Assessing Lung Function Test Behaviours in Petrochemical Workers: Safety Performance and Influencing Factors via Anderson Model

Kunwar Himanshu[1], Dr. Sumit Bhatiya[2]

[1]M. Tech. Scholar, Department of Industrial Safety Engineering, IES-IPS Academy, Institute of Engineering & Science, Indore, 452012, MP, India
Email: *connectwithhimanshu96[at]gmail.com*
[2]Associate Professor at IPS Academy, Institute of Engineering & Science, Department of Fire Technology & Safety Engineering, Indore, MP, India

Abstract: ***In this study, Anderson Behavioural Model is used to investigate factors influencing LFT and measure Peak Expiratory Flow Rate (PEFR) in petrochemical workers. Factors affecting participation in PFT were assessed with a questionnaire based on Anderson's Behavioural Model. A multi-stage sampling approach was employed to account for geography and workforce distribution to ensure a comprehensive representation of the petrochemical plants. This paper aims to add to the understanding of workplace health issues. Schooling level (college/university and above, OR = 0.142, P = 0.0034), and affordability of medical care, (OR = 0.348, P = 0.003) significantly influenced participation among 300 workers. Other important variables were self-care (OR = 4.92, P = 0.0005) daily activity (OR = 7.68, P = 0.0002), pain/distress (OR = 0.487, P = 0.003), concern/depression (OR = 14.40, P <0.0001). Males showed PEFR variability at 0%, 23.3%, and 76.7% and females at 0%, 2%, and 98%. Education in improving PFT participation, financial stability, respiratory health awareness and psychological support is needed to improve PFT participation. Adverse effects of hazardous chemicals need preventative measures as they can be prevented with comprehensive respiratory health checks and educational initiatives. Surmounting financial and knowledge barriers is necessary to increase lung function test participation by petrochemical workers.***

Keywords: Anderson Model, Influencing Factor, Lung Function Test, Petrochemical Industries, Safety Performance

1. Introduction

Pulmonary function test also known as PFT is a test that measures how the lungs are functioning. The National Health Mission (NHM) therefore does recommend an annual lung function check on people who are forty years old and above [1]. The tracking of respiratory illness progression is facilitated by PFTs at both the patient level and the population level. Nonetheless, interpretation variability occurs when similar lung function measurements in litres are different in percentages of references, mainly because of ethnic references, height references, sex references, and age references [2]. When children with chronic diseases transfer from paediatric to adult health care, similar measured values mean different things. Lung tissue and muscles weaken with age, alveolar walls thin, and elasticity declines, all of which complicate interpretation [3, 4]. In 2016, 251 million people had COPD, and the number reportedly increased with population ageing [4]. The objectives of the study are: Utilising the Anderson Behavioural Model to determine antecedents to workers of the petrochemical industry which discourage them from undergoing lung function tests. Further, the study will also identify ports of entry of the hazardous substances and the maximum permissible levels to which these substances can be allowed in the petrochemical industry or working environment of the workers in a Horn of Africa country interested in the successful establishment of the industry. The purpose as put by the authors is to enhance the safety of the workplace, the health check of the employees, and the protection of the employee.

2. Literature Review

These studies indicate that the environment, lifestyle, and indoor conditions significantly impact cardiorespiratory health, particularly due to urbanization and industrialization, which increase air pollution. Key pollutants include NO_2, VOCs, $PM_{2.5}$ and PM_{10}, and UFPs, all linked to cardiovascular and pulmonary diseases [5]. These pollutants can enter the respiratory tract and bloodstream, causing chronic damage. Susceptible populations, such as offspring, mature, and low-income entities, face higher exposure risks [6]. $PM_{2.5}$ is particularly hazardous due to its small size, contributing to breathing ailments like bronchitis, asthma, and COPD [7]. The link between $PM_{2.5}$ and health issues, independent of temperature, necessitates policy interventions to mitigate pollution. PM_{10}, while larger, is prevalent in urban areas due to vehicle emissions and industrial activities [8]. Research by Mozurkewich et al. shows that high NO_2 levels worsen respiratory illnesses by damaging lung epithelial cells and causing inflammation [9]. UFPs exacerbate respiratory diseases, especially in children, as they can penetrate biological barriers and affect multiple organs [10-11]. This underscores the need for stricter regulations around UFP emissions, particularly near high-risk areas like airports. Air quality and respiratory health are influenced by urban planning, with factors such as building density and green space affecting air circulation. Hirzel et al. [12] highlight that poor urban design can trap pollutants, worsening respiratory conditions. In Dhaka, one of the world's utmost unclean cities, extreme $PM_{2.5}$ levels during peak hours lead to severe respiratory effects [13]. Toxic trace elements in $PM_{2.5}$ further exacerbate health impacts. Indoor air pollution is another significant factor in low- and middle-income countries, with gas or biomass cooking releasing harmful byproducts that increase respiratory symptoms. Pan et al. [14] found that prolonged exposure to these fuels heightens respiratory disease risk, particularly for women who cook for extended periods. Fuel stacking in peri-urban sub-Saharan Africa compounds this issue, exposing individuals to harmful contaminants for longer durations. Parvizi et al. [15] emphasize the heightened health risks for women and children compared to men. Damp indoor environments can promote mould growth and VOC release, worsening respiratory illnesses, with gender-specific impacts noted in several studies [16]. Persistent dampness encourages microorganisms, further aggravating respiratory issues. Emerging contaminants like microplastics also pose threats; Jin et al. [17] found that microplastics in the air accelerate lung cell ageing and respiratory failure through oxidative stress. These results focus on the essential for effective interferences to mitigate microplastic impacts on respiratory health. Huang et al. [18] showed that toxic components in incense smoke (auramine) promote lung cancer and chemoresistance in non-small cell carcinoma. Carcinogenic compounds in incense smoke released over long-term exposure harm respiratory health. Gestational exposure to NO_2 and other pollutants disrupts lung development in children, predisposing them to long-term respiratory issues. Prenatal exposure to pollutants affects fetal lung development with lifelong consequences [19]. These findings underscore the need to protect vulnerable populations, including pregnant women and children, from harmful pollutants. Technological advancements, including digital health sensors and GIS-based models, have enhanced our understanding of pollution-health relationships. These tools enable the monitoring of environmental health risks and targeted interventions. GIS-based models used by Hirzel et al. [20] studied the spatial distribution of health outcomes related to urban planning and respiratory health. Biomarker studies have also clarified how pollutants affect health. For instance, Li et al. [21] reported that inflammation worsens air pollution's impact on lung function, while Wang et al. [22] investigated the protective effect of the Nrf2 protein against PM2.5-induced imbalances. Experience shows that switching to cleaner fuels like LPG effectively reduces indoor air pollution. Parvizi et al. [23] demonstrated that using LPG in peri-urban areas reduces exposure to harmful substances detrimental to respiratory health. However, environmental free radicals (EPFRs) within $PM_{2.5}$ continue to worsen oxidative stress, inflammation, and cellular damage. A Nanjing study found that $PM_{2.5}$ chemical composition significantly determines its toxicity, calling for tightened pollution controls [24]. Studies on mice show that NO_2 exposure during pregnancy leads to fetal lung abnormalities and altered long noncoding RNA (lncRNA) expression [25]. Disruptions during critical developmental periods result in lifelong respiratory health consequences. Respiratory disorders are also linked to tobacco goods, including e-cigarettes. Smoking upsurges the peril of bronchitis and COPD [26] and can affect asthma risk [26]. Studies of Paris cab drivers exposed to UFP and black carbon reveal acute respiratory risks, particularly from UFP [27]. Drivers face additional respiratory condition risks from prolonged pollutant exposure during workdays. The impact of acute respiratory infections (ARI) on mental and physical health has long-term consequences, making individualized posts.

