AWARENESS AND RESPIRATORY RISK ASSESSMENT OF CAR PAINT DUST EXPOSED WORKERS IN ISLAMABAD AND RAWALPINDI, PAKISTAN

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A thesis submitted to Bahria University, Islamabad in partial fulfillment of the requirement for the degree of B.S in Environmental Sciences

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We dedicate this thesis to our adored parents, who always stood by our side and gave us their unwavering support.

ABSTRACT

Environmental heavy metal contamination is a global occurrence, many governments still do not prioritize the accompanying environmental and public health consequences. Activities related to car repairing, polishing, painting, etc., have emerged in many developing countries like Pakistan as a consequence of low-level, unspecialized industrial and manufacturing concerns. Workers in irregular small industrial units (SIUs) who work with metal, wood, and spray paints are exposed to a variety of health risks. Numerous workers in Pakistan regularly come into contact with these chemicals, but due to improper reporting, no such data is accessible. The most crucial steps in identifying and preventing a variety of dangers that vary with different occupational categories and job duties are exposure assessments. This study centers on assessing the level of workers' awareness to the use of PPEs, the carcinogenic and non-carcinogenic health risks assessment of metal exposures from scrap paint dust. Samples of scrap car paint dust from Khadda Market, Islamabad and Rawalpindi were collected from 8 different workshops (A–H). They were sieved, filtered, and digested by standard method. The scrap paint dust samples were analyzed for heavy metals by using Flame Atomic Absorption Spectroscopy (AAS). Heavy metals cancerous and non-cancerous risk was determined by calculating the exposure concentration (EC), ($\mu g/m^3$), the estimated daily intake (EDI), (mg/kg/day) of metals, the hazard quotient (HQ) and lifetime cancer risk (LTCR). The results showed a general trend of concentration of metals in scrap paint dust, Cu, >Ni, > Pb, > Cr, >Cd. The concentration of copper was high in all samples of scraped paint collected from workshops in Islamabad and Rawalpindi however the concentrations of nickel, chromium, and lead were increasingly high. Cadmium had the lowest concentrations in all collected samples. The majority of workers do not have formal training in painting or denting; they typically learn about hazards, risks of exposure, and PPE use while performing their duties in the workplace. The use of personal protective equipment was poor, with only 10% workers having access to PPEs, the remaining 90% had no PPEs to wear. Lack of protective equipment was singled out in the targeted workshops to be the main perceived reason for work related exposures among the workers. The results of hazard quotient had shown the descending order of Cr > Cu > Ni > Pb > Cd, the values for Chromium (Cr) were highest among all, with cadmium (Cd) having the lowest values. The results of LTCR had shown the descending order of Cr > Ni > Pb > Cd, the values for Chromium (Cr) were highest among all, with cadmium (Cd) having the lowest values. To raise worker knowledge and awareness of occupational hazards and reduce take-home exposure pathways for both workers and their families, proper trainings should be given.

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LIST OF ABBREVIATIONS

ARSs Auto Repair Shops

ATS American Thoracic Society

AAS Atomic Absorption Spectroscopy

BMI Body Mass Index

DFI Development Finance Institutions

EPA Environmental Protection Agency

EC Exposure Concentration

EDI Estimated Daily Intake

HQ Hazard Quotient

IUR Inhalation Unit Risk

PPE Personal Protective Equipment

ILO International Labor Organization

NCDs Non-Communicable Diseases

NMQE Neuro Musculoskeletal Questionnaire Extended

MCs Automobile Mechanics

LTCR Lifetime Cancer Risk

PNs Spray Painters

RfD Reference Dose

SIUs Small Industrialized Units

UV Ultraviolet

WHO World Health Organization

CHAPTER 1

INTRODUCTION

1.1 Background

One of the most harmful environmental pollutants is heavy metals. They are classified as having an atomic number greater than 20 and possessing metallic characteristics (Tangahu, et al., 2011). It is acknowledged that chemicals are beneficial and useful in a variety of urban and rural activities. Almost 350 chemical compounds have been identified as occupational carcinogens. Many toxic chemicals present major health risks that may result in cancer, respiratory, skin, and reproductive system diseases (WHO/OMS, 2000). According to the ILO, every year there are many incidents involving chemical application in the workplace that results in injuries and fatalities (Report, 1994). Often, heavy metals do not degrade through biodegradation but rather accumulate in living organisms, creating bioaccumulation and subsequent health problems (Pehlivan, et al., 2009).

Automobiles are a necessary component of modern life. The requirement for vehicle service and repair has given rise to an incredibly significant industry called workshop for maintenance and repair (Caldwell, et al., 2000). A substantial portion of the workforce at auto repair shops is made up of men. They complete duties like spray painting, repairs, upkeeping, welding, maintenance, general labor (such as washing, test driving), etc. This informal industry is sometimes referred to as a small and medium-sized business. It is a labor-intensive industry, and there is a wide range in the size of the business, the number of employees, and the nature of the jobs (Sehgal, et al., 2011). Many incidents occur at the small level industries where there were no tools available to determine the severity of the issue. There is good reason to suspect that the effects of hazardous compounds on human health and the environment are far more severe than is currently thought, given that many personnel in the small business industries are underprivileged, unprepared, and usually unaware of the dangers (Matchaba-Hove, 1996).

At these workshops, one can frequently see workers of different ages. This industry is the most difficult to manage and oversee from a health and safety perspective. Many dangers and risks go undiscovered. Heavy equipment, petroleum fuels/oils, extensive use of chemicals, smoke, particulates, and several other pollutants contribute to common work - related hazards such as physical, ergonomic, biological, and chemical dangers in ARS operations. When there is a lack of knowledge about control measures, and application of health and safety regulations and standards, these hazards become more serious (Salvi, et al., 1999). In comparison with employees in other occupations, mechanics experience greater rates of health risks at work. There are many stressors present in this work such as exposure of workers to UV and thermal radiations, working in dusty and noisy environments, work with oil and grease, and other chemicals, fumes, irregular timings and poor body postures, improper tools and machinery and adverse psychological impacts (Hunt, et al., 2000).

In certain areas, the majority of spray painters employed by small industrial sector can be found not just in auto body shops but also in factories that work on spare parts and do woodwork. (Jayjock & Levin, 1984). It is commonly known that the grinding, cutting, welding, prepping cars, and spray-painting procedures used in auto body shops expose the personnel there to harmful contaminants or fumes (Rongo, et al., 2004). Spraying cars and fine woodworking have both been regarded as jobs with substantial exposure to organic solvents (Hooiveld, et al., 2006). Up to 100 distinct chemical substances were recently discovered in the indoor air at an auto painting plant, with acetone, xylene, toluene, methyl ethyl ketone, methyl isobutyl ketone, and hexane accounting for 90% of these. To lower the thickness of the material to a spray-able texture and compensate for climatic factors, a variety of compositions of these chemicals are combined with various additives, such as retarders, accelerators, and levelers (Daniell, et al., 1992).

Auto repair shops (ARSs) and service workshops assist in maintaining the automobiles on the roads. Aside from ARSs and servicing facilities, commercial and private customers also perform roadside auto maintenance and repairs. Slips, stumbles, and falls are significant causes of work-related accidents in ARSs, and the associated workplace accidents are frequently severe. (Ahmad, et al., 2016). Also, concerns of workplace illnesses and disorders are reported, such as the incapacitating dermatitis that ARS employees experience as a result of using paints that contain isocyanates. Previously, such paints were thought to be the primary contributor to respiratory disorders in Asia. White finger and bodily vibration are caused when workers employ power tools in ARS service sectors (HSE, 2009).

In a typical day, auto mechanics adopt various working postures, are exposed to unfavorable psychosocial settings, and do repeated tasks that could put them under stress and contribute to injury causation (Kant, et al., 1990). Health issues, musculoskeletal aches and pains, and workplace exposures have all been linked to increased injury risk in the workplace (Dembe, et al., 2005). Occupational injury incidence has been linked to workplace stresses like extended work hours, congested workstations, noisy environments, and inadequately constructed hand tools and machinery (Zwerling, et al., 1996). To comprehend the occurrence of occupational injury and pinpoint the risk factors among car mechanics, more investigation is required.

1.1.1 Heavy Metal Contamination in automotive paints

Although environmental heavy metal poisoning is a global occurrence, many governments still do not prioritize the accompanying environmental and public health consequences. Activities related to car repairing, polishing, painting etc., have emerged in many developing countries as a consequence of low level, unspecialized industrial and manufacturing concerns (Ohajinwa, et al., 2018). Employees in irregular small industrial units (SIUs) in developing countries who work with metal, wood, and spray paint are exposed to a variety of health risks. Large-scale importation of outdated vehicles, with a rising number, and their repair falling under locally sourced (illegal) pursuits (N. Mbawike, 2007).

Vehicle parts comprise mechanical parts, electronic and electrical parts, polymeric parts, and various parts that may comprise dangerous materials (S. Kalpakjian, 2006). These components are made of steel, chromium, nickel, titanium, and copper, whereas cadmium, chromium, and nickel are found in switches, batteries, headlight bulbs, break lights, data tape recorders, floppy disks, power supply boxes, car stereos, etc. When these cars deteriorate and age, they present a threat to both the environment and public health (J. Hirsch, 2004).

The workers at the workshops who tend to fix these vehicles are subjected to heavy metal contamination through scraped car paint dust in a variety of ways, which include encounter with workshop equipment, handshakes, body hugs, transferring car items, and inhalation of microscopic air suspensions. In Africa, these facilities are typically located beside bustling yet crowded roadways, mixed in with other commercial activity, making it easy for people to get into contact with toxic substances through paint dusts (Kyere, 2016).

