Occupational Safety and Health Practices in Chemical and Paint Industry in Punjab 2021

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Acronyms

OSH	Occupational Safety & Health
ILO	International Labour Organization
PEQS	Punjab Environmental Quality Standards
OSHA	Occupational Safety & Health Administration
NCOC	National Command and Operation Center

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1. Introduction

Chemicals are used in virtually all work activities, thus presenting certain chemical risks in many workplaces worldwide. Furthermore, many thousands of chemicals are used in substantial quantities, and many new chemicals are also introduced into the market each year.

Workers are among those most exposed to hazardous chemicals and waste in various sectors worldwide, particularly in developing countries, economies in transition and the informal economy. Moreover, workers are exposed to them throughout the entire supply chain: from production to handling, storage, transport, disposal and treatment of waste chemicals.

The chemical industry of a country is an indication of the overall economic development and its growth potential. Recent development in technology, particularly in synthetic materials has made the industry of prime importance. However, this sector is underdeveloped and unable to meet the present and future needs of the economy. The chemical industry holds a tremendous future to flourish, which the low level of chemicals production can judge in terms of volume and value. Therefore, the chemical industry will enjoy the benefits of a seller's market as long as the government adheres to its policy of support for its growth [1].

At the time of independence, the chemical industry was practically non-existent. The chemical industry in Pakistan has, by and large, developed on a fragmented and ad hoc basis motivated by a combination of the existence of a small local market and attracted by traditionally high tariffs. As a result, it suffers from the lack of scales, national integration and consequent non-competitiveness. However, there are sectors where some scale and integration has been achieved based on the growing local market [2].

Occupational injuries or work accidents are considered a problem for the workers and the employer itself. In addition to endangering the lives and well-being of the workers, these accidents cause an increase in workplace absences and a reduction in labour productivity, resulting in an additional burden for the companies [3]. The International Labor Organization (ILO) has estimated that these occupational injuries and diseases, on average, have an economic cost of 1% - 3% in developed whereas 4% of GDP in developing countries [4].

It is also estimated that approximately 2.3 million fatalities and 300 million accidents occur in the workplaces worldwide each year. Even then, these estimates do not correctly portray the graveness of the problem [5]. This problem is more severe in developing countries, where the working conditions are mostly considered substandard, the health care facilities are not advanced, or the workers have not been provided with sufficient training. Moreover, the safety conditions greatly vary from country to country and from sector to sector within a single country [6].

Effective control of chemical risks at the workplace requires an efficient flow of information from the manufacturers or importers to the users of chemicals on potential hazards and on the safety precautions to be taken. Employers should follow this flow of information to ensure that the necessary measures protect the workers, public, and environment.

The condition of occupational safety and health in Pakistan has been in dire need of an urgent revamp, whether the legislation, implementation of laws, data collection or the resources required. The legislation has been updated according to the changing technologies in various industrial sectors, but much needs to be done. For example, the "Punjab Factories Act 1934" does not apply to enterprises employing less than ten workers. Furthermore, it does not cover the agriculture and construction sectors and informal and seasonal workers [7]. Rules under the "Punjab Occupational Safety and Health Act 2019" need further development.

Handling chemicals at any stage is cumbersome and risky. Therefore, the safety and security of chemicals and related facilities is essential for avoiding chemical accidents and preventing inadvertent and deliberate misuse of chemicals [10].

Likewise, paints and coatings include paints, varnishes, lacquers, stains, printing inks, and more, which use many chemicals. Traditional paints consist of a dispersion of pigment particles in a vehicle comprising a film-former or binder (usually an oil or resin) and a thinner (usually a volatile solvent) with a wide variety of fillers and other additives.

Traditional paints were under 70% solids, with the remainder mainly being solvent water-based latex paints, two-part catalyzed paints, high solids paints (>70% solids), plastisol paints (pigments and plasticizers) and powder coatings.

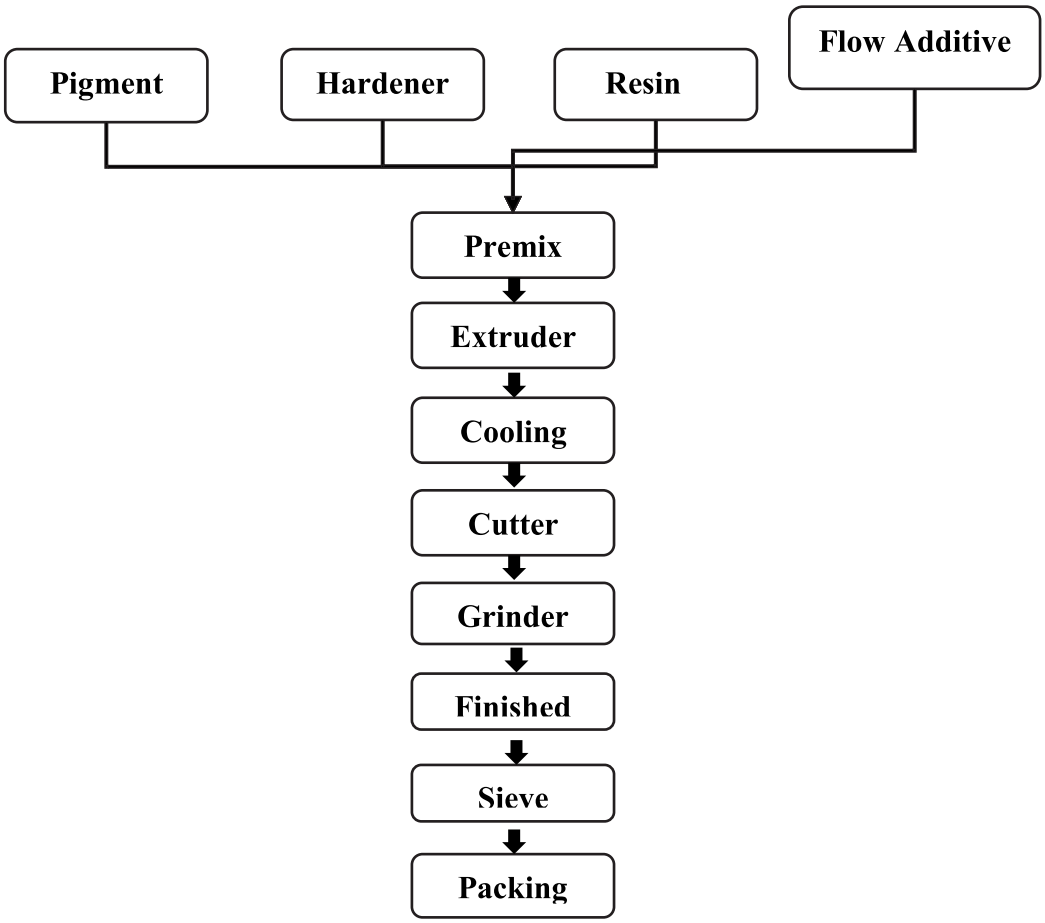
The paint industry in Pakistan produces a wide range of finished and intermediate products, including pigments, distempers, plastic emulsion, enamel, undercoat, primers, rubber paint, aircraft paint, and marine paint, anticorrosive paint, anti-fouling paint, etc. The paint industry in Pakistan is experiencing an annual growth rate of around 6–8 per cent. During 2018, the capacity attained was approximately 18 million litres of paint (Economic Survey of Pakistan, 2018). This high growth is due to the ongoing growth in the construction and automotive industry [11].

