulted in an EPV of approximately 5.3–5.7. Consequently, these specific models were interpreted with caution due to potential overfitting and reduced precision. Multicollinearity among predictors was assessed using Variance Inflation Factors (VIFs), with all values remaining below 2.5, indicating no significant redundancy among variables such as age and work experience.

In addition, model robustness was affirmed by the Hosmer–Lemeshow goodness-of-fit test. All four multivariable models demonstrated an adequate fit to the data, with p-values ranging from 0.248 to 0.801, well above the 0.05 threshold. Additionally, multicollinearity was assessed using Tolerance and Variance Inflation Factor (VIF) metrics. No significant collinearity was found, as all VIF values remained below the conservative threshold of 2.5 (ranging from 1.0171 to 1.993), and all tolerance values remained above 0.4, indicating that overlapping variables such as age and experience did not bias the estimates.

3. Results

3.1. Demographic and Occupational Characteristics

Table 1 displays descriptive socio-demographic characteristics of the participants. The participants were mostly male (96%), with a mean age mainly in the 35–44-year range (44%). In terms of ethnicity, 96% of participants were Black, while White and Indian participants accounted for the remaining 4%. Most had significant experience, with 48% working for 11–20 years. A majority (76%) were non-South African nationals. Most (61%) worked 8 h shifts, but 34% worked longer than 8 h. Only 15% were active smokers. Importantly, 92% had not received any health and safety training in the past 12 months.

Table 1. Descriptive statistics of the sociodemographic characteristics of the participants.

Characteristics	Category	N (%)
Gender	Male	146 (96%)
	Female	6 (4%)
Age group	18 to 24 years	5 (3%)
	25 to 34 years	23 (15%)
	35 to 44 years	67 (44%)
	45 to 54 years	51 (34%)
	55 and over	6 (4%)
Nationality	South African	37 (24%)
	Non-South African	115 (76%)
Level of education	Never attended	4 (3%)
	Attended Primary education (did not complete)	4 (3%)
	Completed Primary education	8 (5%)
	Attended Secondary (did not complete)	37 (24%)
	Completed Secondary education	80 (53%)
	Has a post-school qualification	19 (12%)
Working hours	Less than 8 h	7 (5%)
	8 h	93 (61%)
	More than 8 h	52 (34%)
Number of years working	Less than one year	5 (3.28%)
	1 to 5 years	21 (13.81%)
	6 to 10 years	33 (21.71%)
	11 to 15 years	38 (25%)
	16 to 20 years	36 (23.68%)
	20 years or more	19 (12.5%)

3.2. Workplace Factors and Compliance

The observational data revealed significant gaps in primary safety controls, indicating widespread non-compliance with occupational health and safety regulations. The most critical deficiency was in engineering controls: only 17% of workshops had a functional spray booth with an extractor fan, whereas 64% of workshops lacked any spray booth, whether metal, plastic, or cardboard. Therefore spray painting was conducted indoors in the open air. Ventilation was primarily reliant on natural means alone (79%). Administrative controls were similarly lacking: 83% of workshops had no on-site health and safety policy, only 17% had a valid City of Johannesburg public health permit, and just 19% were situated in the correct industrial zone as required by municipal town planning schemes. Regarding personal protective equipment (PPE), usage was inconsistent. As shown in Figure 2, while high compliance was reported for overalls and safety shoes (83% always wearing them), compliance with respiratory and eye protection was suboptimal. Although 49% of workers used N95 masks, only 25% used respirators with filters, and just 41% reported consistent mask use. The use of safety goggles was also limited, with only 33% always wearing them.