Research suggests that cadmium, which is already found in developed countries and causes a broad spectrum of acute and chronic disorders, may have modest renal repercussions that induce a detectable increase in the expulsion of micro proteins in the urine at low ambient levels of exposure (A. Akesson, 2005). The majority of exposures come from practices including brazing, soldering, metalwork, scraping, plating, and spraying, and metallic processing, which are common in unregulated workplaces for vehicle repair and spray painting (Adei, et al., 2011).

Among the many heavy metals discovered in scraped car paints, cadmium is dangerous both by inhalation as well as ingestion, has an exceptionally long half-life, accumulates in the kidney, lungs, and liver, is highly toxic, and can potentially trigger biological system disruption even when present at extremely small concentrations than the majority of toxic metals (A. Bernard, 2008). Persistent exposure causes chronic bronchitis, impaired pulmonary function, pneumonia, and other respiratory consequences (Bradshaw, et al., 1998). It also causes nasal mucosa bleeding ulcers and incisions. It is well established that chromium (VI) causes cancer. The oxidation, hemolysis, and organ failure features of chromium (VI) are what cause its acute toxicity (A.D. Dayan, 2001).

Nickel can cause various pathological effects. However, its adverse health effects are dependent on the exposure route and classification. These include systemic, immunologic, reproductive, developmental, and carcinogenic effects (Das, et al., 2008). Although the kidney is the primary organ where nickel accumulates, other conditions such as bronchial inflammation, bronchial cell hyperplasia, and lumen congestion can also happen (Gupta, et al., 2006).

In the human body, heavy metals interfere with trace minerals, hinder and fight with proteins and enzymes for binding sites, and weaken the immune system (Nduka, et al., 2008). Non-communicable diseases (NCDs) like cardiovascular disease, diabetes, cancer, renal diseases, liver failure, and other conditions that may be related to exposure to heavy metals are now widely detected and reported and may be more prominent among automotive workers, according to a study by Unachukwu and colleagues (Orisakwe, et al., 2007).

Nitrogen dioxide is a gas that is released by vehicle repair workshop processes including welding, gas cutting, and petrol car exhausts. This gas can aggravate the lungs and lead to conditions like emphysema, pneumonia, respiratory failure, asthma, bronchitis, and lung problems. Sulfur dioxide is released during product combustion, which reduces atmospheric visibility, causes smog, air pollution, and disrupts the operation of the respiratory tract and airways (Balashanmugam, 2012).

1.2 Literature Review

Workplace stressors that affect mechanics' health and safety include hot, noisy settings, demanding postures, inadequately made tools and equipment, and unfavorable psycho-social conditions. Vyas, (2011), conducted a study from July 2010 to December 2010, Ahmedabad, a city in India's western province. The study's objectives were to look at occupational injury trends and pinpoint factors at work that can cause incidents among car mechanics. Male employees (N=153) were given a description ergonomic checklist as well as questionnaires on general health and psycho-social concerns. The job stressors connected to occupational injury were found using correlation statistics and relative risk variables. Workers reported injuries at a rate of 63%. The most commonly reported injuries were cuts. Injury occurrence among car mechanics was linked to a poor work environment, the characteristics of the tools and machines, poor health, and psycho-social stressors. (Vyas, 2011)

This study provides comprehensive information on work-related injuries suffered by auto mechanics. According to their results, mechanics had a high rate of occupational injuries, with the hand being the most frequently injured body part (Nduka, et al., 2019). The incidence rate of occupational injury was higher for mechanics who worked long hours, were young, had much less job experience, and had discomfort and other signs of illness. Bad workplace environment and psycho-social components of employment elevated the workers' danger of getting hurt. The study determined that the adoption of personal protective equipment along with efficient worker protection training would be a feasible and successful way of avoiding many of these injuries in this workplace where guards and personal protective equipment were not in use (Benavides, et al., 2000).

The solvent, lacquer, paint, and hardener systems utilized in the spray-painting operations are what cause the harmful particulates or vapors to be present in the small-scale informal car body and furniture manufacturing sectors. It is commonly known that exposure to this industry's personnel has negative health effects. Adei, et al., (2011), carried out a study between October 2005 and May 2006 involving 150 paint sprayers who were situated at 83 spraying workshops in 9 neighborhoods of Kumasi, Ghana, the goal of the study was to evaluate how the automotive, furniture, and coffin spray painting industries in Kumasi Metropolitan perceived workplace chemical risks, safety procedures, and their implementation. In the Kumasi Metropolitan Area, nine (9) suburbs, eighty-three (83) spraying workshops, and one hundred fifty (150) randomly sampled paint sprayers were chosen for the study. To gather information for analysis, a mix of surveys and purposeful interviews were used. Only 0.7% of respondents stated they always wore the proper Personal Protection Equipment (PPE) when spray painting, indicating a significant amount of self-reported exposure to spraying fumes (Daniell, et al., 1992). Almost all of the employees were conscious of the obvious health risks, such as coughing, throat discomfort, headaches, and breathing problems, but they were unaware of how seriously these risks could endanger their health. Respondents were asked to give law enforcement in regard to safety procedures, and a low rating was recorded; EPA and DFI officials explained this by saying that not enough staff and resources were available to complete the task successfully. Significant contributors to the occupational chemical hazard exposure in the paint spraying business include a lack of chemical education and the implementation of safety measures in the city. Thus, the study advised that the government need initial accreditation training to work and run a paint spraying workshop and training program every two years. (Adei E., 2011).

One of the toxic metals utilized in vehicle paints to enhance resistance to corrosion and reflective qualities is chromium (Cr). However, exposure to the hazardous form of chromium, hexavalent chromium Cr (VI), is linked to harmful health effects such lung cancer. Mwaia, and Faridah, (2023), conducted a study, to assess the concentration levels of Chromium in Kenyan Retail Shops' Automobile Paints. In order to determine the Cr levels in the automobile paints frequently used by spray painters in unofficial settings in Nairobi City, study was conducted (Were, et al., 2017). Three sets of samples of red, blue, and green automobile paint were examined for chromium content in triplicate. The same samples were also utilized to determine the lead concentration. Samples of vehicle paint were purchased from eight formal and unofficial retail locations. Atomic absorption spectroscopy was additionally employed to assess the Cr concentrations. The ranges of the mean and standard deviation (SD) of the Cr levels found in unofficial retail outlets was 120.510.6 to 2771.935.6 parts per million (ppm). On the other hand, those from the official retail locations ranged from 39.3 ppm to 461.9 ppm and were significantly lower (p 0.05). Several colors and retail stores had different Cr levels in their car paints (Nakashima, 2001). With the exception of one retail store, significant quantities were found in all paint samples bought from the unofficial retail outlets. Spray painters in the informal sector employ a variety of automobile paints with elevated Cr levels, which calls for a thorough study of Cr in these contexts as well as health-driven approaches for tackling related health implications (Mwaia, 2023).

In developed nations, there has been substantial research on worker safety and chemical pollution, but there is no evidence of this in developing economies. A thorough research was conducted by Vattanasit, et al., (2021), to assess worker exposure to chemicals as well as the application of personal protective equipment (PPE) in Nakhon Si Thammarat, Thailand. In three automobile repair shops, levels of toluene and heavy metals like lead, chromium, and cadmium were detected in the automobile paints. Metal contamination on employees' hands (n = 24) and toluene exposure measured by urine hippuric acid (n = 27) were also discovered. Surveys were utilized to collect data on the workers' personal hygiene routines and PPE use. The national standard values of toluene (200 ppm) and the metals (Pb (ND-26.34), Cr (0.02-4.46), and Cd (ND1.44 g/m3), correspondingly, were not exceeded by the mean ambient levels of toluene (0.04-18.26

ppm) or the metals in any of the locations (2017) (Badjagbo, et al., 2010). Paint spray booths had the greatest mean ambient levels of these chemicals, followed by nonprinting areas and office spaces, respectively. A painter had a higher urinary hippuric acid concentration (1.13 g/g creatinine), although it was still below the 1.6 g/g creatinine biological exposure threshold that is considered to be safe (2014). On the other hand, repair and maintenance workers were discovered to have the greatest concentrations of lead and chromium found on the employees' hands. Metal contamination was thought to be primarily caused by close hand contact while not wearing gloves (Vattanasit, et al., 2021).

This study highlighted the problem of work-related harmful air pollutants and employee protection in local small automotive repair businesses in Thailand. Body mechanics had the greatest average levels of the metals found on their hands (non-painting tasks). The primary causes were suggested to be scraping dust generated during surface preparation without using protective gloves and direct hand contact with the metal surfaces of the cars. The workers did not adequately implement PPE use. To raise worker knowledge of hazards and reduce take-home exposure pathways for both workers and their families, training should be given (Castaño, et al., 2019).

One of the occupations with the highest risk of work-related musculoskeletal problems is auto repair. Few scientific literatures have looked at the incidence and causes of work-related musculoskeletal diseases among mechanics worldwide. Even fewer studies in this area exist in Ethiopia. Therefore, a study was conducted by Tamene, et al., (2020), in this study, which was conducted in 2019 in Hawassa, South Ethiopia, the incidence of self-reported work-related musculoskeletal problems and their contributing factors were examined. A cross-sectional institution-based study including 344 auto mechanics in the city of Hawassa was conducted. The Nordic Musculoskeletal Questionnaire-Extended (NMQ-E) was utilized to evaluate nine different body regions for work-related musculoskeletal problems (S. Bevan, 2015). The data were characterized using descriptive statistical analysis and multivariate analysis, which were then utilized to pinpoint risk factors for musculoskeletal problems at work. For this working group, the positive incidence rate of work-related musculoskeletal conditions was 47.7% (95% CI) (42.7–53.2). AOR: 2.40, 95% CI (1.24-4.62), physical exertion while using tools (AOR: 2.40, 95% CI (1.24-4.62)), job stress (AOR: 4.54, 95% CI (2.44-8.46), and routinely lifting, pushing, and pulling loads higher than 20 kg (AOR: 4.85, 95% CI (2.65-8.87)) were found to be related variables (Coelho, 2011). This study indicated a 47.7% incidence of musculoskeletal issues in the workplace. The causes were stress, lack of training, physical handling of heavy weights, repetitive motions, and forced exertion. Workers' awareness of ergonomics should be raised through education. Also, owners need to look at measures to reduce or get rid of the risk factors that these workers are exposed to for developing musculoskeletal ailments. Mechanization of dangerous duties needs to be looked into as well (Tamene A. M., 2020).