It is worldwide accepted that about 60% of paint manufacturers employed around 20 workers. However, only about 3% had more than 250 workers, indicating a predominance of small shops, most of which would not have in-house health and safety expertise. In Pakistan, the paint industry works in both organized and unorganized sectors. The organized paint sector consists of 20 producing units, including four multinational companies, whereas 110 paint producing units operate in the unorganized sector. Although there are no formal figures of the country's paint and coatings industry value and volume, most of the stakeholders put the Pakistani paints and coating industry worth PKR 37 billion (US$ 306 million). The industry has been growing in the range of 4–7 percent (on a value basis) for the past five years [12].

In general, paints and other coatings are a series of unit operations using batch processes. The manufacture involves assembling raw materials, mixing, dispersing, thinning and adjusting, filling containers, and warehousing. Raw materials used to manufacture paints come as liquids, solids, powders, pastes and slurries. These are manually weighed out and premixed. Next, agglomerated pigment particles must be reduced to the original pigment size, and the particles must be wet with the binder to ensure dispersion in the liquid matrix. This dispersion process, called grinding, is done with a variety of types of equipment, including high-speed shaft-impeller dispersers, dough mixers, ball mills, sand mills, triple roll mills, pug mills and so forth. After an initial run, which might take as long as 48 hours, the resin is added to the paste, and the grinding process is repeated for a shorter period. The dispersed material is then transferred by gravity to a let-down tank, where additional material such as tinting compounds can be added. For water-based paints, the binder is usually added at this stage. The paste is then thinned with resin or solvent, filtered, and transferred again by gravity to the can filling area. The filling can be done manually or mechanically.

After the dispersion process, it may be necessary to clean the tanks and mills before introducing a new batch that involves hand and power tools and alkali cleaners and solvents.

Figure-I (Flowsheet Diagram for Paint Industry)



The major hazards associated with the paint and coatings manufacture involve materials handling; toxic, flammable or explosive substances; and physical agents such as electrical shock, noise, heat and cold. In addition, the manual handling of boxes, barrels, and containers containing the raw materials and finished products are major sources of injury due to improper lifting, slip falls, dropping containers, etc.

Chemical hazards include exposure to toxic dust such as lead chromate pigment, which can occur during weighing, filling of mixer and mill hoppers, operations of unenclosed equipment, filling of powdered paint containers, cleaning of equipment and from spills of containers. In addition, the manufacture of powder volatile organic compounds (VOCs) emission is also involved in paint making. Exposure to paint and its fumes have the potential to cause irritation of skin, eyes, and throat, while other paint products contain VOCs that can potentially cause both short-term and long-term health effects [13].

2. Objectives

- To conduct occupational safety and health risk assessment of the Chemical and Paint sector in Punjab.
- To formulate and analyze reports on occupational diseases and to suggest control measures.

3. Methodology

In Punjab province, the available data shows that the total number of chemical and paint industries registered with the Labour and Human Resource Department is 84. The visits were conducted in registered chemical and paint industries of district Lahore and Sheikhupura. These industries include:

Sector	Sampled units
Chemical Industries	03
Paint Industries	04

In order to analyze the condition of occupational safety and health (OSH), workplace injuries, noise, illumination, audiometry, spirometry, total dust measurement and stack emission testing were performed. In addition, onsite training was conducted. All the field-testing activities were done using state of the art calibrated instruments.

4. Field Testing & Monitoring

A Labour & Human Resource Department team comprising of Sector Specialists & technical staff visited chemical and paint industries and collected data through questionnaires and checklists. In addition, hazards were identified and risk assessment of industries was performed.