3. Methodology

3.1 Source of Information

Using a multi-stage sampling such as based on geographic divide data were collected from workers of all demographics from different regions in India. It was a complex account in the input, and there were many populations. Six administrative zones of North, South, East, West, Central and Northeast states, and union territories were selected. Four to five randomly chosen zones were chosen to ensure impartiality and representation. Two cities within each zone were picked which have a high frequency for a worker to seek jobs to be sampled. The East (Bihar, West Bengal), North (Central, West), South (Central, West), and Central (Central, West) Zones, as well as Assam (Guwahati, Silchar) and Meghalaya (Shillong, Tura) from the Northeast, were selected, randomly, to populate the switchboards. By choosing the percentage of the urban and rural population of India and gender, the sample size was determined by quota sampling. This was a valid study since the workforce of India was quite well represented in this method. As a result, the study brought a clearer and more precise idea of Indian labourers' lives, and followed strict research standards, to illustrate India's wide labour force.

3.2 Criteria for Anderson model:

A. Inclusion Criteria for Anderson model & Peak Expiratory Flow Rate:

a) Indian nationality.
b) Permanent residence in India.
c) Woking in the petrochemical industry for at least 5 years.
d) Voluntary participation in the study.
e) Investigators (after interviewing each patient one by one to evaluate basic skills) used to assess the ability to understand the meaning of each questionnaire entry.
f) Completing the online questionnaire alone (or with assistance from an investigator).

B. Exclusion Criteria for Anderson method:

a) People who were mentally sick or disoriented.
b) People who were taking part in other comparable research initiatives elsewhere.
c) People who refused to cooperate were the exclusion criteria. A mix of systematic checks and self-reporting was the major technique used to assess mental health status (certain local health institutions retain records).

C. Exclusion Criteria for Peak Expiratory Flow Rate:

a) Not taking non-hazardous chemicals.
b) People with known renal, breathing, endocrine, coronary, and nervous system ailments were left out of the study.
c) People who were taking part in other comparable research initiatives elsewhere.
d) People who refused to cooperate were the exclusion criteria.

But often surveyed people had less detailed information about their community than local employees, like neighbourhood committee or health centre members. The data for this study comes from India's states and union territories as a broad public health academic network. Community health centres and neighbourhood committees in selected states were contacted by the researchers from the School of Public Health to participate in the survey. For this purpose, local networks and sites were established. The survey was created as an online questionnaire and local investigators, trained in quota design, recruited them through posters, communication tools and personal interaction. Participants consented to participation and were administered the survey via a provided link, with data automatically collected by the server. Participants were aged 26 to 46, and all participants with incomplete answers or logical errors (e.g. duplicate or implausible height and weight data) were excluded. An 89.8% return rate was achieved with 334 questionnaires received of which 300 were valid.

3.3 The Anderson model:

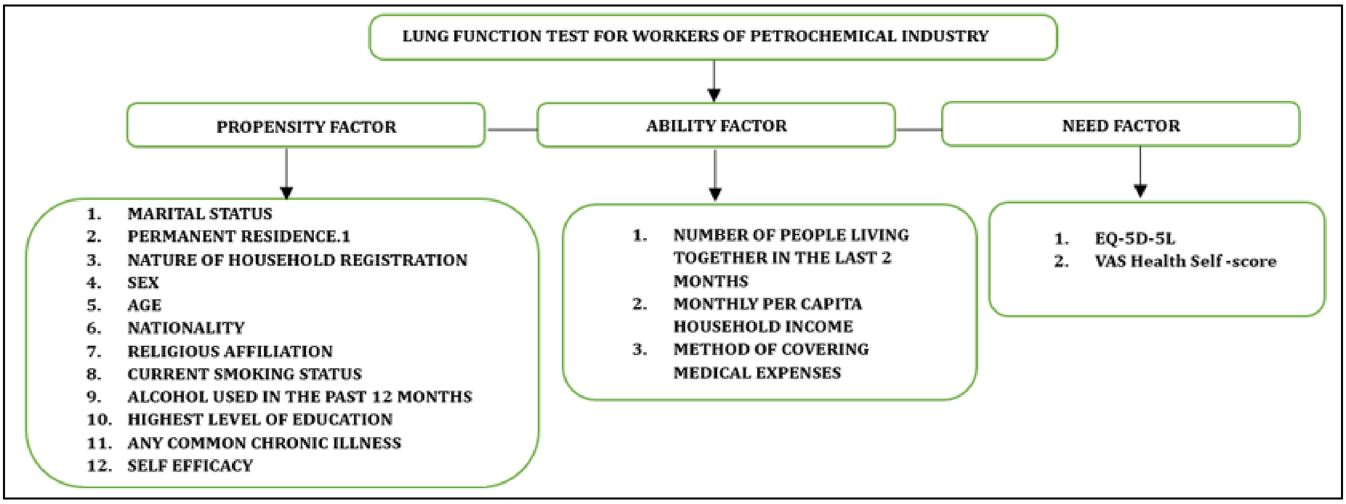

Figure 1: The Theoretical model of this paper [19]

In 1968, Ronald Max Anderson developed the Anderson Model, or Health Service Utilization Model, to investigate individual-level variables related to health service uses [30-31]. Over time it has become a foundation for understanding healthcare utilization behaviours [33]. The model categorizes factors affecting healthcare consumption into three areas: Aptitude (ability to access services, such as financial resources), Need (actual health needs), and Propensity (willingness to use services). [34]. It has been modified by research situations, retaining its basic principles. The SWOT analysis of the work points to the strengths of identifying barriers to access and dictating policy while pointing to weaknesses of their generalizability to different cultural or economic contexts. There are opportunities for standardizing healthcare research in India and to derive lessons to improve access delivery. Nevertheless, a serious issue against this is the model's lack of study and implementation in India, contrary to rendering it incapable of overcoming healthcare issues [23].