Spray painting cars is regarded as a job with a significant risk of developing respiratory infections. Saraei, et al., (2019), study focused on assessing the effect of car paint fumes on respiratory function parameters among employees of a painting workplace in a sizable Iranian auto manufacturing facility. This cross-sectional study involved 820 workers from an auto manufacturing facility, comprising 389 assembly line workers and 431 spray painters (case group) (control group). All individuals underwent spirometry under routine circumstances in accordance with the American Thoracic Society (ATS) Clinical Practice Guidelines (Maslow, et al., 2012). The forced vital capacity (FVC), forced expiratory volume in one second (FEV1), forced vital capacity to forced expiratory volume ratio (FEV1/FVC), and forced expiratory flow at 25% and 75% of lung volume (FEF25-75) were recorded. When contrasted with the control group, painters with more than ten years of experience had lower expected values for FEV1/FVC (P= 0.005), FEV1 (P= 0.008), and FEF25-75 (P= 0.003). In terms of spirometric parameters, painters subjected to solvent-based paints did not vary from painters exposed to water-based paints (P>0.05). The findings showed that spirometric parameters were affected by automotive spray painting. A modest drop in the average values of these indicators signals the need for frequent medical checkups, awareness to occupational safety, and effective solutions. (Saraei, et al., 2019).

Due to Nigeria's economic issues, which hampered local manufacture, there has been a significant increase in the purchase of secondhand cars. Since most of these vehicles have gone beyond their useful lives in the country where they were manufactured, they require some repairs and rebuilding. Nduka., et al., (2019), conducted a study which concerned the evaluation of the cadmium, chromium, and nickel health risks for humans associated with the repairing of purchased secondhand vehicles. 56 Japanese-made automobiles' scraped paint dusts were gathered from 8 separate panel beating (body works) facilities in southeast Nigeria. They underwent the usual method's homogenization, mixing, fine-particle separation, filtering, and digestion. Atomic absorption spectrophotometry (AAS, 200A) was used to evaluate the filtrates for cadmium, chromium, and nickel. Levels in workshops F and D were greater than those in workshops A, B, C, E, G, and H and had the highest concentrations of cadmium (mg/kg) at 3.58 0.02 and 3.36 0.04, respectively. Chromium (mg/kg) levels were greater in workshops F and G than in the other workshops, at 2.87 0.04 and 2.95 0.06, respectively (Chernyshev, et al., Morphologic and chemical composition of particulate matter in motorcycle exhaust,., 2018). Nickel in workshop A (3.84 0.04) is comparable to other values in the same workshop. Exposure of cadmium in workshops B (1.37E-01), D (1.69E-01), and E (1.79E-01) and inhaling of chromium in workshops G (5.45E02), F (5.29E-02, and C (5.24E-02) had the greatest hazard quotients for adults. Nickel is 1.06E-02 and cadmium is 3.72E-04 in children through ingestion and 3.21E-01 in children through ingestion, respectively (workshop F) (workshop A). Exposure to scrap car paint dust may be of considerable health relevance in Nigeria as it can increase the body burden of some cancer-causing heavy metals. The highest cancer risks were in exponents -4, -7, and -8 (adult) and -3, -6, and -9 (children) for workshops A to H through breathing, intake, and skin contact (Nduka., et al., 2019).

Workers who are exposed to aromatic solvents at work face a number of major health risks, particularly if the surrounding atmosphere makes the exposure worse during normal hours of work. In order to analyze the effects of chemical exposure on hematological variables, a study was conducted on two associated groups, namely automobile mechanics (MCs) and automobile spray painters (PNs), with a focus on environmental factors and workers' individual behavioral traits that may be held accountable for raising exposure risk. Due to the involvement of several elements, it was revealed that work-related exposure may be problematic (Glantz. & William., 1998). PNs are exposed to isocyanate and aromatic solvents at significantly higher rates than MCs, which has a substantial impact on their hematopoiesis. Smoking increases exposure risk in numerous ways, and it has combination consequences with occupational exposure in MCs. These personnel need to be made aware of the importance of using self-protection techniques while performing normal chores, as well as the need for separate research to clarify their actual occupational exposure while removing distracting factors (Kamal. & Malik., 2012).

Numerous workers in Pakistan regularly come into contact to these chemicals, but due to improper reporting, no such data are accessible (Kamal, 2010). Even those who do not directly encounter chemicals at work may be subjected to benzene at various quantities via their surroundings. The most crucial steps in identifying and preventing a variety of dangers that vary with different occupational categories and job duties are exposure assessments. Numerous studies have included demographic characteristics in exposure evaluations, including age, gender, body mass index (BMI), smoking status, and consumption of particular types of food that has been contaminated (Kato, et al., 1993). In order to reduce health hazards, it is important to keep these characteristics in mind while establishing rules and regulations for potentially dangerous activities. Educating employees about workplace pollutants and other related dangers should be a top emphasis in developing nations like Pakistan. Large-scale, in-depth hazard assessments should be conducted to evaluate the current state of occupational safety, and actionable steps should be done to reduce it in the future (Snyder, 2000).

1.3 Problem Statement

The process of automobile repairing includes fixing, servicing, and repainting car bodywork. Due to harmful material releases from paint procedures and work operations, which can be harmful to both workers and the environment, automotive workshops are under great concern from occupational health and safety's point of view. Paint is made up of pigment suspended particles in a liquid made up of a binding material (resin), a volatile solvent, or water, and admixtures that give the paint its desirable characteristics. Metals may be discharged while vehicle parts are being polished, welded, or painted. Scraped automotive paint dust from refinishing secondhand cars could also expose workers to metals (Nduka, et al., 2019). With this background in mind, this research aims to verify occupational health risk of automotive paints and exposure of workers to heavy metals from scrap paint dust in Islamabad and Rawalpindi's denting and painting workshops. Due to this non-specialty occupation, and lack of education of workers, there is an increased risk for workers becoming impacted by heavy metals and other risks involved in the work. Therefore, the purpose of this research is to demonstrate if scraped vehicle paint dust exposes workers to disease-causing heavy metals like cadmium, chromium, lead, and nickel. Assessing the level of awareness of workers in knowing the risks of their proposed daily work, safety practices, if they take any precautions and wear personal protective equipment or not through structured questionnaires. It would also contribute to the awareness of workers and creation of public health policies to improve the knowledge, diagnostic abilities, and understanding of exposed working groups. Five heavy metals Cu, Pb, Cd, Cr and Ni, will be assessed in the scraped paint dust using the Atomic Absorption Spectroscopy. The main objectives of the study are:

1.4 Research Objectives

1. To evaluate the scrap car paint dust of selected workshops for presence of heavy metals.
2. To assess the awareness level of workers regarding the use of personal protective equipment (PPEs).
3. To assess the presence of expected skin and respiratory diseases among exposed working groups.

CHAPTER 2

METHODOLOGY

2.1 Study Area

The study area of the research comprised of randomly selected four denting and painting workshops in Khadda Market, G-7, Islamabad, and four denting and painting workshops from Khadda Market, Rawalpindi.