5. Hazards Identification & Risk Assessment

Risk assessment activity was performed to assess and analyze the occupational hazards in all sections of chemical and paint industries. Following hazards were identified:

5.1 Chemical Hazards:

Chemical hazards include exposure to toxic dust such as lead chromate pigment, which can occur during weighing, filling of the mixer and mill hoppers, operations of unenclosed equipment, filling of powdered paint containers, cleaning of equipment and from spills of containers

In paint manufacturing, the two white leads (basic carbonate and basic sulfate), leaded zinc oxide, zinc oxide, titanium dioxide, and to a certain extent antimony oxide are used exclusively, mixed with extender pigments like magnesium silicate, barytes, mica, silica, chemically-active pigments zinc pigments used as raw materials. In chemical industries, exposure to ethanol vapours, hydrated lime and calcium carbonate dust was observed. These chemicals could cause corrosion, irritation to eyes and skin, and asphyxiation [14,15].

Chemical exposure without any PPE

5.2 Mechanical Hazards:

In chemical industries, mechanical hazards were observed due to conveyer belts, unguarded machines, welding, lathe machines, and damaged portable and hand tools. In paint industries, mechanical hazards

were observed due to press machines, mixers, unguarded electric motors and belts. These hazards could cause entanglement, crushing, strain and sprain, friction, abrasion and cut [16].

Mixing additives in a paint unit

5.3 Musculoskeletal Hazards:

In chemical and paint industries, ergonomic hazards included repetitive movement, manual loading, improper sitting arrangements. The most significant include force, repetition motion, awkward sustained postures, and static postures. The existence of these hazards increases the potential for developing musculoskeletal disorders (MSDs) such as back injuries, neck injuries, carpal tunnel syndrome, rotator cuff injuries, and others. These musculoskeletal problems are very concerning, especially for working people [17,19].

Workers without any proper sitting arrangement whilst at work

5.4 Biological Hazards:

In chemical and paint industries, hygienic conditions, drinking water and toilet facilities of workplace observed pathetic. In addition, bacteria and organic matter frequently coat the inside of pipes within the distribution systems. These could be sources of new contamination, or they could combine with chemicals already in the water to alter the health risks posed by drinking water [20].

Toilet refuse near workplace (biological hazard)

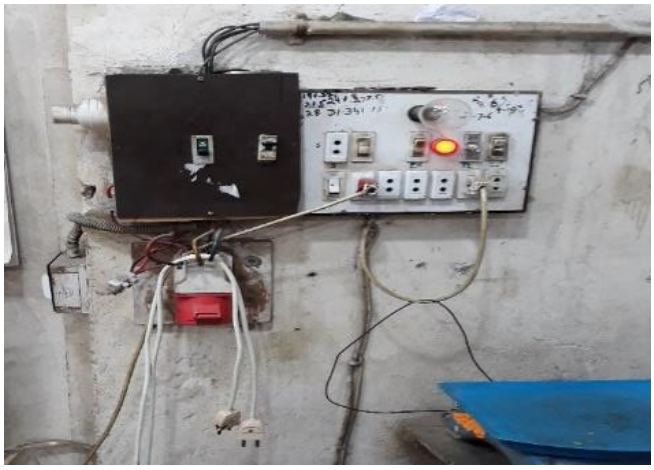
5.5 Physical Hazards:

The major sources of hazards observed in chemical and paint industries were high noise, high temperature and vibration, inadequate ventilation, heat stress, earth moving equipment, crushing of limestone, and mixing of solvents in mixers of high noise in the workplace. In addition, the manual handling of boxes, barrels, containers, etc., which contain the raw materials and finished products, is a major source of injury due to improper lifting, slip falls, dropping containers, etc.

Dust and noise exposure

5.6 Electrical Hazards:

In chemical and paint industries, damaged electrical installations were the primary source of electrical hazards. Electrical injuries may occur in various ways: direct contact with electrical energy, flash burns from the heat generated by an electrical arc, and flame burns from the ignition of clothing or other combustible, nonelectrical materials. In addition, contact with electrical current could cause a muscular contraction or a startle reaction that could be hazardous if it leads to a fall from elevation (ladder, aerial bucket, etc.) or contact with dangerous equipment [21].



Hanging wires and pluges

5.7 Fire Hazards:

In chemical and paint industries, storage of flammable chemicals and fuels in the same storage is the primary source of fire hazards. Inflammable gases and vapours give rise to one of the most dangerous industrial fire risks [22]. Solvents, pigments, ethanol vapours could cause massive fires in the workplace.

Stored chemicals without adequate labelling

6. Demographics

6.1 Worker's Educational Status

The literacy rate reported by workers summarized in **Figure 2** shows that 8.9% were illiterate, 22.3% primary, 30.4% middle, 23.2% matric, 6.3% intermediate, 3.6% graduate while 5.4% had a Masters degree.