3.4 Peak Expiratory Flow Rate (PEFR):

A simple, non-invasive method to assess how rapidly an individual can breathe out, the PEFR test also monitors respiratory conditions (such as asthma) and measurements of lung function. A handheld peak flow meter is used to take readings which are recorded as litres per minute (L/min). The test is conducted by the patient when upright (standing or sitting) and it employs a disposable mouthpiece for hygiene. The patient then inhales deeply seals their lips around the mouthpiece of the device and then forces a breath out forcefully into the device. Accuracy is three times repeated and the highest value is recorded. We compare results to the patient's personal best (if known) or standard reference values (standardized by age, gender, and height). For effective asthma management, patients are advised to maintain a peak flow chart, interpreting results as follows: They go from a green zone, which means 80% to 100% of individual best, safe; yellow zone, which is between 50% and 80%, meaning alert; and red zone, which is less than 50%, means emergency.

4. Research tools

4.1 For Anderson's model:

1) Reliant on measure:

Lung Performance Assessment Status, which was a solitary option quiz; the query was: In our case, the choice was to do nothing, never plan to adopt the behaviour, or else plan to adopt the behaviour within one year, within six months, shortly, at present, in a few weeks, or immediately. In this research, the first three options – not adopting the behaviour – and the last three possibilities - being a 'would be' first adopter at least once at the age of 30 - combined are not practising the lung function testing behaviour. The value for having taken the behaviour in some way was 1 for taking the behaviour at least once, and 0 for the value of not having taken the behaviour.

2) Independent measure:

a) Configuration of tendency factors:

Information on tendency factors was primarily rudimentary data on Statistical attributes and domestic attributes, together with matrimonial status, Sexuality, age, nationality, religious belief, category of domicile status, enduring residential location, current cigarette habit, whether or not they had an alcohol consumption in the past 12 months, BMI, the uppermost schooling level, retired status, the prevalence of communal chronic diseases, (stroke, hypertension, asthma, chronic obstructive pulmonic disease, coronary heart disease, diabetes, cancer Self-efficacy is an individual's subjective rating on in what way capable they are at doing a particular task, and the result is directly linked to an individual's impulse, so self-efficacy can in some way influence healthcare decisions. The New General Self-Efficacy Scale (NGSES) comprises 8 items with 5 response options: strongly oppose, oppose, neutral, support, and strongly support. In this study, self-efficacy was measured using the Universal Self-Efficacy Scale (GSS) [25]. Each response was assigned a score: strongly oppose = 1, oppose = 2, neutral = 3, support = 4, and strongly support = 5. A higher self-efficacy score indicates greater self-efficacy among respondents [25]. The reliability of the scale (Cronbach's α = 0.872) [26] was found to be high.

b) Composition of Ability Factors:

The aptitude factor is usually studied through the number of individuals in the household in the last 2 calendar months, the scheduled monthly per capita revenue of the household, and ways medical expenditures are conventional.

4.2 Composition of Need Factors:

The EQ-5D-5L is not very popular in India as a patient health status instrument or for healthy individuals. As a result, it has limited usage as a measure of health and survival and is not widely working to evaluate the health-related quality of life (HRQOL) within the country. The Indian version of EQ-5D-5L shows high dependability, with a Cronbach's α of 0.624 and a KMO test rating of 0.685, covering 5 dimensions: movement, self-care, everyday actions, agony/uneasiness; and concern/sadness. Each dimension has 5 reply possibilities (no difficulties to extreme difficulties) where if even you have an issue, you are "having a problem." The Health Effect Value Visual Analogue Score (EQ-5D-VAS) measures a person's health state–respondents report how they feel about their health state, scoring on a scale from 0 to 100 (lower = worse) where a higher score represents better health. Scores in this study were categorized as poor (≤60), fair (60–79), and good (≥80). The VAS demonstrates impressive retest reliability (0.99) and the research by Elton et al. reinforces its validity as paralleled validity ranges with the MPQ showed the range of 0.60 to 0.63 in the Indian context indicating the reliability of the tool.

1) For Peak Expiratory Flow Rate:

a) Dependent variable:

The Peak Flow Meter is part of the Peak Expiratory Flow Rate (PEFR) test equipment and measures the speed of forced air exhaled. Digital meters are mechanical meters with additional features such as accurate readings and additional data storage. In clinical settings where recording charts or logbooks are made, hygiene is ensured by disposable mouthpieces, and results can be tracked crosswise over time by recording them in charts or logbooks. In certain cases, an air escape through the nose is prevented by a nose clip to measure air accurately. The cleaning of reusable parts with sanitiser such as alcohol wipes is an important step to cleaning the device, as well as hygiene and reliability.

b) Quality control and Data processing methods:

A systematic plan was followed in conducting the question which surveys with accuracy and overtly ethics. Participants were required to give informed consent and answers were to be independent to minimize bias. Questions in the original questionnaire were followed except that needed explanations were provided to participants who had such issues with literacy or language. Data quality was ensured through the complete or illogical responses. We confirmed data accuracy through several computations and testing, preserving the study's integrity. Scores from self-efficacy, VAS, EQ-5D-5L health status, and demographic variables were entered into R-4.4.2 data analysis of frequencies and percentages. Relationships between market variables were explored via a univariate analysis using the Anderson Behavioural Model; chi-square tests were performed to identify significant patterns. Factors influencing lung function testing were assessed using stepwise binary logistic regression and the dependent variable was the participant's acceptance of testing. Self-efficacy, VAS scores and EQ5D 5L health status, as well as the sociodemographic traits, were treated as variables, and their significance level is α = 0.05.

Table 1: Adjustable preps for Monovariate and Multifaceted analyses.