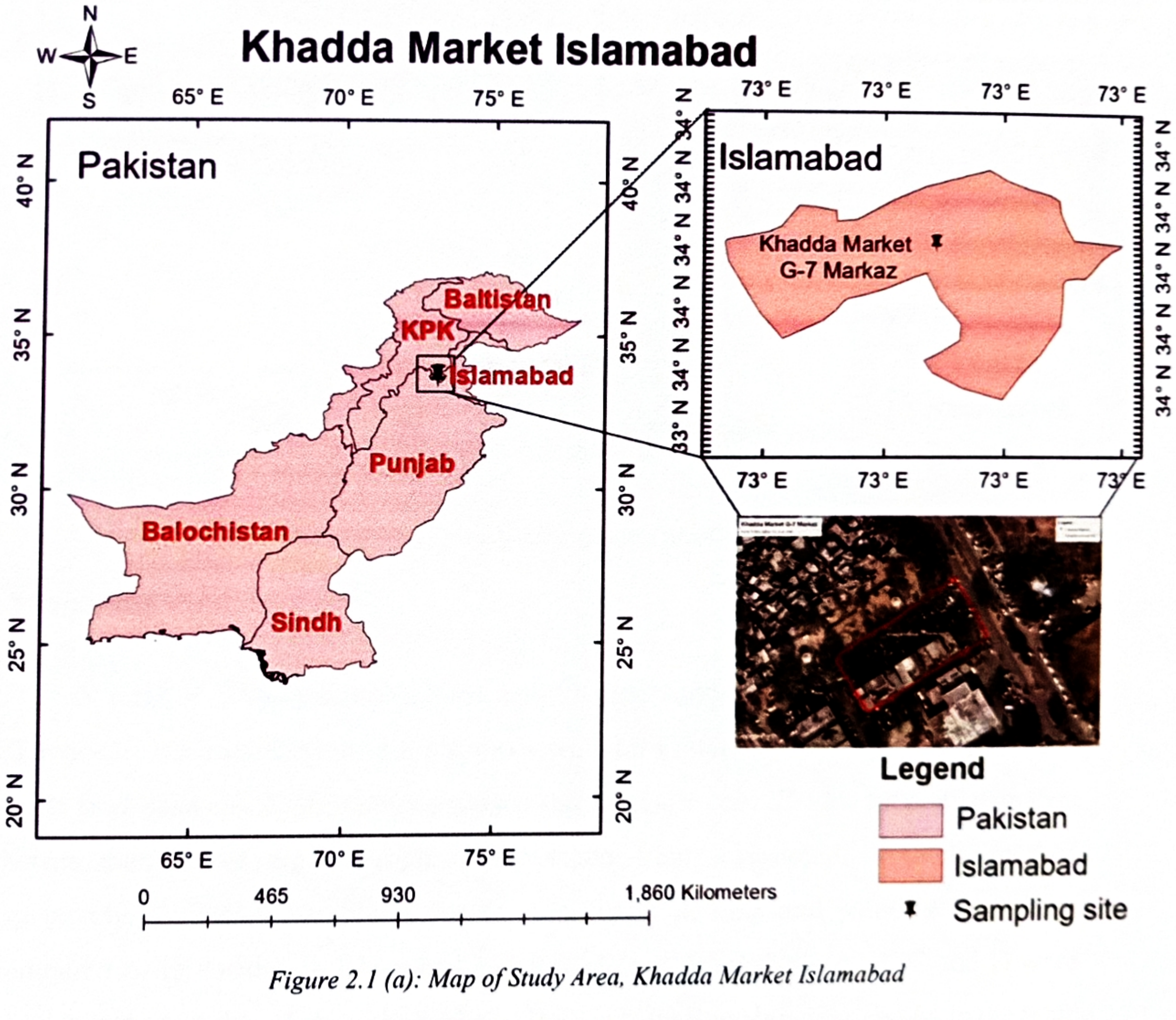

Figure 2.1 (a): Map of Study Area, Khadda Market Islamabad

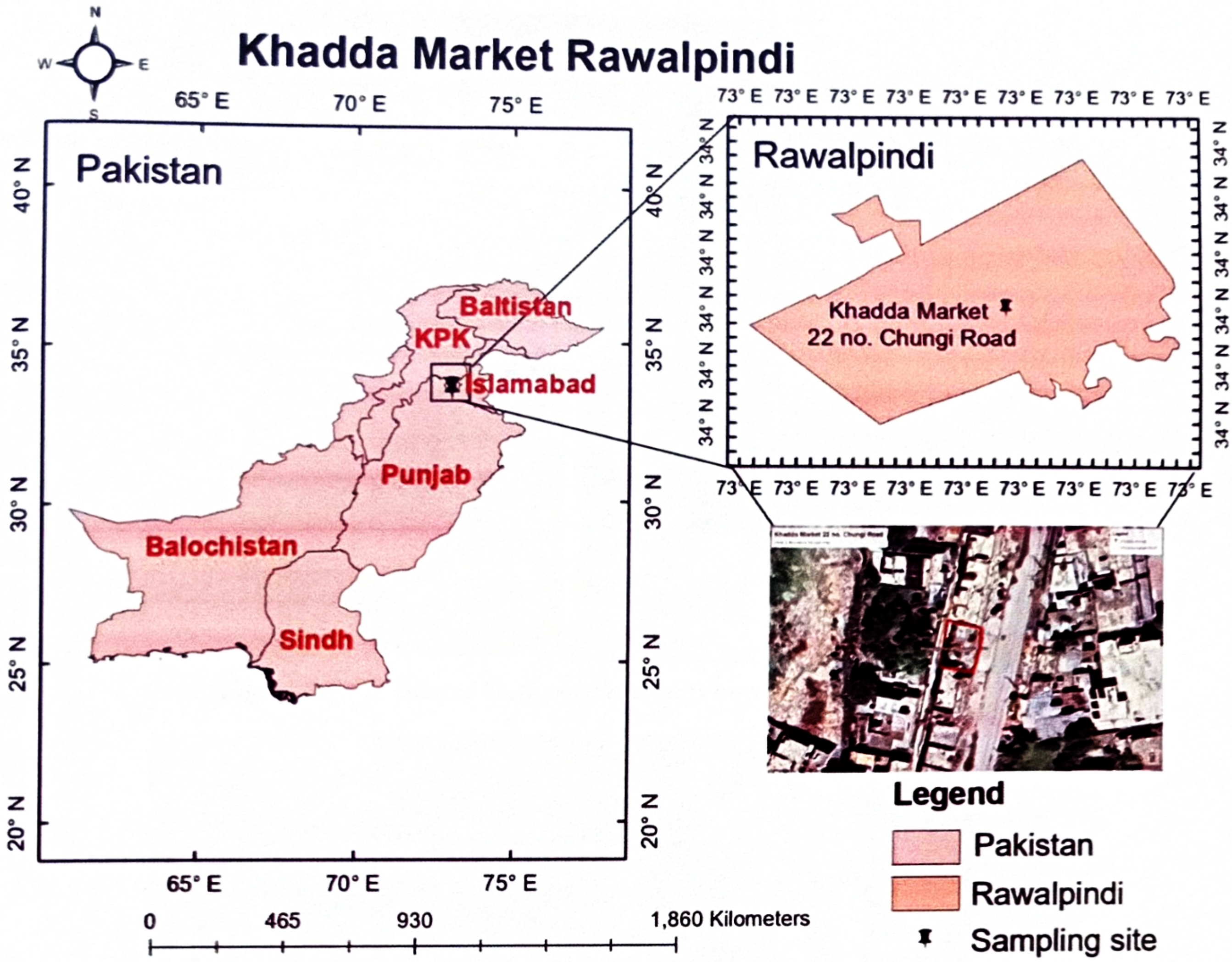

Figure 2.1 (b): Map of study Area, Khadda Market Rawalpindi

2.2 Sampling

A total of sixteen samples were collected of scrap car paint dust. Sixteen (16) different cars were selected from the workshops, with a total of one scraped car paint dust sample from each car. Eight samples were taken from site one, Khadda market Islamabad whereas the rest of eight samples were taken from Rawalpindi, Khadda market, respectively. Collected Samples were from different denting and painting workshops (numbered A–H) located in Islamabad and Rawalpindi. Workshops A, B, C and D were from Islamabad, and workshops E, F, G and H were from Rawalpindi as shown in the table below.

Figure 2.2 (a): labeled black polythene bags used for sampling

Figure 2.2: Collection of samples in black polyethylene bags

Table 2.1(a)2: Samples taken from site , Islamabad

Sample No.	Car Model/Color	Workshop	
1	Suzuki Cultus Black	A	**Islamabad Khadda Market**
2	Toyota Corolla White		
3	Honda Civic Black	B	
4	Honda City Black		
5	Mazda Metallic Color	C	
6	Cultus Silver		
7	Suzuki Mehran White	D	
8	Suzuki Mehran Grey		

Table 2.1(b): Samples taken from site 2. Rawalpindi

Sample No.	Car Model/Color	Workshop	
9	Suzuki Bolan White	E	**Rawalpindi Khadda Market**
10	Suzuki Alto silver		
11	Toyota Corolla Silver	F	
12	Silver Honda Civic Reborn		
13	Grey Daihatsu Charade	G	
14	Suzuki Mehran Black		
15	Toyota Corolla Grey	H	
16	Honda Black		

2.2.1 Sample Preparation

The paint dust was collected from the cars using brush and black polythene bags and stored in black polythene bags before dissolution and analysis. The samples were sieved using stainless steel meshes 40 µm. 3 g of paint dust of each sample were weighed on the weigh machine and added in conical flask/beaker. The flasks/beaker were then labelled accordingly. Using a pipette 15 ml of concentrated nitric acid (HNO_3) and perchloric acid ($HClO_4$) at a ratio 1:1 was added in each flask/beaker, and shaken carefully. The flasks were then put onto the hot plate (WiseStir Wisd MSH 20A) and were shaken every 3 to 5 minutes. The samples were heated on a hot plate at a temperature of 105 °C, allowed to boil for 15 to 20 minutes until all the scrap car paint dust samples were digested and dense fumes were formed. The mixture was then allowed to cool for 10 minutes. 30 ml of distilled, de-ionized water was measured with graduated cylinder, added into the flasks/beakers, and stirred. This mixture was then filtered. Filter paper (Whatman Schleicher & Schuell Grade 42 Ashless Filter Paper - 125 mm) was put in a flask. The mixture was passed through the filter paper and into the beaker. The filtrate in the beaker was filtered for the second time using a new filter paper. The final filtrate was added in the bottles and labelled.

Figure 2.2.1: Labeled bottles containing the filtrate for analysis

2.2.2: Atomic Absorption Spectroscopy Principle

One of the most often employed methods for analytical purposes is atomic absorption spectrometry (AAS) (Sergio, et al., 2018). It has been extensively employed in research labs, as well as in the fields of food, the environment, medicine, petroleum, and other industries. Measurement of element concentrations is done analytically using atomic absorption spectroscopy (AAS). It uses the light absorption caused by various substances to calculate the concentration of each. The absorption of ground state atoms in the gaseous state can be measured by atomic-absorption spectroscopy. The atoms move to higher electronic energy levels after absorbing ultraviolet or visible light (Ahmed, 2012). Once the instrument has been calibrated using standards of known concentration, concentration measurements are typically made using a working curve. A highly popular method for finding metals and metalloids in environmental materials is atomic absorption (Ahmed F, 2006). Four main parts make up an atomic absorption spectrometer: a light source (often a hollow cathode lamp), an atom cell (atomizer), a monochromator, a unit for detection, and a read-out device. The sixteen samples of scraped paint dust were evaluated and analyzed using Atomic Absorption Spectroscopy AAS (Model AA-7000), for five of selected heavy metals naming Lead (Pb), Cadmium (Cd), Nickel (Ni), Chromium (Cr), and Copper (Cu). The standards made for metals were 1,3, and 5 for Lead (Pb), 10, 30, and 50 for Copper (Cu), 0.1, 0.3, and 0.5 for Cadmium (Cd), 1,3 and 5 for Chromium (Cr), and Nickel (Ni).