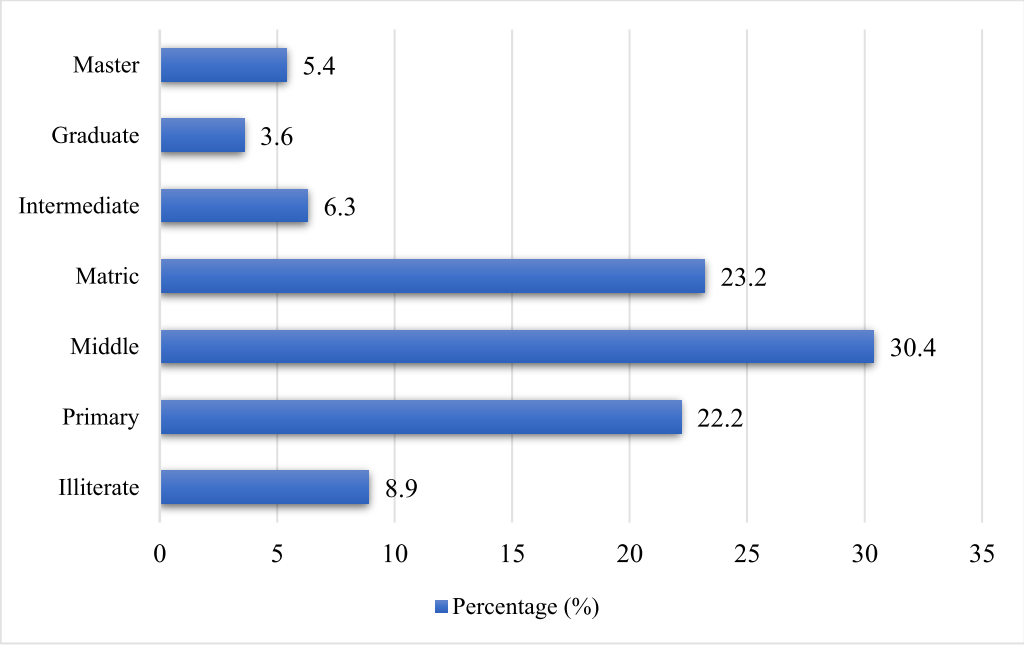


Figure 2: Educational Status of Workers

6.2 Worker's employment status

The employment status reported by workers summarized in **Figure 3** shows that 6.3% were on a contract basis, 8% on a part-time basis, 53% permanent, while 30% were on a temporary basis.

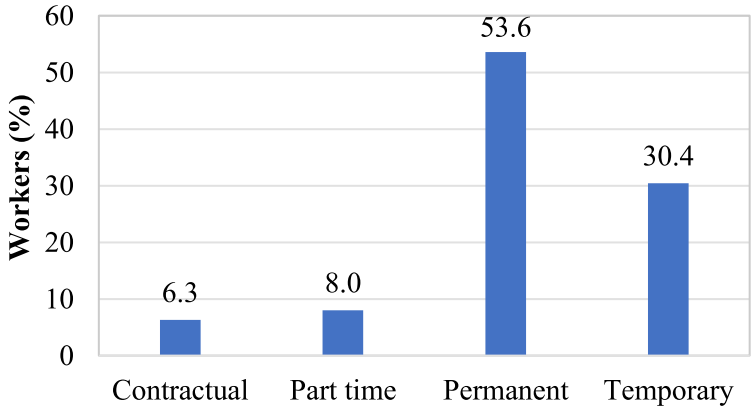


Figure 3: Worker's Employment Status

6.3 Worker's wage

The wage status reported by workers summarized in **Figure 4** shows that ~37% workforce were getting wages in the range of Rs. 17,500 to Rs. 20,000, while ~62% were getting their monthly remuneration above > Rs. 20,000.

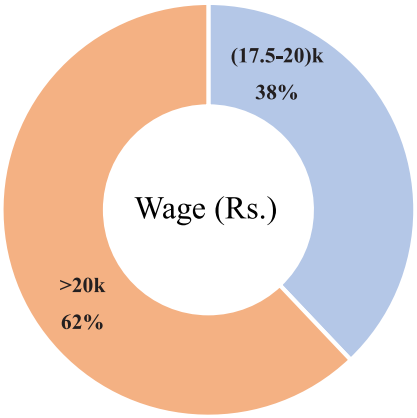


Figure 4 Worker's wage status

6.4 Illumination Testing

The illumination level monitoring was carried out to find out the light intensity in different sections/areas. The measurement was carried out by lux meter (EXTECH, Color LED Light Meter LT-45). In addition, General and localized lighting were measured at the site. Finally, the section-wise light intensity was calculated as the average of values taken at the workplace. Section-wise detail is summarized in **Table 1.**

Paint Industries				Chemical Industries	
Sr #	Department/Section	Illumination level (lux)	Sr#	Department/ Section	Illumination level (lux)
1-	Mechanical workshop near injection molding machine	45.3	1-	Compressor & steam turbine room	174.5
2-	Mechanical workshop near press machine	26.7	2-	Flaker hall	59.5
3-	Mechanical workshop near the folding press	45.3	3-	Workshop	310.4
4-	Enamel near mixing machine	162.5			
5-	Warehouse	301.1			
6-	Enamel near grinding machine	234.6			
7-	Emulsion process area	280.8			

The reference standard is DIN. The permissible limit for rough and bookkeeping /office work is 250 (lux) 500 (lux) respectively for eight hours work shift [23].

6.5 Stack Emission Testing

The stack emission monitoring was carried out during the general shift using calibrated Flue Gas Analyzer Testo 350. The results are summarized below:

Parameters	**Unit**	**PEQS**	**Generator (Cummins)**
Capacity	kVA	-	200
Load	kVA	-	Normal
Fuel	-	-	Diesel
O_2	%	NGVS	14.97
CO	mg/Nm^3	800	205
NO_x	mg/Nm^3	600	385.8
NO	mg/Nm^3	NGVS	353.2
NO_2	mg/Nm^3	NGVS	32.6
CO_2	%	NGVS	4.47
SO_2	mg/Nm^3	1700	0
H_2S	mg/Nm^3	10	71.6
Eff. N	%	--	73.1
Eff. G	%	--	69.2
Final Temp	°C	--	238.5

*The sum of NO and NO_2 values used for the calculation of NO_x value.
**NGVS: No guideline value set for mixed fuel.
***PEQS: Punjab Environmental Quality Standards.[24]

6.6 Chemical exposure and smoking habits of workers:

Impacts of chemical exposure, dust exposure and smoking were studied and summarized in **Figure 5.** The presence of limestone and hydrated lime dust, vapors of ethanol, fumes of resins, and a wide variety of volatile solvents adversely affect workers' health. Data shows that ~92% of the workers were exposed to different dust concentrations, ~8% were addicted to smoking, while ~41% were exposed to various types of chemical exposures during their routine work activities.