Factors	Parameters	Allocation
Tendency Aspect	Matrimonial status	Married = 0; Other = 1
	Place of permanent house	Urban = 0; Rural = 1
	Characteristics of household	Non-agro = 0; Agro = 1
	Sexuality	Male = 0; Female = 1
	Age	26–44 = 0; ≥45 = 1
	Nationality	Indian = 0; Other racial = 1
	Religious belief	No religious affiliation = 1; Religious affiliation = 0
	Cigarette habit	Non- smoker = 0; Smoker = 1
	Have you Gobbled Liquor in the last 12 months?	Never drink = 0; Drink = 1
	BMI (kg/m2)	<18.5 = 0; 18.5–24.9 = 1; ≥25 = 2
	The uppermost level of schooling.	Elementary school and below = 0; Junior high school, Senior high school, and secondary school = 1; College and above = 2
	Any Usual chronic diseases (e.g. diabetes, high blood pressure, etc.)	No = 0; Yes = 1
	Self-Efficacy	>30(high grouping) = 0; 20–30 (medium grouping) = 1; <20 (low grouping) = 2 (completely oppose = 1; oppose = 2; neutral = 3; support = 4; completely support = 5)
Aptitude aspect	Count of people cohabiting during the previous 2 months	0–1 individual = 0; 2–3 individuals = 1; >4 individuals = 2
	Monthly per capita household income (Rupees)	≤20000 = 0; 20001–30000 = 1; ≥30001 = 2
	How medical costs are Covered?	Self-sustained = 0; other = 1
Necessity aspect	EQ-5D-5L	
	Movement	Problematic = 1; No problem = 0

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	Self-care Daily action Agony /discomfort Concern /depression VAS	Problematic = 1; No problem = 0 Problematic = 1; No problem = 0 Problematic = 1; No problem = 0 Problematic = 1; No problem = 0 80–100 score (high category) = 0; 61–79 score (medium category) =1; 0–60 score (low category) = 2
Dependent parameter	Lung Performance Assessment Status	Has not Executed the deed = 0; Has Executed the deed at least one time = 1.

Table 2: Statistical features and consequences of monovariate analysis of lung purpose assessments in petrochemical industry workers (n=300)

Benchmarks	Sharing Characteristics	Proportion of persons	Composition ratio (%)	Proportion of persons tested	Detection rate (%)	χ2	P
Matrimonial status	Wedded Other	260 40	86.7 13.3	190 21	73.0 52.5	7.035	0.008
Count of people cohabiting during the previous 2 months	0–1person 2-3person ≥4 persons	146 94 60	48.7 31.3 20.0	110 71 30	75.3 75.3 50	14.86	0.0006
Place of permanent house	City Village	190 110	63.3 36.7	164 57	86.3 51.8	42.74	0.00011
Nature of household	Non-agricultural Agricultural	290 10	96.7 3.3	204 7	70.3 70	0.0006	0.98
Monthly per capita household income (Rupees)	≤20000 20001–30000 ≥30001	16 61 223	5.3 20.3 74.4	7 58 146	43.7 95.0 65.5	25.85	<0.00001
Gender	Male Female	150 150	50.0 50.0	123 88	82.0 58.7	19.6	0.00001
Age	26–44 ≥45	298 2	99.3 0.7	209 2	70.1 100	0.84	0.36
Ethnicity	Indian Other nationalities	300 0	100 0.0	211 0	70.3 0.0	N/A	N/A
Religious persuasion	Non-Religious persuasion Religious persuasion	290 10	96.7 3.3	208 3	98.6 30	8.06	0.0045
Cigarette habit	No Cigarette habit Cigarette habit	190 110	63.3 36.7	135 76	71.0 69.1	0.13	0.72
Over the past 12 months, have you consumed alcohol?	Never consumed in the past 12 months Consuming	210 90	70.0 30.0	148 63	70.5 70.0	0.007	0.93
BMI (kg/m2)	<18.5 18.5–24.9 ≥25	116 126 58	38.7 42.0 19.3	73 109 29	62.9 86.5 59.0	30.34	0.0024
The Uppermost level of schooling	Preparatory school Intermediate school and secondary school College and above	167 93 40	55.7 31.0 13.3	129 69 13	77.2 74.2 32.5	31.93	0.0011
How medical costs are covered?	self-sustained Non-self-sustained	112 188	37.3 62.7	63 148	56.3 78.7	16.99	0.00004
Retired or not	No Yes	300 0	100 0.0	211 0	70.3 0.0	N/A	N/A
Any Usual chronic diseases (e.g. diabetes, hypertension, etc.)	No Yes	163 137	54.3 45.7	118 93	72.4 67.9	0.73	0.4
VAS	High Category Medium Category Low Category	171 116 13	57.0 38.7 4.3	123 85 3	71.9 73.3 23.1	14.60	0.0007
Self-Efficacy	High Category Medium Category Low Category	154 134 12	51.3 44.7 4	118 88 5	76.6 65.7 41.7	9.042	0.011

Table 3: 5D valuation standing of the worker's population tested for lung purposes.

Dimensionality	No concern				Concern				χ^2	*P*
	Persons Proportion	Percentage of person proportion (%)	Tested People Proportion	Detection rate (%)	Persons Proportion	Percentage of person proportion (%)	Tested People Proportion	Detection rate (%)		
Movement	300	100	211	70.3	0	0.0	0	0.0	0	1.0
Self-care	221	73.7	176	79.6	79	26.3	35	44.3	34.8	0.00045
Day-to-day action	236	78.7	189	80.1	64	21.3	22	34.4	50.4	<0.00001
Pain/ discomfort	193	64.3	126	65.3	107	35.7	85	79.4	6.61	0.01
Anxiety/depression	231	77	193	83.6	69	23	18	26.1	84.08	<0.00001

Table 4: Multifaceted investigation of lung performance assessment in petrochemical industry workers

Indicator	B	Standard error	Waldχ^2	P	OR	OR95%C.I.	
						Upper limit	Lower limit
The Uppermost level of schooling (comparison group = primary school and below)							
Intermediate schools	-0.166	0.300	0.306	0.580	0.847	1.526	0.470
College and above	-1.952	0.384	25.840	0.0034	0.142	0.302	0.067
Way of payment for Treatment costs (comparison group = self-pay)							
Non-self-sustained	-1.057	0.261	16.401	0.0340	0.348	0.579	0.208
EQ-5D-5L Movement (Comparison group = no concern)							
Concern	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Self-care (Comparison group = no concern)							
Concern	1.593	0.281	32.158	0.0005	4.920	8.536	2.832
Day-to-day action (Comparison group = no concern)							
Concern	2.040	0.315	41.941	0.0002	7.680	14.083	4.100
Agony/discomfort (Comparison group = no concern)							
Concern	-0.720	0.284	8.927	0.0030	0.487	0.085	0.280
Concern/depression (Comparison group = no concern)							
Concern	2.670	0.326	67.080	<0.0001	14.400	27.300	7,59
Self-efficacy (Comparison group = High Category)							
Medium Category	-0.560	0.283	3.916	0.0480	0.571	0.956	0.315
Low Category	-1.523	0.616	6.113	0.0130	0.218	0.729	0.065

5. Results

5.1 For Anderson's model

1) Descriptive statistics:

a) Descriptive data of tendency aspects:

An entire of 300 defendants was counted in this report; 0% were aged 51-60;19.33 % were aged 41–50;42% were aged 31-40; 38.67% were aged 21-30;0% were below age 20; the mainstream of marital status was married 86.67% and 13.33% were unmarried or divorced; 63.34% were urban in their place of the house and 36.66% were rural; 96.67 % were non-agricultural and 3.33% were agronomic; the gender ratio was the same for both gender 50%; the ethnicity was Indian 100%; Workers those who have religious beliefs 96.67% and those who have no religious beliefs are 3.33%; The Largest share of respondents had no antiquity of smoking 63.33% and the worker who has a history of smoking 36.67%; 70% of them had never consumed alcohol and they have consumed 30%; 0.67% of the workers comes underweight in BMI whose range was less than or equal to 18.5;54.33% of the workers comes under Healthy weight in BMI whose range was 18.5–24.9; 45% of the workers comes under Overweight in BMI whose range was 18.5–24.9 and lastly 0% of Workers comers under Obese whose BMI range is more than 30; 13.33% of the individuals had an education level of university or above (Table 2); 100% were employed (not retired); 54.33% had no chronic diseases; the high self-efficacy category constituted 51.3%, the medium category 44.7%, and the low category 4% (Table 2).

b) Descriptive data of aptitude aspects:

When considering aptitude factors, 48.67% of households had 0-1 individuals, 31.33% had 2-3 individuals, and 20% had more than 3 people living together in the past two months. 74.33% of families had a per capita monthly income of ≥ Rs30000, and 62.7% of medical expenses were paid by non-self-sustained households (Table 2).

c) Descriptive data of necessity aspects:

The Health Outcome Value Visual Analogue Score (VAS) assesses general health, with scores of 60 or below classified as low (4.3%), 61-79 as intermediate (38.7%), and 80 and above as high (57%) (Table 2). In the EQ-5D-5L, the highest proportion of 'no problems' was recorded in 'self-care' (83.7%), while the greatest percentage of 'problems' was found in 'Agony/discomfort' (46.3%) (Table 3).

5.2 Monovariate investigation of lung performance assessment in petrochemical industry workers

Tendency, aptitude, and necessity aspects were used as autonomous variables, and whether study applicants had accepted the act of lung performance assessment as the reliant variable was used in monovariate analyses. Whether retired, Age, the uppermost level of schooling, conviction (belief), self-efficacy, mode of health care affordability, monthly per-head household revenue, "agony/discomfort" and "concern/depression," and VAS were all statistically meaningfully different (P < 0.05) from one another when it came to the study participants' decision to take the test. On the other hand, regardless of whether middle-aged and younger adults were evaluated, the impacts of marital status (P = 0.008), number of people living together (P = 0.0001), place of residence (P = 0.0001), nature of household registration (P = 0.98), monthly per capita income of household (P = 0.034), gender (P = 0.024), age (P = 0.36), religious belief (P =0.0045), smoking status (P = 0.72), have you Gobbled alcohol in last 12 months (P = 0.934), BMI (P = 0.0012), the highest level of education (P = 0.0005), how medical prices are covered (P = 0.025), any common chronic disease (P = 0.4), VAS (P = 0.00013), and self-efficacy (P = 0.003) was not Reliably substantially different (P > 0.05) (Tables 2 and 3).

5.3 Multi-aspects analysis of lung purpose tests in petrochemical industry workers

The findings from the multi-aspect study indicated that several factors significantly influenced lung purpose testing among workers in the petrochemical industry. These factors included the highest levels of literacy, self-efficacy, accessibility of healthcare, mobility, pain or discomfort, and the presence of apprehension or depression, all of which demonstrated statistically significant differences (P < 0.05) as shown in Table 4. The frequency of lung performance assessment was observed to increase with higher literacy levels, while a decline was noted with lower self-efficacy scores. Specifically, the likelihood of undergoing pulmonary purpose testing was 0.348 times greater for individuals who were not self-funded compared to those who were self-funded regarding healthcare affordability (OR = 0.348, P = 0.034). The mobility of respondents concerning pulmonary function testing could not be assessed, as these workers did not exhibit specific mobility issues. Additionally, the rates of self-care, daily activities, agony/discomfort, and concern/depression were associated with pulmonary function testing at (OR = 4.920, P < 0.00045), (OR = 7.680, P = 0.0001), (OR = 0.487, P = 0.0101), and (OR = 14.40, P < 0.00001), respectively. Furthermore, individuals with junior and senior high school education levels demonstrated higher rates of pulmonary purpose testing associated with those with a college education (OR = 0.85, P = 0.58) and (OR = 0.142, P = 0.003).

Table 5: Multi-functional investigation of Peak expiratory flow rate in Petrochemical Industries

Factors		Number of people	Red zone %	Yellow Zone %	Green Zone %	PEFR Actual	PEFR Predicted (%)
						Mean ± SD	Mean ± SD
Male		150	0	23.3	76.7	422.7 ± 78.05	93.04 ± 13.30
Female		150	0	2	98	515.6 ± 77.60	121.6 ± 10.43
Mean difference						92.9	28.56%
Significance	T value					10.33	18.08
	P value					<0.00001, High	<0.00001, High

5.4 Multi-aspects study of Peak expiratory flow rate on the workers of the Petrochemical industry

The analysis of PEFR based on gender revealed significant differences. Among males (n=150), 76.7% were in the Green Zone and 23.3% in the Yellow Zone, with no one in the Red Zone. Females (n=150) had 98% in the Green Zone and 2% in the Yellow Zone. Males had an actual mean PEFR of 422.7 ± 78.05 L/min and predicted (%) PEFR of 93.04 ± 13.30%, while females had significantly higher values of 515.6 ± 77.60 L/min and 121.6 ± 10.43%, with mean differences of 92.9 L/min and 28.56%, respectively. These differences were statistically significant (t-values: 10.33, 18.08; p < 0.00001). In Other words, females demonstrated better lung function than males, with significantly higher actual and predicted PEFR values and a greater proportion in the Green Zone. This indicates that the observed differences are not due to chance but reflect genuine gender-based variations.

6. Discussions

1) Influence of tendency aspects on partaking in lung performance assessment in petrochemical industry workers

Higher spirometry testing rates were seen among the younger population because they were more aware, more motivated, and more able to look for and understand information about respiratory health. Moreover, middle-aged, and people above 40 with more education participated more in spirometry, perhaps owing to greater healthcare access, and understanding and priority of early disease screening. Participation was also influenced by occupational factors, with particularly middle-aged, non-retired individuals more likely to undergo testing, at least partly because of workplace health policies. However, older individuals and those with a primary level of education demonstrated subordinate levels of participation, and a higher rate of lung impairment [29]. Furthermore, persons with religious affiliations had a higher incidence of lung impairment, which may be attributable in part to variability in attitudes toward health testing among religious and nonreligious persons. Participation was strongly influenced by self-efficacy, such that persons with greater confidence in managing their health were more likely to test and adopt health-promoting behaviours.