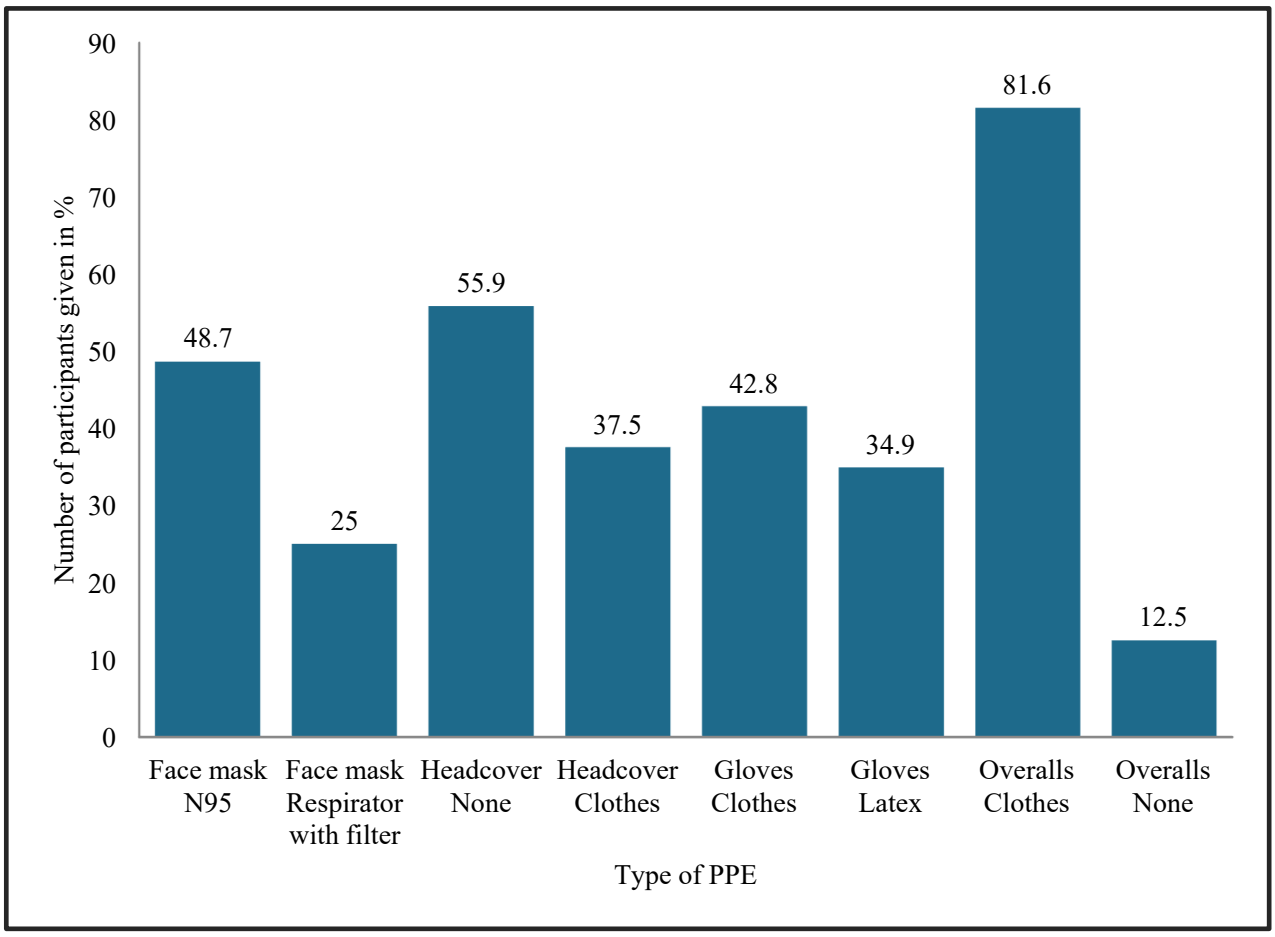


Figure 2. Common PPE utilised in the vehicle spray-painting workshop.

3.3. Knowledge, Attitude, Practice Scores

Participants demonstrated high awareness, with a mean Knowledge score of 45.29 (SD = 6.025) out of 50. Attitude was moderately positive (mean = 21.95, SD = 6.349 out of 35). However, self-reported Practice scores were low (mean = 9.01, SD = 5.275 out of 20), indicating poor adherence to safety protocols, such as reading chemical labels and post-shift showering. Table 2 illustrates the summarised KAP Score. Meanwhile, Tables 3–5 outline

the questions under the knowledge, attitude, and practice construct and the participants' responses to each question.

Table 2. Summary of the composite scores from respondents for knowledge, attitude and practice constructs.

Scale	Possible Range	Mean (±SD)	Actual Range
Knowledge Score	10–50	45.29 (±6.025)	22–50 = 28
Attitude Score	7–35	21.95 (±6.349)	7–35 = 28
Practice Score	4–20	9.01 (±5.275)	4–20 = 16

Table 3. Lists all the questions and the percentage responses under the knowledge construct.