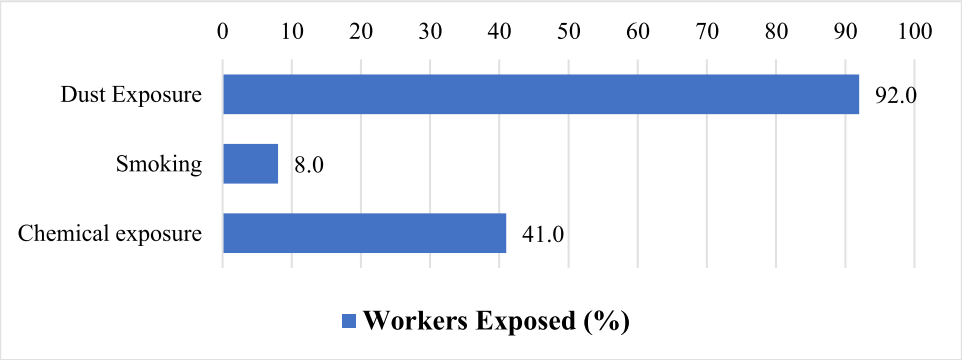


Figure 5: Wokers exposure to chemicals and dust

Spirometry testing was performed using MIR Spirodoc Spirometer to analyze the effect of chemical exposure on the worker's respiratory system. 132 workers were randomly selected from 1200 workers working in chemical and paint industries to perform spirometry testing. The results were analyzed and presented in **Figure 6,** demonstrating that ~44% of the workers had normal spirometry, while ~40% had mild to moderate restriction, and ~7% had severe respiratory restriction.

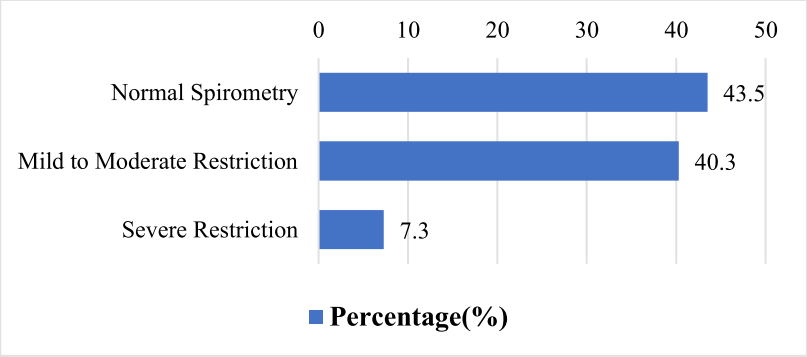


Figure 6: Pattern of spirometry of workers

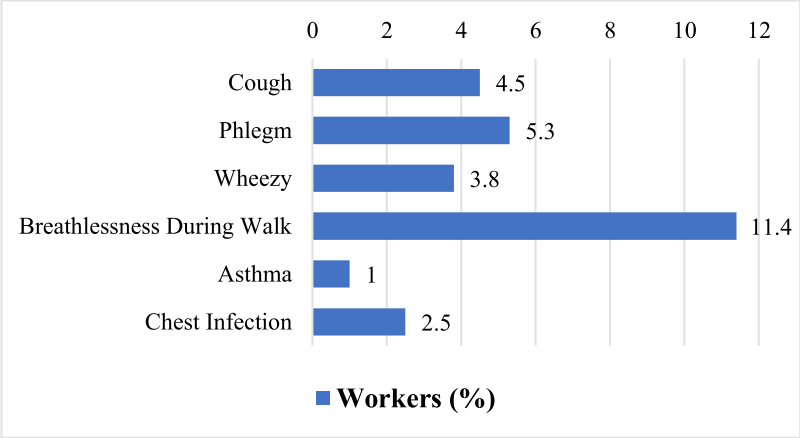


Figure 7: Respiratory problems

Data related to respiratory ailment among workers is summarized in **Figure 6.** Based on these facts, it was found that ~4.5% of the workers were having cough while ~5.3% phlegm, ~3.8% wheezy condition, breathlessness during the walk, chest infection was recorded as ~5.3%, ~3.8%, ~11.4%, and ~2.5% respectively. However, ~1.0% had reported about history of asthma.

At different sections of the industry, exposure monitoring of total dust (personnel exposure) was performed by using Casella personal dust sampler. The results are presented in **Table 2** with a maximum concentration of dust as 4.43 mg/m^{3,} which was less than the threshold limit of 10mg/m^3 as per ACGIH standards.

Paint Industry				Chemical Industry	
Sr#	**Department/ Sections**	**Total Dust (mg/m^3)**	**Sr#**	**Department/ Sections**	**Total Dust (mg/m^3)**
1-	Box Press	2.73	1-	Main workshop	0.87
2-	Box Cutter	0.94	2-	Bio gas plant	0.48
3-	Injection Molding	2.00	3-	Furnace	1.06
4-	Box Folding	1.57	4-	Mechanical service	1.55
5-	Enamel Filling	1.17	5-	Boiler house	1.86
6-	Vinyl Filling Hall	1.89	6-	Electrical steel plant	1.82
7-	Enamel Production Hall	2.02	7-	APC plant	1.26
8-	Vinyl Production Hall	4.43	8-	Mechanical alcohol plant	1.31
9-	NC-hall (car paint)	0.7	9-	Chemical alcohol plant	1.12
10-	Paint Lab	1.53	10-	Mechanical workshop hq	1.55
11-	Chemical Hall	1.78	11-	Maleic Anhydride	1.07
12-	Store	3.81	12-	Electrical	2.85

Table 2: Total dust monitoring (personal exposure) in different sections

6.7 Noise measurement:

Noise level monitoring was performed with Casella Precision Sound Level Meter-Type 2100. The measured values in dB(A), are presented in **Table 3.**