2) Aptitude aspects were the key swaying aspect on partaking in lung performance assessment in petrochemical industry workers:

Individuals whose medical expenses were covered had a significantly more complex rate of pulmonary purpose testing than self-payers. Among income groups, those earning ≥ rupees 30,001 had the highest testing rates, followed by those earning 20,001-30,000, and the lowest was among that earning ≤ rupees 20,000. A chi-square test displayed no momentous difference between the 20,001-30,000 and ≥ 30,001 income groups. The multifactorial analysis indicated that coverage of medical expenses, rather than income alone, is the key factor influencing testing rates, as higher-income groups generally have better health insurance.

3) Outcome of necessity aspects of partaking in lung purpose tests in Petrochemical industry workers:

The study grounded on Anderson's behavioural concept shows that 'necessity aspects' as measured by EQ-5D-5L and VAS self-ratings strongly influence people from the petrochemical industry's willingness to participate in spirometry testing. People are more likely to test if they think they are sicker or have more medical needs. For example, people with mobility problems responded more frequently as reported by EQ-5D-5L, whilst those with pain, discomfort, or depression reported less frequently. Often, health screening involvement is increased because people with more severe mobility problems face more severe health issues. However, individuals who have pain, anxiety or depression are inclined to rate less and have lower self-efficacy (as health exams) [34], and this decreases participation. People with better self-ratings of their health tend to participate more in lung function testing and generally are younger healthier and more proactive about initiating testing.

4) Insights into Pulmonary Health Through Peak expiratory flow rate Analysis:

The analysis of PEFR highlights significant Sexuality-based differences in lung performances. Among males, 76.7% were in the Green Zone (normal function) and 23.3% in the Yellow Zone (moderate impairment), while 98% of females were in the Green Zone and only 2% in the Yellow Zone. Notably, no participants fell into the Red Zone (severe impairment), indicating an overall absence of severe lung dysfunction. Females demonstrated significantly higher PEFR values than males. The actual mean PEFR for males was 422.7 ± 78.05 L/min, with a predicted PEFR of 93.04 ± 13.30%, compared to 515.6 ± 77.60 L/min and 121.6 ± 10.43% for females. The differences of 92.9 L/min in actual PEFR and 28.56% in predicted PEFR were highly significant ($p < 0.00001$). These findings suggest superior pulmonary health among females, possibly due to physiological, environmental, or lifestyle factors. Additional study is warranted to discover these differences and their inferences for respiratory health management.

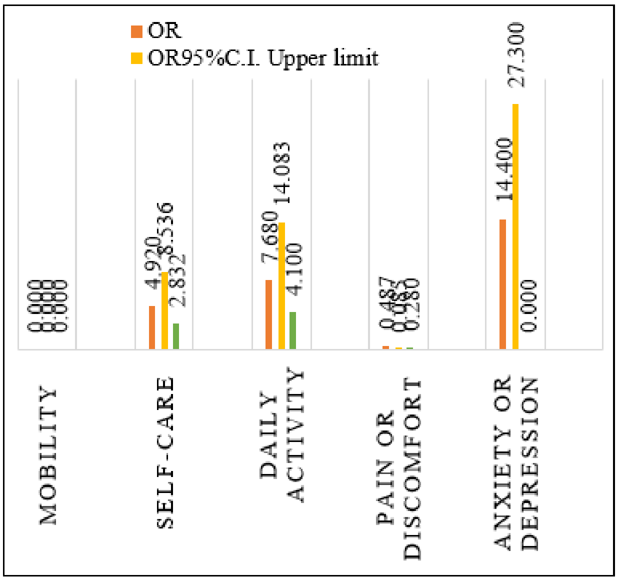

Figure 2: Comparison graph of OR and OR 95%C.I.

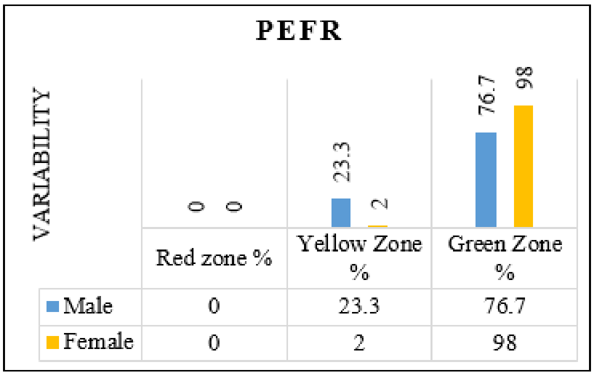

Figure 3: Comparison of variability between men and women

Table 6: Chemicals and airborne pollutants with their exposure route, Permissible exposure limit, and Mitigation strategies

Chemical/ Pollutant	Exposure Routes	PEL Value	Health Risk Assessment	Mitigation Strategies	Source/ Regulation
Vinyl chloride	Inhalation, dermal interaction	1 ppm (TWA)	Carcinogenic, Respiratory irritation, CNS effects, dizziness, fatigue.	They employ closed systems, otherwise sufficient ventilation, offer respirators to the workers and have regular health monitoring of workers.	OSHA (29 CFR 1910.1017)
Hydrochloric acid (HCl)	Inhalation, dermal interaction, ingestion	5 ppm (Ceiling)	Respiratory irritation, burns to skin and eyes, chronic bronchitis (bronchiolar damage).	Install local exhaust ventilation; provide chemical-resistant PPE; supply emergency eyewash station(s).	OSHA (29 CFR 1910.1000 Table Z-1)
Chlorine gas	Inhalation	0.5 ppm (TWA), 1 ppm (STEL)	Chemical Burns, Severe Respiratory irritation, Pulmonary edema, Fatality Potential.	Air monitoring in continuous, PPE with chemical resistant gloves and respirators and emergency evacuation plans.	OSHA (29 CFR 1910.1000 Table Z-1), ACGIH TLV
Mercury (if applicable)	Inhalation, dermal contact	0.1 mg/m³ (TWA)	Neurotoxicity, kidney damage, and chronic exposure can cause tremors and cognitive effects.	It is neurotoxic, can damage the kidneys and cause tremors and cognitive effects.	OSHA (29 CFR 1910.1000 Table Z-2)
Volatile Organic Compounds (VOCs)	Inhalation	Varies; Benzene: 1 ppm (TWA)	Potential carcinogenicity (e.g., benzene, vinyl chloride) CNS effects (e.g., dizziness, head ache), respiratory irritation.	Vapour recovery systems should be used, good ventilation provided, respiratory protection provided when necessary, and regular monitoring of workplace air quality established.	OSHA (29 CFR 1910.1028 for benzene), other VOCs follow industry-specific guidance
Particulate matter (PM)	Inhalation	5 mg/m³ (Respirable), 15 mg/m³ (Total Dust)	(COPD), respiratory and cardiovascular issues. Lung cancer.	Air filtration systems, dust masks or respirators and engineering control are advisable to minimize dust generation.	OSHA (29 CFR 1910.1000 Table Z-3)
Ethylene oxide	Inhalation, dermal interaction	1 ppm (TWA)	Reproductive toxicity, carcinogenic (linked to	Single-use close systems, monitor air levels, supply respirators, and educate the workers on safe handling practices.	OSHA (29 CFR 1910.1047)