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Total
K1. Do you think working in spray painting can be dangerous to your health and safety?	Count	2	7	1	40	102	152
	Row N %	1.3%	4.6%	0.7%	26.3%	67.1%	100.0%
K2. Do you think sanding, priming, and polishing can expose you to hazardous chemicals?	Count	3	6	8	44	91	152
	Row N %	2.0%	3.9%	5.3%	28.9%	59.9%	100.0%
K3. Are you aware that exposure to organic solvents may cause eye problems (reduced vision, excessive tear production, eye pain, red eye and eye irritation	Count	4	6	3	53	86	152
	Row N %	2.6%	3.9%	2.0%	34.9%	56.6%	100.0%
K4. Are you aware that exposure to organic solvents may cause respiratory problems? coughing, chest pain and chest wheezing	Count	2	9	9	47	85	152
	Row N %	1.3%	5.9%	5.9%	30.9%	55.9%	100.0%
K5. Are you aware that some exposure to organic solvents may cause asthma?	Count	3	3	4	42	100	152
	Row N %	2.0%	2.0%	2.6%	27.6%	65.8%	100.0%
K6. Are you aware that exposure to organic solvents may cause skin rash and itching?	Count	2	7	8	41	94	152
	Row N %	1.3%	4.6%	5.3%	27.0%	61.8%	100.0%
K7. Are you aware that exposure to organic may cause headaches/drowsiness/confusion?	Count	5	19	15	22	91	152
	Row N %	3.3%	12.5%	9.9%	14.5%	59.9%	100.0%
K8. Do you think it is necessary to wear personal protective equipment (PPE) when working with spray painting?	Count	0	0	2	22	128	152
	Row N %	0.0%	0.0%	1.3%	14.5%	84.2%	100.0%
K9. Do you think the use of a spray booth will help reduce exposure to organic solvents	Count	0	0	1	15	136	152
	Row N %	0.0%	0.0%	0.7%	9.9%	89.5%	100.0%
K10. Do you think it's necessary to regularly wash hands, shower and change clothes before leaving work	Count	0	3	4	16	129	152
	Row N %	0.0%	2.0%	2.6%	10.5%	84.9%	100.0%

Table 4. List questions in the attitude construct and the percentage of respondents in each category.

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Total
A1. There is little I can do to avoid exposure to solvents in my line of work.	Count	85	37	6	17	7	152
	Row N %	55.9%	24.3%	3.9%	11.2%	4.6%	100.0%
A2. It is primarily the employer's responsibility to ensure a safe working environment.	Count	46	21	21	37	27	152
	Row N %	30.3%	13.8%	13.8%	24.3%	17.8%	100.0%
A3. Wearing personal protective equipment (PPE) is effective in preventing health problems from solvents	Count	4	9	7	88	44	152
	Row N %	2.6%	5.9%	4.6%	57.9%	28.9%	100.0%
A4. Painters who don't use solvents safely are likely to develop health problems.	Count	11	31	55	33	22	152
	Row N %	7.2%	20.4%	36.2%	21.7%	14.5%	100.0%
A5. I feel confident in my ability to handle solvents safely.	Count	11	31	55	32	23	152
	Row N %	7.2%	20.4%	36.2%	21.1%	15.1%	100.0%
A6. Proper ventilation in the workshop is essential for my health	Count	8	22	37	61	24	152
	Row N %	5.3%	14.5%	24.3%	40.1%	15.8%	100.0%
A7. I believe my health is at risk because of my work with solvents	Count	9	26	33	61	23	152
	Row N %	5.9%	17.1%	21.7%	40.1%	15.1%	100.0%

Table 5. All the questions and the percentage response under the practice construct.

		Never	Rarely	Sometimes	Often	Always	Total
P23. Do you follow health and safety protocols?	Count	88	26	8	12	18	152
	Row N %	57.9%	17.1%	5.3%	7.9%	11.8%	100.0%
P24. Do you frequently wash your hands at work?	Count	50	11	18	38	35	152
	Row N %	32.9%	7.2%	11.8%	25.0%	23.0%	100.0%
P25. Do you take showers/baths at the end of the shift?	Count	84	17	14	15	22	152
	Row N %	55.3%	11.2%	9.2%	9.9%	14.5%	100.0%
P26. Do you read instructions on the labels of chemicals?	Count	94	26	9	3	20	152
	Row N %	61.8%	17.1%	5.9%	2.0%	13.2%	100.0%