Figure 2.2.2: Analysis of Samples through Atomic Absorption Spectroscopy (AAS)

2.3 Health risk Assessment

A structured questionnaire was designed that considered age, work experience, training, and was specially designed for the purpose of determining the awareness on the use of PPE, the health and safety of workers, and occupational health hazards associated with scrap car paint dust. A number of questions were asked related to exposed working group in workshops (attached as Annexure I). These questions were asked in relation to health risk assessment if the workers are having any health impacts associated with the heavy metal exposure and contamination.

2.3.1 Heavy metals cancerous/non-cancerous risk

Exposure to heavy metals can be through different routes. It can be through inhalation of air pollutants, it can be through exposure to dusts which are contaminated, it can be through ingestion of contaminated water or food etc. Heavy metals being toxic even at low concentrations pose a serious threat. Some of them are even cancerous and in extreme cases they can even cause death (Hejna et al., 2018).

For this purpose, Health risk assessment holds a great significance to know the possible harmful effects on humans due to exposure to toxic metals. It is done by considering the existing exposure data to measure the impact of a particular pollutant's exposure on human health (Morakinyo et al., 2017).

In this research heavy metals cancerous and non-cancerous risk was determined by calculating the Exposure Concentration (EC $\mu g/m^3$), the estimated daily intake (EDI mg/kg/day) of metals through scraped paint dust and then calculating the Hazard Quotient (HQ) and Lifetime Cancer risk (LTCR).

2.3.2 Exposure concentration

The exposure concentration for carcinogenic risk was calculated using the following formula (Othman et al., 2020):

$$EC\ (\mu g/m^3) = (CA\ (\mu g/m^3) \times ET(hour/day) \times EF(days/year) \times ED(years))/AT \times 365 days \times 24 hours \ldots\ldots\ldots (1)$$

$$AT = ED \times 365\ days/year \times 8\ hours\ per\ day \ldots\ldots (2)$$

Where EC is exposure concentration, CA is concentration of pollutant, ET is exposure time which is taken 8 hours per day for the exposed group of workers, EF is exposure frequency, ED is exposure duration and AT is averaging time. Values for exposure time is 8 hours/day, exposure frequency is 365 days and exposure duration are 8.5 years (average value). Averaging Time (AT) was calculated using equation 2. (Rostami, et al., 2021)

2.3.3 Estimated daily Intake (EDI)

It is expressed as daily dose on per unit body weight basis, it is dose rate which gets averaged over a specific period of exposure time. This is calculated for chemical or contaminants which have non-carcinogenic effects or non-chronic effects. It is represented as mg/kg/day (USEPA, 1989). Formula for the calculation of estimated daily intake (EDI) is given by: (Rostami, et al., 2019)

$$\text{EDI (mg/kg/day)} = \text{C (mg/m}^{3)} \text{ x IR (m}^3\text{/day) x ET x EF x ED/BW x AT}\ldots (3)$$

EDI = Estimated Daily Intake (mg/kg-day), C = Concentration of Contaminant (mg/L, mg/m^3), InR = Inhalation Rate (L/day, m^3/day), EF = Exposure frequency (days/year), ED= Exposure duration (years), BW= Body Weight (kg) and AT= Average time (days/year). For the calculations, the exposure duration ED was 8.5 years. Exposure time (ET) was 8 hours/day, Exposure frequency (EF) was 365 days and Inhalation rate was taken 20 m^3/day (Junhua Ma, 2012). The average body weight for calculations was 70kg.

2.3.4 Hazard quotient

According to the kind and harmful characteristics, many pollutants have diverse impacts on our bodies that are either carcinogenic or non-carcinogenic. A measure used to evaluate the non-carcinogenic effects is the hazard quotient (HQ) (Ezemonye, et al., 2019). It can be calculated using the equation that is provided below. Hazard quotient was calculated for non-cancerous risk using the following equation (Othman et al., 2020)

$$HQ= EDI/RfD \ldots\ldots\ldots (4)$$

Where HQ is hazard quotient, EDI is estimated daily intake and RfD is reference dose level. The hazard quotient for inhalation was calculated. The reference doses for inhalation for Ni, Cr, Cu, Cd, and Pb are 2×10^{-2}, 2.86×10^{-5}, 4×10^{-2}, 3×10^{-5}, 1×10^{-3}, and

3.5×10^{-3} respectively (Hashemi et al., 2020) (S Buranatrevedh, 2014). When the HQ value exceeds 1, it is thought that the body exhibits non-carcinogenic effects. It is assumed to have insignificant non-carcinogenic effects on the human body if it has a value of less than 1 (Agoro, et al., 2020)

2.3.5 Lifetime cancer risk

The formula given by the United States Environmental Protection Agency (USEPA) was used for the assessment of cancerous risks for heavy metals (Rostami et al., 2021):

$$LTCR = EC \times IUR \ldots\ldots\ldots (5)$$

Where, LTCR is lifetime cancer risk, IUR is Inhalation cancer unit risk and EC is exposure concentration.

The IUR values of Cd, Cr, Ni and Pb are 1.8×10^{-3}, 8.4×10^{-2}, 2.6×10^{-4} and 8×10^{-5} ($\mu g/m^3$) respectively.

2.4 Statistical Analysis

To calculate the means and standard deviation, for the data IBM SPSS (statistical package for social sciences version 25 (SPSS 25).

CHAPTER 3

RESULTS AND DISCUSSIONS

This chapter discusses the results of questionnaire surveys and heavy metal analysis, from the samples of scraped paint dust collected from the two workshops in Islamabad and Rawalpindi.

3.1 Questionnaire Surveys

A total of 40 vehicle repair workers participated in this study. A total of forty questionnaire surveys were used to obtain the information from two of the targeted workshops in Islamabad and Rawalpindi Khadda Market. Mostly the workers were auto denters and painters specially trained for car painting and repairing.

3.1.1 Subject Specifications and the application of PPE at workplace:

Information on the demographic characteristics of the study participants and their personal information e.g., their weight and height as noted from the surveys is represented in Table below. All of the forty workers (40) (100%) were male. The mean age of the respondents with standard deviation is shown in the table with respect to age groups.

Parameters	Variables	Number	Percentage	Mean (±) Standard Deviation
Age	< 25 25-35 36-45 >=46	23 11 4 2	57.5 27.5 10 5	19.2± 2.80 28±3.13 37.7±1.70 50±1.41
Level of Education	None Primary Matric FA/Intermediate	14 18 6 2	35 45 15 5	
Weight (kg)	< 50 50-70 >70	6 29 5	15 72.5 12.5	41.8±2.63 58.6±5.23 79±5.47
Height (cm)	< 150 150-170 >170	1 30 9	2.5 75 22.5	125 163.4± 5.30 176.3± 4.09

Table 3.1.1 (a): Demographic characteristics of study respondents (n=40)

With respect to education, only 2 (5%) of the respondents had completed their secondary education while 14(35%) of them did not attain any formal education. A majority, 18 (45%) of the respondents had only attained primary education. The results from the surveys revealed that the workers had no training related to vehicular work, and no use of personal protective equipment was observed on both the sites.

A significant percentage of the participants were seen wearing long pants, a shirt with folded sleeves, and a typical fabric glove. Nobody was utilizing special PPEs, chemical cartridge respirators, safety masks or chemical resistant gloves instead, they wore temporary or fabric face masks. More information on the use of PPE use and personal hygiene habits for preventing metal exposure was gathered in Part II. Long pants and shirts, which can be considered normal routine wearing clothes were used by the majority of the workers respectively, however only few claimed to use face masks and gloves routinely. Only a small number of the individuals claimed to regularly wash their hands before drinking, compared to a higher percentage who did so before eating.

Using the data from their weight and height, the BMI of all forty workers was also calculated. Weight in kilograms divided by square height in meters (kg/m^2) is how the body mass index is determined (Tamene A. M., 2020). For this study, the body mass index (BMI) has been calculated for the workers of both study areas, the Khadda Market in Islamabad and one in Rawalpindi. BMI of total forty workers has been calculated twenty from each site, which showed the varying results of BMI.

Table 3.1.1 (b): Body Mass Index (BMI) of vehicle repair workers in Islamabad and Rawalpindi Khadda Markets.

Categories of Variables	Frequency (n=40)	Percentage (%)	Mean ± SD
	BMI		
Under Weight	7	17.5	16.04±1.00
Normal Weight	25	62.5	21.02±1.75
Overweight	6	15	26.35±1.38
Obese	2	5	32.51±2.89

3.1.2 Knowledge of Physical Hazards

The amount of hours a worker worked per day and his or her familiarity with risky equipment behaviors were found to be significantly related. Those who work for extended periods (5 to 8 hours or more) are more likely to be aware of hazards than those who do not. The majority of workers work long hours, elevating their likelihood of encountering physical risks, according to site surveys conducted in the research area. Most workers put in longer hours to fulfill deadlines and, occasionally, to undertake other tasks at work like painting and auto repairing. The majority of workers do not have formal training in painting or denting; thus, they typically learn about hazards, risks of exposure, and PPE use while performing their duties in the workplace.