			leukaemia) and respiratory irritation.		
Ethylene glycol vapours	Inhalation, dermal interaction, ingestion	50 ppm (AIHA WEEL)	Single-use, close systems, monitor air levels, supply respirators and educate the Worker on safe handling practices.	Good ventilation, gloves and goggles and appropriate training to use them.	AIHA (Workplace Environmental Exposure Level)
CO, NOx, SOx (combustion emissions)	Inhalation	CO: 50 ppm NOx: 25 ppm SOx: 2 ppm (TWA)	CO: NOx: Asphyxiation, headache, dizziness; SOx: Respiratory irritation, asthma trigger;	You can improve combustion processes, use scrubbers or catalytic converters, or distribute those CO monitors to confined spaces.	OSHA (29 CFR 1910.1000 Table Z-1)
Methane (CH_4)	Inhalation	No PEL; oxygen displacement monitor	Asphyxiation concentrations of oxygen by displacing it.	Maintain proper ventilation in places that are enclosed monitor the methane level, and use explosion-proof equipment.	Industry guidance, NIOSH RELs
Dust (e.g., from PVC, HDPE, PET)	Inhalation, dermal interaction	5 mg/m³ (Respirable), 15 mg/m³ (Total Dust)	Respiratory irritation, potential long-term pulmonary effects	Install dust assortment systems, provide dust covers, ensure proper storing and management of materials, and enforce good organization practices.	OSHA (29 CFR 1910.1000 Table Z-3)
Toxic gases (ethylene oxide, vinyl chloride)	Inhalation, dermal interaction	Varies; e.g., Vinyl Chloride: 1 ppm (TWA)	Carcinogenic, neurotoxicity, and irritation of the respiratory tract	Continuous air monitoring, use of gas detection systems, respirators, and training on emergency response procedures.	OSHA (29 CFR 1910.1017 for vinyl chloride, 1910.1047 for ethylene oxide)
Greenhouse gases (CO_2, CH_4)	Inhalation: in confined spaces	CO_2: 5,000 ppm (TWA), 30,000 ppm (STEL)	Asphyxiation in confined spaces	Install gas monitoring systems, provide ventilation, and implement safety protocols for confined space entry.	OSHA PEL for CO_2 (29 CFR 1910.1000 Table Z-1); Methane follows industry best practices
Fly ash	Inhalation, dermal interaction	5 mg/m³ (Respirable), 15 mg/m³ (Total Dust)	Respiratory irritation, potential heavy metal exposure	Use bag strainers or electrostatic precipitators, enforce PPE use (e.g., masks), and ensure consistent cleaning of ash-handling areas.	OSHA (29 CFR 1910.1000 Table Z-3)
Cooling tower drift (waterborne pollutants)	Inhalation of aerosols, dermal interaction	No PEL; control microbial growth	Risk of Legionnaire's disease, skin irritation	Install drift eliminators, ensure water treatment to control microbial growth, and provide training on handling and maintenance of cooling towers.	Industry guidance (e.g., ASHRAE Standard 188 for Legionella management)

5) Exposure Routes and Exposure Limits of Harmful Substances on Petrochemical Workers:

The Anderson Model Behavioural Test has given us important information on why petrochemical workers do not take lung function tests. Education, financial considerations, and personal health beliefs are the key factors that cause this issue. Workers choosing to ignore the tests is a real problem, especially since many of the hazardous substances they encounter in their work environment. These hazardous chemicals can be accidentally or intentionally exposed through inhalation of Vinyl Chloride, Hydrochloric Acid (HCl), Chlorine Gas, Mercury, Ethylene Oxide, Ethylene Glycol, Para-Xylene, Acetic Acid, and Ethylene through inhalation, dermal contacts or through ingestion; they also include Particulate Matter (PM), Nitrogen Oxides (NOx), Carbon Monoxide (CO), Sulphur, Volatile Organic Compounds (VOCs), and these exposures carry long term health risks of breathing illnesses, cancer, neurological damage, and the like. Regular lung function tests for exposure can be helpful in the early diagnosis of health problems associated with exposure, and many petrochemical companies do not practice routine tests. Reducing risks requires education of workers on the risks of hazardous substances and exhibition of the need to wear Personal Protective Equipment (PPE). Management Responsibilities: Require lung function tests for all workers; Constantly Educate and train on PPE usage and compliance with safety protocols; raise awareness of health impacts from exposure to hazardous chemicals. By prioritizing worker education, and ensuring compliance with safety the petrochemical industry can through measures and routine health monitoring of workers, reduce the health risk caused by exposure to hazardous substances and improve workplace safety. Workers are exposed to dust, fumes, chemicals, ultrafine particulates (UFPs) PM2.5, and PM10 at different levels in petrochemical industries. These can find their way into your body through several different routes, with varying degrees of ill effect. The first entry routes for these pollutants are Inhalation: Dust and Fumes: During the petrochemical processes, workers may inhale dust particles, fumes, and gases. These substances can also be inhaled and into the respiratory system, causing respiratory diseases and increasing the likelihood of exacerbating asthma or COPD; Ultrafine Particles (UFPs): They can get so tiny that UFPs can sink and go deep into the lungs, and even into the blood flow and possibly cause cardiovascular and respirational problems; PM2.5 and PM10: Small enough to slip by nasal filters and invade the lungs, these also can inflame and damage lungs and contribute to bronchitis, asthma and cardiovascular diseases. The second entry route is Dermal Absorption: This may include direct contact with toxic chemicals, oils, solvents, dust etc. through the skin of the worker. Extended use can cause skin irritation, thus chemical absorption into the bloodstream can damage internal organs or lead to chemical poisoning. The third entry route is Ingestion: Under certain conditions, workers may inadvertently ingest hazardous materials when dust or chemical particles settle on food, hands, or equipment. This can lead to systemic exposure, which can cause a range of toxic effects on the liver, kidneys, and other organs. Lastly, the fourth entry route for these chemicals and airborne pollutants is Ocular Exposure: The mucous membranes of the eyes also allow chemicals, dust and fumes to enter the body causing eye irritation, damage or increased absorption of the harmful substances into the bloodstream. It follows that these exposure routes need to be minimized and that protective equipment such as respirators, gloves and goggles, adequate ventilation and safety procedures are used. However, there are ways to reduce these risks: Regular health monitoring and training in safety are not routinely imposed.