3.4. Prevalence of Self-Reported Health Symptoms

Based on a cohort of 152 participants, the analysis of self-reported symptoms revealed distinct patterns across physiological systems. Ocular manifestations were the most prominent, with red eye being the single most common symptom, affecting 42.1% of participants. Neurological symptoms were also frequent, with 37.5% of the cohort reporting recurrent headaches. In contrast, a significant majority of participants reported no symptoms in the dermatological (73.7%), respiratory (75.7%), and ocular (39.5%) categories. Respiratory complaints were particularly rare, with the most common issues being recurrent cough and chest pain, each present in only 8.6% of participants. Dermatological concerns were similarly uncommon, with skin rash and itching each reported by 13.2% of the sample. Table 6 outlines the prevalent symptoms reported.

Table 6. Summary of the prevalent symptoms reported.

Symptoms Category	Most Prevalent Symptoms	N (%)
Central nervous system	Recurrent headache	57 (37.5%)
	Dizziness	35 (23%)
	Anxiety	1 (0.65%)
	No symptoms	59 (38.8%)
Ocular Eye	Reduced vision	1 (0.65%)
	Excessive tear production	1 (0.65%)
	Eye itching	15 (9.86%)
	Red eye	64 (42%)
	Eye paint	11 (7.23%)
	No symptoms	60 (39.47%)
Dermatological/skin	Skin rash	20 (13%)
	Skin itching	20 (13%)
	No symptoms	112 (74%)
Respiratory	Recurrent cough	13 (8.5%)
	Chest wheeze	10 (6.57%)
	Wheezing with breathlessness	1 (0.65%)
	Chest pains	13 (8.5%)
	No symptoms	115 (75.65%)

3.5. Association Between KAP and Health Symptoms

The adjusted logistic regression models revealed clear patterns in the relationship between KAP constructs and health outcomes (Table 7). Key findings showed that knowledge was a significant, independent protective factor against eye, dermatological, and respiratory symptoms, with each one-point increase in knowledge score linked to a 15.4%, 8.5%, and 11.0% reduction in the odds of reporting these symptoms, respectively. Self-reported practice was protective only against dermatological symptoms, with a one-point increase associated with a 10.9% decrease in odds. In contrast, attitude was not significantly associated with any of the measured health outcomes. Additionally, none of the KAP constructs were found to be related to the reporting of central nervous system (CNS) symptoms, such as headaches and dizziness.

Table 7. Adjusted Odds Ratios from Logistic Regression Models Predicting Health Symptoms among Spray Painters (n = 152).

Health Outcome	Predictor	Adjusted Odds Ratio (AOR)	95% Confidence Interval	*p*-Value
Eye Symptoms	Knowledge Score	**0.846**	0.760–0.942	**0.002**
	Attitude Score	0.929	0.855–1.009	0.080
	Practice Score	0.966	0.879–1.062	0.476
Dermatological Symptoms	Knowledge Score	**0.915**	0.850–0.984	**0.017**
	Attitude Score	1.034	0.948–1.128	0.456
	Practice Score	**0.891**	0.794–1.000	**0.050**
Respiratory Symptoms	Knowledge Score	**0.890**	0.815–0.971	**0.009**
	Attitude Score	0.995	0.899–1.101	0.919
	Practice Score	0.966	0.848–1.101	0.607

Table 7. *Cont.*

Health Outcome	Predictor	Adjusted Odds Ratio (AOR)	95% Confidence Interval	*p*-Value
CNS Symptoms	Knowledge Score	0.957	0.891–1.029	0.234
	Attitude Score	0.999	0.932–1.072	0.986
	Practice Score	0.998	0.918–1.085	0.962

Note: All models adjusted for age, smoking, working hours and years of experience. AOR = Adjusted Odds Ratio.

4. Discussion

This study presents two key, interconnected insights into occupational health among automobile spray painters in an urban South African context. Firstly, it underscores a notable lack of basic engineering and administrative controls, creating a high-risk exposure environment. Secondly, despite this insufficient setting, it recognises workers' knowledge as a statistically significant factor that affects certain preventable health outcomes.

The limited use of spray booths (17%) and reliance on open-air spraying (64%) are concerning and reveal a systemic failure to implement the hierarchy of controls. This aligns with research from other LMICs indicating cost as a major barrier [15].