Paint Industry			Chemical Industry		
Sr#	Department/Sections	Noise level dB(A)	Sr#	Department/Sections	Noise level dB(A)
1-	Mechanical workshop near injection molding machine	84.2	15-	Raw Storage Parking area	61.7
2-	Mechanical workshop near press machine	87.9	16-	Finished good packing area	59.6
3-	Enamel near mixing machine	90.0	17-	Mechanical workshop (during welding)	93.2
4-	Mechanical workshop near the folding press	74.6	18-	Flaker hall	90.1
5-	Enamel near grinding machine	90.4	19-	Production & Distillation area	82.1
6-	Emulsion process area	80.2	20-	Compressor & steam turbine	93.6
7-	Warehouse	48.9	21-	Near cooling tower	77.1
8-	Near Generator	90.2	22-	Scrapyard	68.1
9-	Varnishing Packing area	95.8	23-	Alkyd Resin area	76.2
10-	Varnishing Mixing area	94.9	24-	Boiler area	88.5
11-	Enamel Production area	101.9	25-	Turbine area	118.2
12-	Enamel packing	84.4	26-	Alcohol plant	79.2
13-	Laboratory	86.0	27-	CO_2 plant	78.3
14-	Raw Material hall	70.1	28-	Workshop area	83.2

* The reference standard for OSHA permissible limits is 85 dB(A) for eight hours work-shift [25].

Table 3 Audiometry monitoring of workers:

The exposure of high noise levels was detected by using Sibelmed Audiometer. 94 workers were recruited by adopting convenient sampling techniques from the list of workers provided by the management of the enterprises. The percentage of workers as affected due to high noise exposure is summarized in **Figure 8,** which revealed that ~6% were normal, ~78% had slight to moderate hypacusia, ~15% had severe hypacusia.

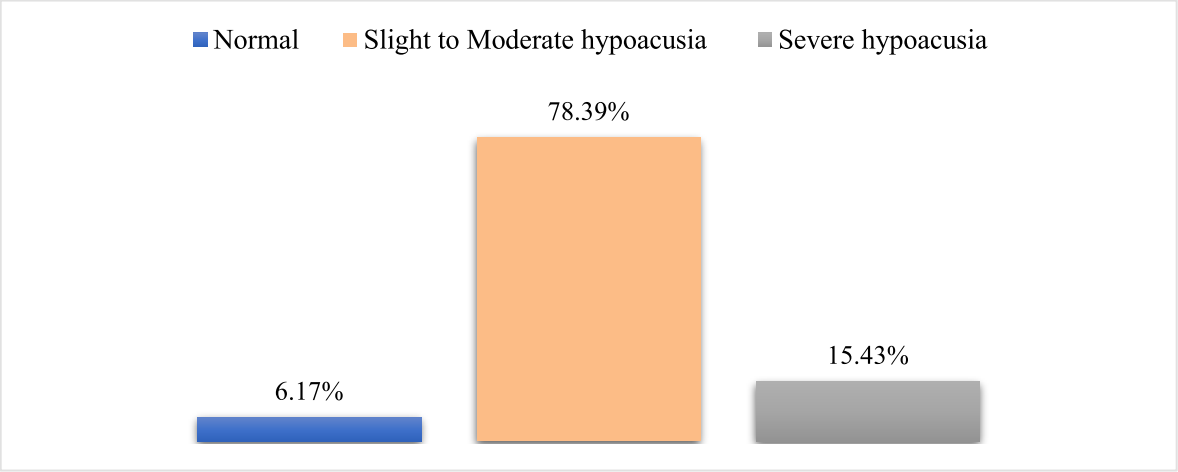


Figure 8: Impacts of noise exposure on worker's health

6.8 Physical activities and ergonomics issues:

Data related to physical work activities and their effect on workers' health was collected and graphically presented in **Figure 9**. It was noted that musculoskeletal disorders (MSD) were observed in workers based on their activities. In addition, these physical activities adversely affect workers' health recorded as, which may cause body weakness ~14.4%, backache ~13.6%, difficulty in moving legs/arms ~6.1%, moving head ~4.1%, bending knees ~6.8%, squatting ground ~1.5%, climbing stairs~1.5%, and back injury ~9.1% and MSD by use of mask ~6.4 %.