6) Comprehensive Safety Strategies to Mitigate Hazardous Exposure in Petrochemical Industries:

a) Ensuring that an entire set of control measures is in place to protect workers from the harmful substances in petrochemical industries is essential. The measures are engineering controls, administrative strategies, personal protective equipment (PPE), hygiene strategies, emergency preparedness, and deploying protocols in a strict manner approaching regulatory standards. The first line of defence against hazardous exposures is engineering control measures. Source capture ventilation and advanced airing systems are installed to remove fumes, dust, and gases. An enclosed or sealed system is utilized in the handling any of toxic substances to minimize the release of emissions. Ultrafine particles and other airborne pollutants are collected with high efficiency by Ultra-fine particle filter filters and electrostatic precipitators. In addition, real-time leak detection systems provide an added safety control for leak detection of hazardous chemicals such as VOCs and gases.

b) Likewise, workplace safety must be maintained by administrative controls. Training workers about the jeopardies of exposure, safe use of PPE and handling chemicals are all needed. Regular air quality monitoring allows pollutant levels to stay at acceptable levels. Handling, storing, and disposing of hazardous substances needs to be developed and enforced by standard operating procedures (SOPs). Lung function tests can pick up early health problems as can periodic health checks, and rotational shifts mean less time spent in a high-risk environment. The final barrier to exposure is personal protective equipment (PPE). Training workers about the risks of exposure, appropriate use of PPE, and safe handling of chemicals are essential. Regular air quality monitoring helps ensure pollutant levels remain within permissible limits. Developing and enforcing standard operating procedures (SOPs) for handling, storing, and disposing of hazardous substances is critical. Periodic health checks, including lung function tests, can detect early signs of health issues, while rotational shifts can limit prolonged exposure to high-risk environments.

c) Personal protective equipment (PPE) serves as a concluding barrier against exposure. To filter particulate and vapours, workers should be given respirators or masks of the appropriate type, such as an N95 or equivalent grade. Dermal contact is prevented with chemical-resistant gloves, coveralls, aprons, and safety goggles or face shields from contact with the organs of the body. To safeguard hearing in high-noise environments people are advised to use earplugs or earmuffs.

d) Good hygiene standards need to be maintained in the workplace. It should include hand washing stations containing soap and water places close to the work areas with clean areas far from hazardous substances for eating and drinking. Showering and changing rooms are used for decontamination of contamination. The dust and chemicals should be constantly cleaned from work surfaces and equipment.

e) Lastly, it also focuses on emergency preparedness. Spill containment and cleanup procedures should be taught to workers, and first aid stations and emergency eyewash facilities are to be provided. It prepares workers and practices evacuation plans in case of chemical leaks or fires, when you least expect it, to save your life.

f) In the end, regulatory standards must be followed. A worker's health is protected by making sure that workplace exposure levels stay below permissible exposure limits (PELs) set by agencies such as OSHA, ACGIH, or BIS. Hazardous substances are properly labelled and safety data sheets (SDS) are provided so workers know what is in front of them. Regular safety audits can discover and solve potential hazards to continually grow safe working conditions.

As a result of implementing these measures, petrochemical industries reduce workers' exposure to toxic materials dramatically and protect their health while creating a safer working environment.

7. Conclusion

Several factors including education, financial incentives, as well as personal health beliefs, influence the participation of petrochemical workers in lung function tests. According to experience, the more aware people are of what the competition is when applying for positions, the higher the levels of education those people are. Another important factor is financial: Is it the worker paying or is it the employer? Access improvements can also reduce barriers in participants' own time. Participation is affected by health conditions and psychological factors like anxiety or depression as well as by participants with a chronic disease such as hypertension or diabetes. Younger workers, although not as restricted in terms of mobility, may be reluctant to relocate, at least in part caused by health perceptions. As well as psychological factors, such as self-efficacy, lower stages of self-efficacy result in lower stages of test partaking. Participation also varies as a function of demography, such as residence and marital status – urban workers are more likely to participate. Participation is additionally influenced by occupational exposure to dangerous substances and cultural beliefs. Peak Expiratory Flow Rate (PEFR) Analysis: A gender-based analysis of Peak Expiratory Flow Rate (PEFR) was carried out for petrochemical workers and shown to have significant gender-based differences in lung function. Pulmonary health was better in the females (98% in the Green Zone [normal function] vs. 76.7% in males). When the actual mean PEFR was looked at, males had a mean PEFR of 422.7 L/min and women had a significantly higher mean PEFR of 515.6 L/min. These findings suggest that the outcome of lung function testing is influenced by gender, education, and psychological factors. To increase lung function test (LFT) participation, and PEFR assessments, among petrochemical workers, the need is to address barriers related to education, support, and psychological.

8. Strengths & Limitations

In this sense, the strengths of the study include the comprehensive framework of the context of Anderson's model to examine all the factors affecting lung purpose testing behaviour among petrochemical workers. With abundant statistical analysis used to validate, and with the 300-participant sample from multiple demographics increasing sample generalizability, the results are especially strong. Further, the research points to important factors, like education, finances, and psychology as well as other aspects, which help to feed into public health policy to promote respiratory health. The study also has limitations, however. Limits of the cross-sectional design do not allow us to reach conclusions about long-term trends or changes in behaviour over time. However, using self-reported data may be subject to bias as people may over or underestimate their health behaviour. Moreover, the results from the study may not be easily applicable to other industries. However, the overall picture painted on the population of petrochemical workers is not necessarily reflected in the sample. Finally, the complexity of the survey process may have repelled some of the possible respondents and reduced the response rate reducing the results.

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Declaration of Competing Interest

I solemnly declare that the work I have submitted in this theory is entirely my unique work and has not been submitted for anything else to be examined or qualified. This is not part of any other course or program. Secondly, I have no conflicts of interest, financial, personal, or professional, that may have caused damage to the objectivity and validity of the research. This declaration stores my dedication to academic honesty and moral basic principles in this investigation.

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