In addition, installing a compliant spray booth with LEV requires a capital expenditure based on the authors' field observations and informal consultations with local suppliers of approximately ZAR 80,000–150,000 (USD 4500–8500), which is too high for many informal micro-enterprises with narrow profit margins and limited access to credit. In these cases, 'non-compliance' signifies economic exclusion rather than deliberate disregard. This could also explain the low number of workshops with a public health permit (17%) from the municipality. However, documents such as health and safety policies require no major capital expenditure and therefore represent straightforward non-compliance, which represent 83% of the workshops; therefore, enforcement should be immediate. In this context, workers are forced to rely on personal protective equipment (PPE), yet our data show inconsistent use of appropriate PPE, particularly respirators and eye protection. Other scholars have noted that incorrect PPE use places workers at risk of exposure to various hazardous substances [26]. Although some employees reported using respirators, Manganyi et al. [27] argue that their use does not necessarily ensure protection against potential exposure; respirators must be correctly designed to fit each employee's facial features to guarantee maximum protection, and further training should be provided on how to wear them correctly. The gap between high knowledge and poor practice, notably in reading labels and maintaining hygiene, may suggest a disconnect between awareness and practical behaviour, influenced by factors such as resource limitations, perceived self-efficacy, or habituation from extensive work experience [28,29].

The primary analytical finding is that knowledge consistently predicts lower odds of symptoms affecting organs with direct, perceptible exposure routes: the eyes (through irritation), the skin (through contact), and the respiratory tract (through inhalation). This suggests that informed workers are more likely to adopt specific, targeted protective behaviours such as occasionally using goggles, washing affected skin, or wearing a mask, even if their overall practice score remains low. The relationship between improved practice and fewer dermatological symptoms supports this, underscoring the importance of concrete actions such as glove use and hygiene.

Although knowledge was consistently associated with lower odds of eye, dermatological, and respiratory symptoms, self-reported practice showed a significant protective effect only for dermatological outcomes (AOR = 0.891, $p = 0.050$). For eye, respiratory, and CNS symptoms, practice scores were not significantly related to symptom reporting. This pattern raises an important question: why does practice not appear protective, and

what accounts for the disconnect between knowledge and practice? We propose several non-mutually exclusive explanations:

The null association between practice symptoms and practice probably reflects a combination of reverse causality, measurement limitations, ineffective practice, and genuine ineffectiveness for certain exposure pathways. Besides the possibility of behavioural ineffectiveness or measurement limitations, it is important to consider the role of statistical power. Due to a reduction in the planned sample size from 193 to 152 and the low prevalence of certain outcomes, such as respiratory distress (24.35% reporting symptoms), the study may have been underpowered to detect small but meaningful associations. This increases the risk of a Type II error, in which a true protective effect of safety practices might not reach statistical significance. Therefore, the null results in these categories should be seen as 'absence of evidence' rather than 'evidence of absence' of a behavioural effect.

These explanations together suggest that improving worker practice is insufficient without concurrent structural interventions to ensure that practice is correct, effective, and supported by appropriate engineering controls. Future research should employ longitudinal designs with objective observational measures of practice quality (e.g., fit testing, direct observation of PPE use) to disentangle these mechanisms

The lack of association between any KAP construct and CNS symptoms is instructive. CNS effects such as headaches and dizziness are often linked to ambient air concentrations of volatile solvents, an exposure pathway that is less amenable to individual behavioural control without effective ventilation [30]. This result underscores the limits of behavioural interventions alone. Where exposure is pervasive and systemic (as indicated by the lack of booths), individual knowledge cannot overcome the lack of engineering controls. This bifurcation of results underscores the need for a dual approach: worker education can mitigate some direct-contact and inhalation risks, but preventing systemic exposure requires enforceable mandates for engineering controls.

The study did not collect data on non-occupational environmental exposures that might confound the link between spray-painting work and reported symptoms. This is especially relevant for (1) ambient air pollution, (2) residential conditions, and (3) household occupational co-exposures; some participants may engage in additional informal work. Failing to consider these factors likely results in residual confounding and an overestimation of the proportion of symptom burden due to occupational solvent exposure. The extent of this bias remains unclear. However, our main focus, KAP scores, is unlikely to be closely linked with residential environmental quality, thus reducing confounding of the KAP–symptom relationship. A confounder would need to be associated with both KAP and symptom status; there is no reason to believe that workers with higher knowledge are more likely to live in less polluted areas. Nonetheless, this remains an untested assumption.