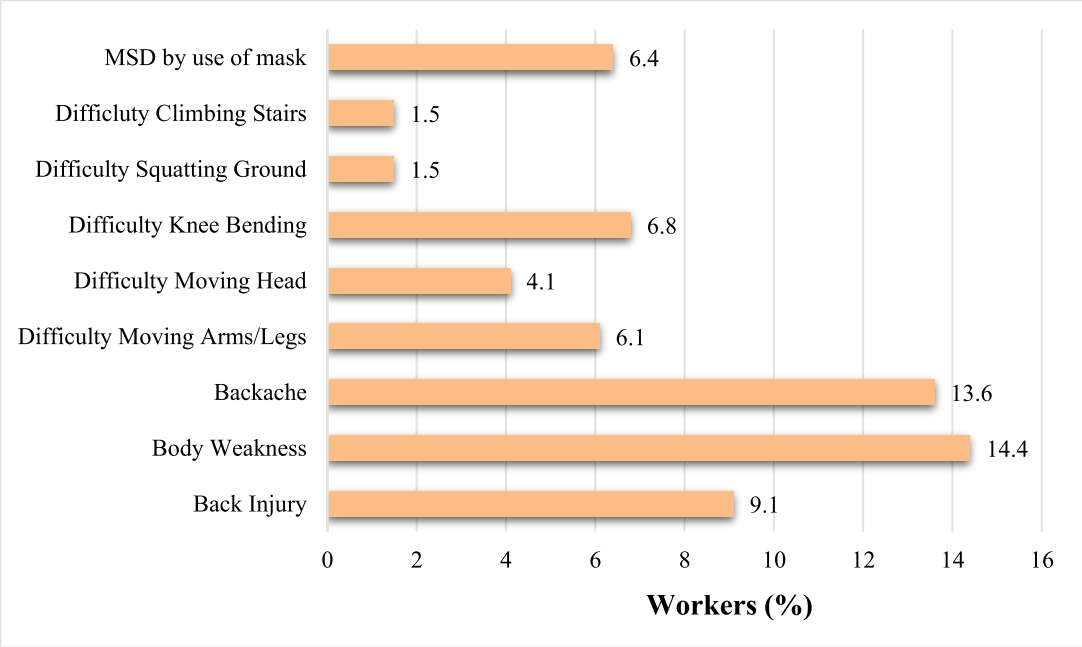


Figure 9 Impacts of physical work on worker's health

6.9 PPE's compliance by workers

Data was gathered to analyze PPE's compliance by workers, and PPE's providing trend of the employer is summarized in **Figure 10**. It was observed that ~84% were not having PPE'S and 16% were not adhering to or partially (which means using safety shoes/helmets while not wearing reflective jacket/goggles or vice versa) wearing PPE's at work site.

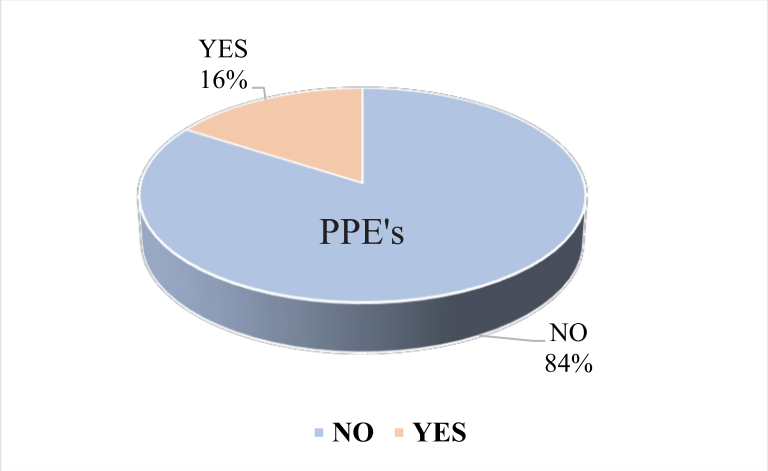


Figure 10 PPE'S compliance by workers

7. About COVID-19:

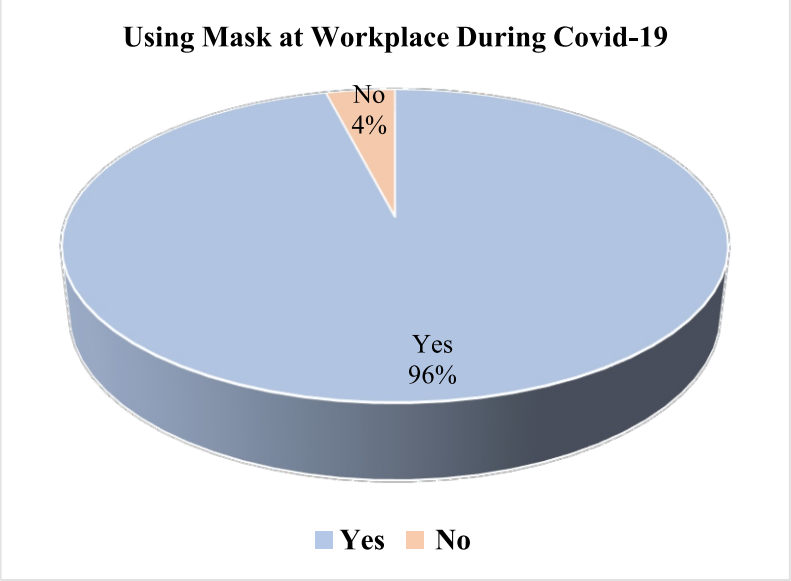
The COVID-19 pandemic has changed the world. As the science revealed that the COVID-19 virus was spreading via airborne droplets, public health and safety and health experts recommended the use of face coverings or respirators when around other people. COVID-19, which started in 2020 and is continuing into 2021, the SAA Centre for the Improvement of Working Conditions & Environment (SAACIWCE), Directorate General Labour Welfare Punjab, Labour & Human Resource Department received multiple requests for COVID-19 related trainings and follow-ups of standard operating procedures and performed several compliance assistance activities on respiratory protection at workplaces. As a result, SAACIWCE provided valuable information about occupational safety and health, risk assessment activities and personal protection to groups of employers, workers, and future workers during the pandemic.

It is the obligation of the employers, workers, and their organizations to collaborate with health authorities to prevent and control COVID-19. Cooperation between management and workers and their representatives is essential for workplace-related prevention measures. Workers are responsible for following measures for occupational safety and health, infection prevention and control

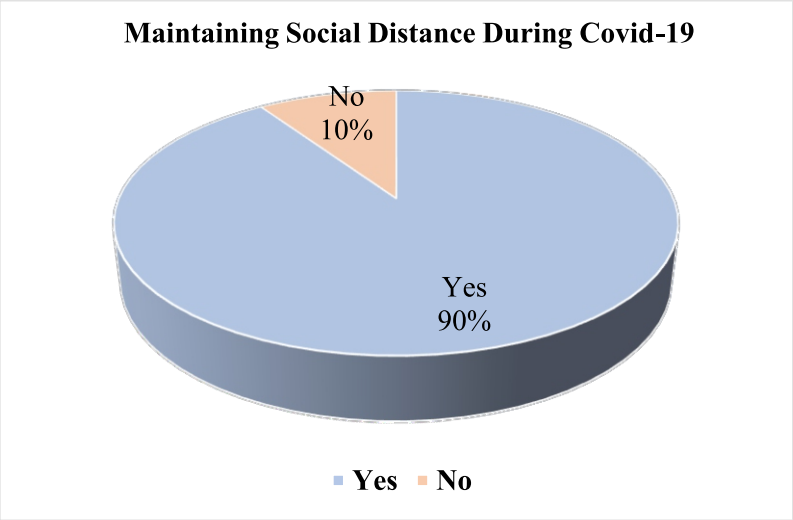
established for their workplace, and participating in training provided by the employer. Workers should immediately report to their supervisor any situation which may present an imminent and severe danger to their life or health. Even workers have the right to remove themselves from any workplace that they reasonably believe presents an imminent and serious threat to their life or health and should be protected from any undue consequences as a result of exercising this right (POSH Act 2019).