Table 3.1.2: Types of physical hazards reported (n = 40)

Type of physical hazards Observed	Number (%)
Sharp edge metal	36 (90%)
High exposure to sunlight/UV rays	28 (70%)
Heat (Extreme temperatures)	30 (75%)
Bright light at time of welding	31 (77.5%)
Loud noise	40 (100%)
Vibrations	14 (35%)

3.1.3 Characteristics of workplace

The overall workshops were outdoor near public pathways, space for vehicles was open in both workshops with small rooms for repairing equipment and other things. The space was open for natural ventilation. The space of work was also being used for keeping their personal stuff. All these were situated in the same room. The workshops were very congested. The workshops were located at locations which are very noisy because of close proximity to traffic load, vehicular movement, and busy roads. There was no cleanliness and hygienic practices being observed on both the sides. Paint, finishing supplies, and solvents had been stored in storage drawers and shelves, but most of them were not organized in the way they should have been. Site observation revealed that employees spray paint outside where the vehicles are parked and kept, especially when they paint tiny auto body parts.

Table 3.1.3: Worker's safety assessment chart (n=40)

Variables	Category	Frequency & Percentage %
Training for scrapped car painting work	Yes No	4 (10%) 36 (90%)
Duration of experience of working in painting workshops	Less than 1 year 5 years 10 years More than 10 years	18 (45%) 10 (25%) 5 (12.5%) 6 (15%)
Work duration	8 hours 10 hours 12 hours	8 (20%) 9 (22.5%) 23 (57.5%)
Familiarity with use and maintenance of PPEs	Yes No	8 (20%) 32 (80%)
Safety measures while working with scrapped car paint dust	Yes No	4 (10%) 36 (90%)
PPE offered at workshops	Yes No	4 (10%) 36 (90%)
Workers getting PPEs themselves	Yes No	5 (12.5%) 35 (87.5%)
Handling of chemicals during repairing & painting	Yes No	26 (65%) 14 (35%)
Occupational hazards that usually occur	Dust particles Exposure to loud noises Suffocation None	13 (32.2%) 24 (60%) 2 (5%) 1 (2.5%)
Cars painted in a day	1 - 5	35 (87.5%)

	6 -10 10-15	5 (12.5%)
Are there any safety guidelines or regulations being followed	Yes No	5 (12.5%) 35 (87.5%)
Physically demanding work	Yes No Often	27 (67.5%) 4 (10%) 9 (22.5%)
Awareness related to health hazards at work	Yes No	21 (52.5%) 19 (47.5%)

3.1.4 Worker's Safety Assessment:

All groups of workers had reported exceedingly high exposure levels to at least one hazard (Table 4). Major exposure was reported to loud noise (60%) and dust particles (32.2%). In addition, the survey findings showed the worker's exposure to sharp metals, exhaust fumes, welding fumes, electric shocks, and fumes due to spray painting and soldering. The use of personal protective equipment was poor, with only 10% workers having access to PPEs, the remaining 90% had no PPEs to wear. Only 12.5% workers were getting PPEs and the remaining 87.5 were not getting PPEs. Lack of protective equipment was singled out in the targeted workshops to be the main perceived reason for health problems among the workers. Thirty-two (80%) out of forty workers had no familiarity with the use of personal protective equipment. 87.5 % of workers said that there are no regulations and guidelines being followed to avoid workplace hazards. Almost 90% of workers had no training in regard to scraped car painting and denting.

3.1.5 Worker's health assessment

Questions were asked pertaining to workers' health condition due to the exposure to heavy metals, poor working conditions and related to workplace environment to workers. All the questions were qualitative in nature. When working in direct sunlight, near paint and thinner, or both, the painters had headaches. Those who work with scraped paint mostly cited respiratory and eye issues. Garage workers reported being exposed to oil, grease, and gasoline, which they connected to skin issues and digestive discomfort. The workers connected automobile battery chemical exposures to headaches, dizziness, and respiratory tract issues. The workshop employees working with metal felt the need to lower the level of excessive noise.

Table 3.1.5: Workers Health Assessment n=40

Variable	Category	Percentage
Worker/denters	Smoker	22 (55%)
	Non-smoker	18 (45%)
Inhalation and skin exposure to dust (scraped paint dust) and other pollutants in the air	Yes	37 (92.5%)
	No	3 (7.5%)
Any allergies and skin allergic reactions on hands, skin, etc. While working with cars and paints	Yes	14 (35%)
	No	26 (65%)
Presence of any symptoms such as cough, flu, fever among workers due to dust or other pollutants	Cough	22 (55%)
	Flu	
	Fever	2 (5%)
	None	16 (40%)
Is there Poor ventilation in the painting areas compared to non-painting areas?	Yes	13 (32.5%)
	No	27 (67.5%)

Is it a threat for people working non painting areas?	Yes	13 (32.5%)
	No	27 (67.5%)
Direct hand contact of workers with metal surface of vehicles and scraped paint dust	Yes	40 (100%)
	No	
Accumulation of dust (heavy metals) on hands (as hands are majorly used)	Yes	33 (82.5%)
	No	7 (17.5%)
Do they use their own clothes or use special clothes at workshops?	Own clothes	37 (92.5%)
	Special Clothes	3 (7.5%)
Do they clean their hands while eating during lunch time in workshops?	Yes	35 (87.5%)
	No	5 (12.5%)
Do workers change their clothes while going to home?	Yes	21 (53.5%)
	No	19 (47.5%)

Around 55 percent of the workers were smokers. Thirty-seven out of forty workers said that they experience inhalation and skin exposure to scraped paint dust and other pollutants in the working environment. 35% of workers experience allergies on their hands as they are involved while working with paints and oils. 33 (82.3%) workers said that there could be an accumulation of dust and other pollutants on their hands. Twenty-two out of forty (55%) people experience a cough once in a while, and only 5% reported having a fever sometimes. All forty workers reported direct use of hands and contact with metal surfaces of vehicles and scraped paint dust. The ventilation was good in the painting areas compared to the surrounding areas.

3.2 Health risk assessment

3.2.1 Heavy metal analysis

The concentrations of Lead (Pb), Copper (Cu), Cadmium (Cd), Chromium (Cr), and Nickel (Ni) were determined in sixteen scraped paint dust samples taken Khadda market in Islamabad and Rawalpindi using the Flame Atomic Absorption Spectroscopy (AAS).

3.2.2 Concentration of metals in scraped paint dust

The concentrations of metals in scraped car paint dust from four workshops A, B, C, and D from Khadda market, Islamabad had shown a descending order shown in the table. It is clear from the trend that the copper (Cu) had the highest concentration in all paint samples. Nickel, Chromium, and Lead, had also shown slightly increased concentrations in all samples. The concentrations of metals in scraped paint dust from four workshops E, F, G, and H from Khadda market, Rawalpindi had shown a descending order as shown in the table. The concentration of copper was high in all samples of scraped paint collected from workshops in Islamabad and Rawalpindi however the concentrations of nickel, chromium, and lead were increasingly high. Cadmium had the lowest concentrations in all collected samples.

Table 3.2.2: Trends for concentrations of metals in all workshops

Samples	Trend of concentrations of metals	Samples	Trend of concentrations of metals
1	Cu >Pb > Ni > Cr > Cd	9	Cu >Ni > Cr >Pb >Cd
2	Cu > Ni > Pb >Cr >Cd	10	Cu >Ni >Cr >Pb > Cd
3	Cu >Pb > Ni > Cr > Cd	11	Cu > Pb >Ni > Cr >Cd
4	Pb >Cu >Ni >Cr >Cd	12	Cu > Cr > Ni > Pb >Cd
5	Pb > Cr >Ni >Cu >Cd	13	Ni > Cu > Pb > Cr >Cd
6	Ni >Cu >Pb >Cr > Cd,	14	Cu> Ni > Cr > Pb > Cd
7	Cu >Ni >Pb >Cr >Cd	15	Cu> Ni> Cr > Pb >Cd
8	Cu > Ni > Pb >Cr >Cd	16	Cu > Cr >Ni > Pb > Cd

3.2.3 Estimated daily intake (EDI) of metals

Average daily intake (ADI) in terms of mg/Kg/day was calculated for the exposed group of workers, separately by using equation (3) and calculations are shown in the tables, respectively. For the calculations, the exposure time (ET) was 8 hours/day, exposure frequency (EF) was 365 days and Inhalation rate was 20 m^3/day. The average body weight for calculations was 70kg. The exposure duration (ED) was taken 8.5 years (average value) based on the average working time of the workers in the workshops.

3.2.4 Hazard quotient (HQ)

To analyze the non-carcinogenic effects, hazard quotient was also calculated. The results of HQs for workers were acquired by utilizing Equation (4) and are presented in tables for workshops A, B, C, D, E, F, G, and H, respectively. The HQ of all heavy metals entering through inhalation from dust exceeded the permissible limit. The HQ values for all metals exceeded the value of 1 except for cadmium that indicates that the body exhibits non-carcinogenic impacts. The results of hazard quotient had shown the descending order of Cr > Cu > Ni > Pb > Cd, the values for Chromium (Cr) were highest among all, with cadmium (Cd) having the lowest values. For workshops, E, G, and H the values of Pb were also less than 1.

