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Urinary Bladder Cancer with Dye Exposure in Textile Industry Workers in Pali District, Rajasthan

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ABSTRACT

Introduction: Urothelial carcinoma is the most common invasive cancer of the urinary tract. Development of bladder cancer is a long-term sequel of occupational exposure of aromatic amines (2-naphthylamine, 4-aminobiphenyl and benzidine) and 4,4'-methylenebis (2-chloroaniline), which can be found in the products of the chemical, dye. Dyeing industry worker are occupationally exposed to various toxic chemical and dye which causes hazardous effects on vital organs like Bladder, lung, liver and kidney. There is scarce data which explains the long-term exposure effects of dye and chemicals on these organs.

Objectives: We wanted to study the diagnostic efficacy of non – invasive Biomarker Bladder Tumor Antigen in assessing renal function derangement of occupationally exposed Dye industry workers and also to evaluate the Hepatic and Renal functional health of Textile Industry workers in Pali District of Rajasthan, India.

Methods: For the current study we recruited 100 occupationally exposed (cases) and 100 non exposed subjects (controls) of either sex. The study was approved by institutional ethics committee Pacific Medical University, Udaipur, Rajasthan. Urine and blood specimen was obtained from both groups. Serum specimen was utilized for Renal, Liver function tests and Serum GGT analysis and Urine specimen was utilized for Urine Bladder tumor antigen, Cytology, hematuria and urinary Protein Creatinine Ratio analysis. The statistical analysis was performed by using SPSS version 23.

Results: Serum bilirubin (OR 2109120.18, P value 0.007*), SGOT (OR 5179.44, P value 0.009*), SGPT (OR 8.450, P value 0.009*), alkaline phosphatase (OR 3.009, P value 0.009*), Blood Urea (OR 920.285 P value 0.00991*), Creatinine (OR37.258 P value 0.0030*), Urine Protein (OR 1.487 P value 0.00995*), Urine Creatinine (OR 8.326 P value 0.0020*), Urine Protein. Creatinine Ratio (OR 14.982 P value 0.0023*) and Urine Bladder Tumor Antigen (OR 42.695 P value 0.00430*) levels and were found to be significantly increased in Moderate exposure (10-20 years' group) and Severe/Long-Term exposure (20-30 years' group) as compared to Mild exposure (<10years group) and Healthy Controls with no history of occupational exposure.

Conclusions: Severe/Long-Term exposure (20-30 years' group) of toxic dyes and chemicals had caused increased Bladder Tumor Antigen levels severe Hepatic and Renal functional health derangement in Textile Industry workers of Pali District.in Rajasthan, India. These results suggest that the risk factor for development of bladder cancer is occupational exposure to aromatic amines (2-naphthylamine, 4-aminobiphenyl and benzidine) and 4,4'-methylenebis (2-chloroaniline), which can be found in the products of the chemical, dye. Thus, early screening will result in best prognosis along with improved industrial hygiene. We also strengthen the evidence to support new guidelines for an early screening of urinary tract cancer by urine cytology screening, starting with initial exposure, reassessed during years of working life.

Keywords: *Pali, Bladder Cancer, Textile Dye, Textile Industry worker, occupationally exposed, Hepatotoxicity*.

1. INTRODUCTION

Bladder cancer is one of the deadliest urological diseases urinary system. Cancer is the most common type of bladder cancer. This type is present in 90% of bladder cancer patients. Squamous cell carcinoma and adenocarcinoma, although less frequently (5% and 2%, respectively) are associated with advanced stages and have a higher mortality rate than urothelial carcinoma [1]. The World Health Organization ranks bladder cancer the ninth most commonly diagnosed cancer. Men have a higher incidence and it is the 13th most common cause of cancer death in the world. Bladder cancer is the most expensive malignant tumor due to the cost of treatment [2-5].

The global burden of cancer is estimated to have increased many folds with 18.1 million new cases of cancer and around 9.6 million deaths in 2018. Death due to bladder cancer is one of the leading causes of cancer mortality in developed countries and accounts for 3.4% of worldwide cancer burden [6]. Pali is the largest erstwhile hand processing clusters, now gradually moving to power processing machines. The area constituting Pali district has been known for a number of industries, best known for dyeing and printing of cotton and synthetic fabric [7].

According to joint survey of District Industries Centre (DIC), Pali and Pollution Revenue Association in the year 2008-2009, there were 867 registered units, engaged in various cotton and synthetic textile processing operations. The dyeing and printing industry are the major source of livelihood in this region. The common jobs handled by them are spinning, weaving, dyeing, printing, finishing and a number of other processes that are required to convert fiber into a finished fabric or garment. Working for a long period of time without rest, absence of personal protective equipment and inadequate provision of ergonomic facilities at workplace leads to major health-related issues among the workers [8-9].