Our findings support and expand the Health Belief Model. High perceived knowledge (perceived susceptibility and severity) seems to motivate some beneficial action cues (protective behaviours), thereby reducing specific threats. However, for threats influenced by environmental factors (e.g., CNS effects), perceived barriers (e.g., lack of spray booths) may be so high that they can negate the model's predictive ability.

Furthermore, these findings have immediate and significant implications for local enforcement policies. Environmental Health Practitioners (EHPs), as the primary inspectors for public health regulations, need to move beyond occasional permit checks and adopt proactive, evidence-based enforcement strategies. Inspection procedures should be explicitly revised to emphasise verifying functional engineering controls, specifically, the presence and operational status of spray booths with local exhaust ventilation, as a mandatory compliance measure. Additionally, the role of EHPs should be expanded to include targeted educational outreach during inspections, providing guidance on proper PPE use

and hygiene practices. This approach helps bridge the critical gap between regulation and practical application at the workshop level.

Furthermore, the study's findings can be applied to other Southern African Development Community (SADC) member states, due to shared patterns of labour migration across the region, as evidenced by 76% of the study population reporting that they are non-South African. Additionally, these countries share a regulatory legacy of occupational law with South Africa and face comparable resource constraints. Conversely, generalisability is limited to (a) formal sector workshops with operational spray booths and LEV; (b) high-income country contexts with strict enforcement and accessible PPE supply chains; (c) workers with formal occupational health and safety training; (d) non-urban or rural settings where workshop density and ambient pollution profiles vary.

Strengths and Limitations of the Study

Strengths include the mixed-methods approach (observation and survey), a high response rate, the use of validated symptom questions, and the control of key confounders in the analysis. Limitations include the cross-sectional design, which prevents causal inference; reliance on self-reported symptoms without clinical verification and practices, which are susceptible to recall and social desirability bias; and the focus on a single metropolitan region, which may limit generalisability. The absence of environmental monitoring data on solvent concentrations restricts a full explanation of the CNS symptom findings. Moreover, the absence of an unexposed group limits conclusions about absolute occupational risk and makes it difficult to establish causality. Additionally, 24 workshops did not participate, which may have introduced selection bias. This bias likely inflates estimates of compliance and underestimates symptom prevalence, as workshops with poorer safety records may have been more inclined to decline participation. If so, our estimates of inadequate controls are conservative, and the actual gap between knowledge and practice may be larger than we observe.

5. Conclusions

This study concludes that, in the high-risk context of informal spray-painting workshops in Johannesburg, a setting characterised by a critical lack of engineering controls such as spray booths, workers' knowledge acts as a significant and independent protective factor. It effectively reduces the likelihood of reporting solvent-related symptoms in organs with direct exposure routes, namely the eyes, skin, and respiratory tract. However, the analysis clearly defines the limits of this protective effect: knowledge shows no association with symptoms related to the central nervous system, such as headaches and dizziness, which are linked to widespread ambient solvent concentrations. This distinction emphasises that while knowledge can empower individuals to mitigate certain direct-contact risks through behavioural changes, it cannot replace the need for systemic engineering controls that regulate overall airborne exposure.

Therefore, effective public health intervention requires a comprehensive, two-pronged approach that addresses both structural deficiencies and individual responsibility. Enforcement by authorities such as the Department of Employment and Labour and Municipal Environmental Health must be revitalised to ensure the installation and operation of spray booths with local exhaust ventilation, and to consider supportive measures such as phased compliance or subsidies for small enterprises. At the same time, this structural directive needs to be paired with targeted, practical behavioural strategies. Training programmes should go beyond basic awareness campaigns to emphasise skills-based education in the proper selection, use, and maintenance of personal protective equipment, especially respirators and safety goggles, along with safe chemical handling, hygiene measures, and early

symptom detection. Only by adopting this combined method can the occupational risk profile be comprehensively addressed.

Future research should expand on these findings by using longitudinal study designs combined with objective environmental monitoring, such as personal air sampling and residential exposure for assessment of solvent levels. This approach would enable a clearer understanding of causal relationships and address the confounding that may result from the environment other than the workplace and offer a more detailed insight into how measurable exposure levels, knowledge, specific protective practices, and health outcomes over time are connected.

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