3.2.5 Carcinogenic risk assessment (LTCR)

The inhalation of scrap paint dust contaminated with metals for long-term exposure throughout life is considered to be carcinogenic (Cancer could be developed in various parts of the body). According to the United States Environmental Protection Agency (US EPA, if cancer risk values lie between 10^{-6} to 10^{-4}, it results in tolerable risk but if it is less than 10^{-6} it can be neglected while, CR values more than 10^{-4} are unacceptable. The results of LTCR had shown the descending order of Cr > Ni > Pb > Cd, the values for Chromium (Cr) were highest among all, with cadmium (Cd) having the lowest values. Metals Pb, Cr, and Ni had values of CR in the range of -2-3 which is unacceptable.

Table 3.2: Results of health risk assessment for heavy metals for all workshops

Metals	Sample No.															
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
	EC(μg/m³)															
Pb	10.43	181.8	235.6	404.21E2	1.153	117.8	96.53	36.25	12.23	10.43	0.019	12.69	82.0	1.09	12.23	30.31
Cu	11.15E3	639.4	112.20E2	158.41E2	0.452	539.9	20.13E 2	29.16E 2	458.6	24.70E 2	0.049	592.4	287.1	522.7	741.1	211.6
Cd	0.846	7.71	0.709	0.320	9.1E-5	0.102	0.102	0.674	0.263	4.461	2.7E-4	1.773	0.423	0.606	0.217	0.251
Ni	103.3	375.1	166.9	446.1	0.127	1029.4	545.6	757.1	163.56	134.9	0.018	213.8	374.0	183.0	447.4	95.50
Cr	65.42	800.9E2	98.13	170.4	0.048	42.09	70.34	35.45	46.78	63.59	8.9E-3	257.3	70.22	85.78	138.4	117.8
	EDI(mg/kg/day)															
Pb	0.029	0.051	0.0672	1.153	1.37	0.033	0.027	0.010	3.49E-3	2.9E-3	0.019	3.6E-3	0.023	3.13E-4	0.0034	8.6E-3
Cu	3.18	0.182	3.202	0.452	0.076	0.154	0.575	0.832	0.131	0.708	0.049	0.169	0.082	0.149	0.21	0.060
Cd	2.4E-4	2.19E-3	2.02E-4	9.1E-5	5.9E-4	2.9E-5	5.9E-4	1.9E-4	7.5E-5	1.3E-3	2.7E-4	5.05E-4	1.2E-4	1.72E-4	6.2E-5	7.1E-5
Ni	0.029	0.107	0.047	0.127	0.265	0.293	0.155	0.216	0.046	0.038	0.018	0.061	0.107	0.052	0.127	0.027
Cr	0.018	0.022	0.028	0.048	0.350	0.012	0.020	0.010	0.013	0.018	8.9E-3	0.073	0.020	0.024	0.039	0.033
	HQ															
Pb	8.28	14.57	17.48	329.4	373.4	9.42	7.71	2.85	0.99	0.85	5.42	1.03	6.57	0.09	0.97	2.45
Cu	79.5	4.55	80.05	11.3	1.90	3.85	14.4	0.80	3.27	17.7	1.22	9.22	2.05	3.72	5.30	1.50
Cd	0.24	2.19	0.202	0.091	0.59	0.029	0.59	0.19	0.075	1.20	0.27	0.50	0.12	0.17	0.06	0.07
Ni	1.45	5.35	2.38	6.35	13.25	14.65	7.75	10.8	2.30	1.90	0.9	3.05	5.35	2.60	6.35	1.35
Cr	629.4	769.2	979.0	1678.3	12237.7	419.6	699.3	349.6	454.5	629.4	311.2	2552.4	699.3	839.2	1384.6	1153.8
	LTCR															
Pb	8.3E-4	14.5E-3	20.4E-3	3.23	36.6E-2	9.4E-3	7.7E-3	2.9E-3	9.7E-4	8.3E-4	5.4E-3	1.0E-3	6.5E-3	8.7E-5	9.8E-4	2.4E-3
Cu																
Cd	1.5E-3	13.8E-3	1.27E-3	5.8E-4	3.8E-3	1.8E-4	1.8E-3	1.2E-3	4.7E-4	8.0E-3	1.7E-3	3.2E-3	7.6E-4	1.1E-3	3.9E-4	4.5E-4
Ni	26.8E-3	97.5E-3	43.3E-3	11.5E-2	24.2E-2	26.7E-2	14.1E-2	19.6E-2	42.5E-3	35E-3	16.6E-3	55.5E-3	97.2E-3	47.5E-3	11.6E-2	24.8E-3
Cr	5.48	67.7E-2	195.6	34.2E-2	103.1	3.53	5.90	2.97	3.92	5.34	2.631	21.61	5.89	7.20	278.5	9.89

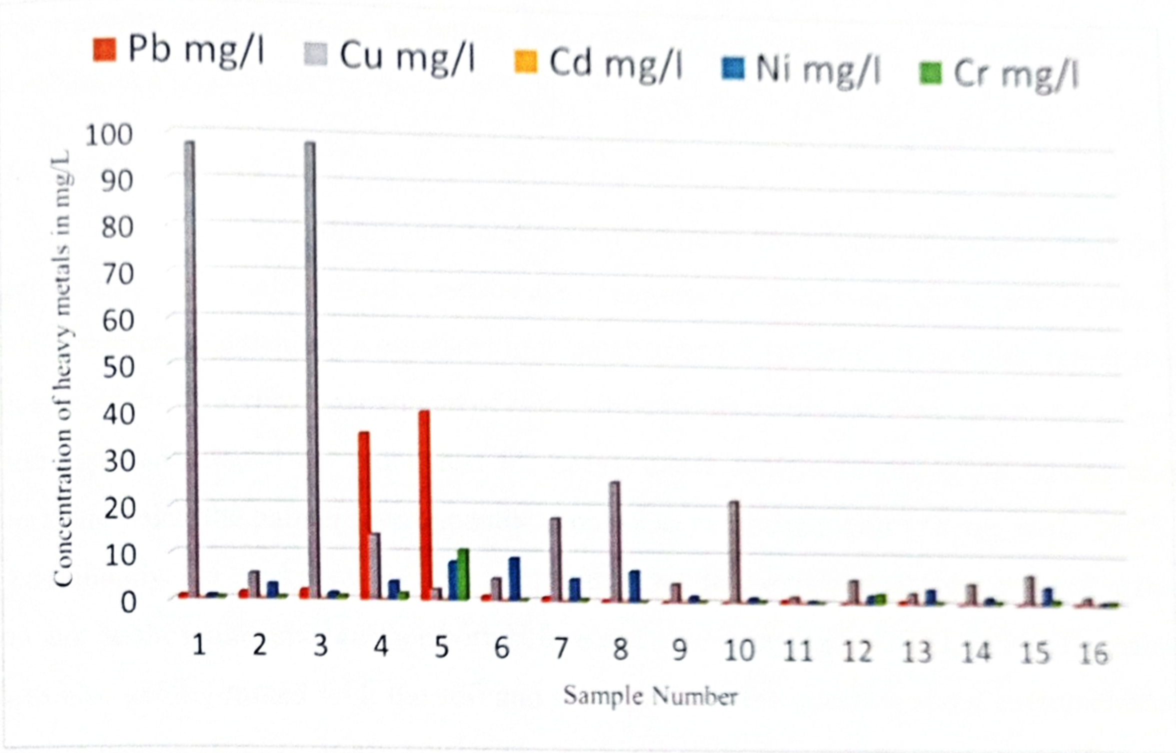

Figure 3.2: Concentration of metals in scrap paint dust (mg/L)

A study conducted by Huang et al. (2010) evaluated the metal contents of paint dusts in paint manufacturers and discovered that solvent-based paint vendors had noticeably higher Pb concentrations (15,680 11,780 g/g vs. 57.46 22.42 g/g). This conclusion is in line with current research showing lead, copper, nickel, and chromium were present at significant concentrations in the scrap paint dust. (Huang, et al., 2010). Our results are also in line with the findings of Orisakwe, et al., (1996) and colleagues, who found that respiratory problems linked to occupational exposure to particulate insults in 'Okada' (motorcycle) operators in Nigeria revealed profound consequences for health. The hazard quotient of the five heavy metals from scrap car paint dust suggests there may be a reasonable level of toxicity through inhalation primarily among workers than through ingestion and dermal contact. (Orisakwe, et al., 1996).

Proximity with sharp objects, high noise, heat, spray paint, and welding are all considered risky, and contact to welding fumes and paint dust put workers at risk of getting sick. This highlights once again how dangerous these health issues can be. Our results correspond with those of Gomes (2002) et al., who studied workers who were subjected to intense heat and noise. Only a small number of workers wore protective equipment, and the majority were exposed to fumes from welding, sparks, paint dust, and radiation (Gomes, et al., 2002).

3.3 DISCUSSIONS

Since there is a significant relationship between knowledge of physical hazards, and occupational health hazards, and the use of personal protective equipment among small scale painting and denting workshops in Islamabad and Rawalpindi twin cities, this study evaluated the awareness assessment of automobile paints on occupational health and safety and assessed scraped car paint dust for heavy metal contamination. When mixing and spraying paint, the painters were mostly exposed to paint chemicals (Zheng, et al., 2010). Additionally, the workers were also getting exposed to the paint dust that persisted in the air and on the paint spray surface both before and after spraying (ACGIH, 2014). The paint was also getting mixed with the soil and water, raising the question about environmental contamination (Kawai, et al., 1993). The ambient air in non-painting areas was likely to get polluted with the chemical due to the spraying of paint on small car body parts outside the workshops, as well as the disorganized keeping of paint cans and solvent containers (Obi, et al., 2006). Although the main route of the chemical exposure is thought to be by inhalation, none of the workers reported wearing chemical resistant breathing masks (Vitayavirasuk, et al., 2005). Additionally, at such workplaces the routine work with cars and paints may indicate that using either PPE was ineffective at reducing exposure to scrap paint dust or any other chemicals. Some of the workers were seen wearing hand gloves, they are often well resistant to organic solvents (Low, et al., 1988). The strength and leaking of the gloves were not reported. The workers' usage of long pants and a folded-sleeved shirt was an alternate to avoid contact with their skin. To ensure enhanced safety, all painters should be given chemical protective suits with covers (Maduabuchi, et al., 2006). For the sake of the workers' health, PPE must be worn consistently. The majority of workers in this survey who self-reported using PPE never used gloves, and none of them used gloves on a daily basis. Metals could also be present on the hands of the workers risking the health of workers. Additionally, the fabric gloves utilized by such shops may permit some chemicals to penetrate through to the skin (S. Wilbur, 2012). We discovered that employees were subjected to a variety of work-related risks, did not wear safety equipment, and experienced health issues that were thought to be related to their jobs (Sabty-daily, et al., 2005).