The pandemic has severely hampered the risk assessment activities on OSH during the field visits while maintaining the day-to-day guidelines issued by the Primary and Secondary Health Care Department, Government of the Punjab in accordance with the National Command Operation Centre (NCOC). During the OSH risk assessment activity, some questions related to the COVID-19 were also incorporated into the questionnaire. Analysis of the data showed that in the Chemical & Paints sector, as handwashing facilities were provided to the workers, on average, every worker washed their hands nine times daily. In these times of the pandemic, wearing a mask at the workplace is mandatory.

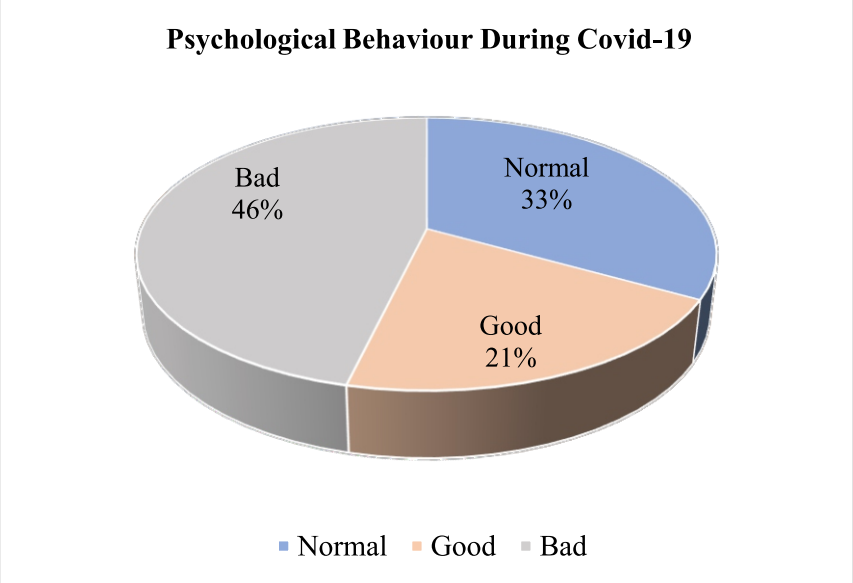
Around 96% of workers responded they were using a mask at the workplace. An average of Rs.461/- per month was being spent on purchasing them by the employer.



The data showed that around 90% of the workers and their co-workers maintained social distancing while at work. By applying statistical tools on the data, it was evident that the respiratory problems among the workers were more who were repeatedly using the mask due to non-availability of sufficient financial resources or carelessness in using them. These results are in agreement with the research studies conducted by the University of Health Sciences Lahore.



Workers were asked about the psychological behaviour during the covid-19 times. 21% of the workers responded to the behaviour as good, 33% normal, while 46% bad.



8. Recommendations and Suggestions

1. Safety and emergency procedures must be developed. In addition, material safety data sheets (MSDS) must be provided in the workplace.
2. Personal protective equipment for chemical handling must be provided to workers
3. Chemical risk assessment must be frequently performed in workplaces
4. Training related to safe, handling, storage, utilization of chemicals must be provided to workers
5. Mechanisms must be developed for secondary containment and spill control.
6. Storage of chemicals must be done per their hazard classifications.
7. Hazard communication program must be developed
8. Guidelines must be prepared for the safe disposal of chemicals
9. Engineering controls must be introduced to minimize the exposure of chemicals to workers
10. Spill kits must be provided in the workplace

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(Annexture # 1)

10. Checklists for workplace inspection

Chemical Risk Assessment Checklist			
Hazard Identification	**Yes**	**No**	**Action Required**
Were all the risks a worker could suffer while handling, using, and storing the hazardous chemicals managed?			
Were the safety data sheets (SDS) related to hazardous chemicals available at the workplace and provided to workers?			
Were the hazardous chemicals labelled with the necessary information?			
Were the mandatory personal protective equipment provided to workers?			
Were the procedures exist for decontamination of the workplace in case of a chemical spill?			
Were flammable, reactive and toxic chemicals stored in highly ventilated areas and a separate compartment?			
Was ventilation equipment provided for removal of contaminants and operating correctly?			
Were employees complaining about dizziness, headaches, nausea, irritation, or other discomfort factors when they use solvents or other chemicals?			
Were chemicals, which give off toxic asphyxiant, suffocating or anaesthetic fumes stored in remote or isolated locations from the workplace?			

11. Light Level Monitoring Checklist

Date: _____ **Time:** _____

Sr. No.	Departments/ Sections	Light Level (lux)	Average light Level (lux)	Remarks
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				

12. Noise Level Monitoring Checklist

Date: _____ **Timing:** _____

Sr. No.	Departments/Sections	Noise Level dB(A)	Remarks
1.			
2.			
3.			
4.			
5.			
6.			
7.			

Under ADP Scheme Capacity Building of Occupational Safety and Health (OSH)
Regime to Promote Safer Working Conditions at Workplaces)
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