Employers and employees were both aware of the risks to their health posed by the workplace and the environment, but a lack of defined regulations on informal labor and the lack of job security discouraged investments in occupational health and safety (Rongo, et al., 2004). It was noted during the questionnaires that the employees did not consider health complaints to be their primary issues. Employers and employees were more focused on their daily wages and income sources (Zhao, et al., 2014). The importance of occupational health and safety is diminished by the short lifespan of many such workshops. It is necessary to conduct further research on the living conditions and health of small workshop employees. Particularly, an impartial assessment of the alleged health issues is required. (Packard, 1989)

According to this study, the levels of all metals except for cadmium in scrap paint dust were increasingly high. The cancer-risk range for all five metals, cadmium, copper, lead, nickel, and chromium through inhalation was between 1.2 and 97.5 x 10^{-3} and 5.76 x 10^{-4} and 42.5 x 10^{-3}, respectively (Bradshaw, et al., 1998). This suggests that the exposed subjects in the research region are at risk. In addition to the heavy metals (Cd, Cr, Cu, Pb, and Ni) in paint, paint aerosols can also be dangerous since they have a similar impact to microscopic welding particles, which can seriously harm human health (Kirichenko, et al., 2017). The results support recent research (Chernyshev, et al., 2018) showing, despite the benefits that automobile transport provides for individuals, it has a negative influence on public health. This study, along with others, shows that occupational and local exposures are the most obvious scenario of heavy metal or chemical danger that could be connected to dust from waste automobile paint (Das, et al., 2008). Working in or living close to auto-panel workshops exposes people to heavy metal dangers from the automobile paint dust matrix, which might impair their body immunity (Clausen & Rastogi, 1997). Fifty five percent of the workers are already smokers with compromised immunity or weakened immune system, therefore exposure to heavy metals through scrap paint dust on daily basis may further aggravate their health conditions (Figueroa, 2008).

CONCLUSIONS

In local, small-scale painting and denting workshops in Islamabad and Rawalpindi, this study draws attention to the problem of workplace contaminants and worker personal safety. A study was conducted to see the level of awareness among workers on the use and application of PPEs, and the occupational health hazards and safety. The scrap paint dust was also evaluated for the presence of heavy metals. Scrap paint dust samples had increasingly prominent levels of metals, and all the samples were determined to have the highest level of copper (Cu), the levels of Ni, Pb, and Cr levels were likewise discovered to be the increased in all samples, with the exception of cadmium (Cd), which had an exceptionally low concentration in all samples. The results showed a general trend of concentration of metals in scrap paint dust, Cu >Ni > Pb > Cr >Cd. Direct hand contact with the cars' metal surfaces and painting without wearing proper PPEs, breathing (inhalation) in the contaminated air, were suggested as the main exposure sources. Lack of protective equipment was singled out in the targeted workshops to be the main perceived reason for work related exposures among the workers. To raise worker knowledge and awareness of occupational hazards and reduce take-home exposure pathways for both workers and their families, proper trainings should be given.

RECOMMENDATIONS

In the present research, occupational knowledge on the use of PPEs, scrap paint contamination with heavy metals, and health effects among workers were evaluated in painting and denting shops in Islamabad and Rawalpindi; to date, no published data on this issue could be discovered. Within a particular worker demographic, attention was also paid to the impact of workplace surroundings on exposure levels and health conditions. Workers' protection and monitoring systems are an overlooked issue in Pakistan. Future research should concentrate on "healthy workplaces," "increasing awareness among workers, small scale auto repair denters, and painters, "prevention," and "additional research." Healthy workplaces are essential for workers. In addition, it is important to disseminate study results to other workers and locals in order to increase awareness, the need for regulations in the unorganized sector. There is a need for health information on occupational exposures, mishaps, respiratory symptoms, and the availability of personal protective equipment (PPEs). Additionally, the importance of screening employees, vaccinating against any infections, providing first aid kits, PPEs, and providing care for those who are impacted is necessary.

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ANNEXURE I

Worker's Demographic Information

Name	
Gender	
Age	
Weight	
Height	
Qualification	
Smoker	

Worker's Safety Assessment

1. **Did you receive any training for scrap car painting work?**
   a) Yes
   b) No

2. **What kind of training or certification do workers normally have for working in a scrap car paint dust workshop?**
   a) None
   b) Daily work routine
   c) Special training
   d) Other

3. **What is the duration of your experience of working in the scrap car paint dust workshop?**
   a) Less than 1 year
   b) 5 years
   c) 10 years

d) More than 10 years

4. Are you familiar with the proper use and maintenance of personal protective equipment (PPE)?

a) Yes

b) No

5. Do you take safety measure while working with scrap car paint dust?

a) Yes

b) No

6. Which PPE do you use?

a) All PPE

b) Only mask

c) Only gloves

d) Only glasses

e) No PPE

7. Is PPE offered at workshops?

a) Yes

b) No

8. If PPE is not given by the workshop, do you purchase it yourself?

a) Yes

b) No

9. Which methods are used here for scrap car paint repairs?

a) Sanding

b) Filling

c) Priming

d) Buffing

e) Other

10. How often do you encounter challenges related to scrap car paint repairs?

a) Never
b) Rarely
c) Sometimes
d) Frequently

11. Do you or other workers manage the disposal of hazardous materials, such as scrap car paint and dust?

a) Yes
b) No

12. What kind of occupational hazard usually occurs here?

a) Dust particles
b) Exposure to loud noises
c) Suffocation
d) Other

13. How many cars do you paint in a day?

a) 1 - 5
b) 6 -10
c) 10-15
d) More than 10

14. Have you ever encountered any issues or challenges while working on a specific type of car or model?

a) Yes
b) No

15. Are you able to follow detailed instructions and procedures to ensure workplace safety and compliance with regulations?

a) Yes

b) No

16. Do you follow all safety regulations and guidelines while working in the workshop?

a) Yes

b) No

17. What is your work duration?

a) 8 hours

b) 10 hours

c) 12 hours

d) other

18. Do you work extra hours of work on weekends?

a) Yes

b) No

19. Do you work in a physically demanding environment that requires standing for prolonged periods of time, bending, and lifting heavy objects?

a) Yes

b) No

c) Often

20. Have you ever noticed any visible dust or other particulate matter in the air while working in the workshop?

a) Yes

b) No

21. Are you aware of the health hazards associated with working in this denting & painting workshop?

a) Yes

b) No

22. Is there a regular cleaning schedule in place to remove dust and debris from the workshop surfaces?

a) Yes

b) No

Worker's Health Assessment

23. Do you have any physical limitations or health conditions that may impact your ability to perform the tasks required in the workshop?

a) Yes

b) No

24. Before working in the workshop, did you have any health issues or symptoms like respiratory or skin diseases?

a) Yes

b) No

25. Do you have any health problems or symptoms related to your work in the workshop, such as respiratory problems or skin irritation?

a) Yes

b) No

26. At the end of day what type of physiological stresses you feel?

a) Headache

b) Nausea

c) Muscle and joint pain

d) Skin/eye irritation

e) None

27. Do you feel better when you are not dealing with or working with scrap car paint?

a) Yes

b) No

28. Do you have any disease?

a) Respiratory disease

b) Eye irritation/burning

c) Skin disease/irritation

d) Other

29. Are you concerned about your health when you work with scratched car paint?

a) Yes

b) No

30. Inhalation and skin exposure to dust (scraped paint dust) and other pollutants in the air.

a. Yes

b. No

31. Any allergies and skin allergic reactions on hands, skin, etc. While working with cars and paints (cars)

a. Yes

b. No

32. Presence of any symptoms such as cough, flu, fever among workers due to dust or other pollutants

a. Cough

b. Flu

c. Fever

d. None

33. Is there Poor ventilation in the painting areas compared to non-painting areas?

a. Yes

b. No

34. Is it a threat for people working non painting areas?

a. Yes

b. No

35. Direct hand contact of workers with metal surface of vehicles and scraped paint dust

a. Yes

b. No

36. Accumulation of dust (heavy metals) on hands (as hands are majorly used)

a. Yes

b. No

37. Do they use their own clothes or use special clothes at workshops?

a. Own clothes

b. Special clothes

38. Do they clean their hands while eating during lunch time in workshops?

a. Yes

b. No

39. Do they change their clothes while going home?

a. Yes

b. No

Workshops Hazard Assessment

Physical Hazards	YES	NO
Sharp edge metal		
High exposure to sunlight/UV rays		
Heat (Extreme temperatures)		
Bright light at time of wielding		
Loud noise		
Vibrations		

AWARENESS AND RESPIRATORY RISK ASSESSMENT OF CAR PAINT DUST EXPOSED WORKERS IN ISLAMABAD AND RAWALPINDI, PAKISTAN

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