Processing and dyeing is one of the critical procedure in textile industry in which the workers get exposed to a number of hazardous chemicals like caustics, bleaching agents, chromophores and organic solvents like formaldehyde, benzene and different chemical dyes. These chemicals gain entry into the human body through inhalation or skin contact. Systemic effect may occur beyond the site of contact if the hazardous chemicals and dye is absorbed into blood stream and distributed throughout the body. The textile industries use different kinds of dyes including the most commonly used azo dyes which are aromatic hydrocarbon derivatives of benzene, toluene, naphthalene, phenol and aniline. A wide variety of azo dyes are being increasingly used in textile dyeing and printing process. Azo dyes are very toxic and carcinogenic to human beings. The solvents used by the workers in different sections licit carcinogenic effect on direct contact with these workers. The workers in the dye units are suffering from various disease like Liver and kidney damage, itching, bladder cancer etc [10].

Since the last century, the second important risk factor for the development of bladder cancer is occupational exposure in the textile industry, after the risk of tobacco smoking, the relative risk (RR) of occupational exposures was 13.4 [95% CI 1.5–48.2] in dye workers [11]. Van Hoogstraten, et al. found that 20% of all bladder cancers could be attributed to occupational exposures to aromatic compounds, such as benzidine, 4-aminobiphenyl, b-naphthylamine, 4-chloro-o-toluidine, as well as polycyclic aromatic hydrocarbons (PAHs) in the textile dye industry [12]. These chemical exposures could be specific agents associated with bladder cancer [13]. Smokers who work with carcinogens chemicals have a significantly higher risk of bladder cancer. The rise in incidence and mortality among women in East Europe region is due to the prevalence of cigarette smoking, while the decrease in mortality rates in some of the Western countries is attributed to the decreasing prevalence of the use of tobacco [14].

Bladder cancer is a disease in which abnormal cells multiply without control in the bladder. The most common type of bladder cancer begins in cells lining the inside of the bladder and is called transitional cell carcinogen [15]. Bladder cancer is the fourth most common type of cancer among men and the eighth most common among women [16]. Several bladder tumor markers show higher sensitivity than cytology. Proteomic and gene profiling approaches are being used to find new biomarkers to assist in the molecular profiling of bladder cancer [17]. Tumor markers are substances that can be found in the body when cancer is present. They are most often found in the blood or urine and most tumor markers are proteins. The marker is usually found by combining the blood or urine with man-made antibodies that react with the tumor marker protein [18]. Family history of bladder cancer is considered a higher risk. The cause probably is lower penetrating DNA variants and many such pathways were reported which influences risk through one or more different cancer pathways [19-21].

Urine cytology has been the established non-invasive method for the detection and follow-up of bladder cancer in combination with cystoscopy. As mentioned above, urine cytology exhibits high specificity but suffers from a significant weakness in its very low sensitivity to well-differentiated bladder cancer [22]. The BTA Stat and BTA tests are two in vitro immunoassays that detect human complement factor H-related protein (hCFHrp) in the urine samples of patients with urothelial carcinoma [23]. A high concentration of hCFHrp in the urine of patients with bladder cancer hinders the easy detection of hCFH, which is present in minimal quantities in normal healthy individuals. Therefore, the accuracy of the tests

relies on the detection of hCFHrp, not hCFH [24-27].

Liver is the main organ responsible for biotransformation and detoxification process of these chemicals and solvents used in textile processing industries. As a result, it becomes the prime target organ for the chemical induced tissue injury [28]. Renal damage resulting from toxic exposure is progressive and will, if untreated, end in irreversible renal disease. As renal damage from solvent exposure may remain clinically silent for many years due to the large functional reserve capacity of the kidney, it is necessary to apply sensitive, reliable early indicators ("biomarkers of effect") to detect early effects and prevent further damage [29].

Thus, we wanted to study the diagnostic efficacy of non – invasive Biomarker Bladder Tumor Antigen in assessing renal function derangement of occupationally exposed Dye industry workers and also to evaluate the Hepatic and Renal functional health of Textile Industry workers in Pali District. Of Rajasthan, India.

2. AIM

To study the diagnostic efficacy of non – invasive Biomarker Bladder Tumor Antigen in assessing renal function derangement of occupationally exposed Dye industry workers and also to evaluate the Hepatic and Renal functional health of Textile Industry workers in Pali District. Of Rajasthan, India.

3. OBJECTIVES

We want to study diagnostic efficacy of non – invasive Biomarker Bladder Tumor Antigen in Bladder cancer test with dye exposure as compare to conventional Diagnostic method for Bladder Cancer. We also wanted to evaluate the Liver Function test and kidney Function Test in Textile Industry workers Pali District.

4. METHODOLOGY

The present study was conducted in the Department of Biochemistry, Pacific Medical University and its associated group of hospitals, Udaipur, Rajasthan. The study was approved by institutional research ethical committee of Pacific Medical University (approval letter no. Ref. No. PMU/PMCH/IEC/2023/15). Sample size was calculated on basis of this formula n = 4pq/e2 and the analytical cross-sectional study was carried out among textile industrial workers residing in industrial area and age and sex matched non-textile workers (Comparison group) residing approximately 15-20 km away from Industrial area of Pali city of Rajasthan. The study period was around 1.5 year during 2023-2024. Written informed consent was taken from workers who were enrolled in the study.

Inclusion criteria

Healthy individuals aged 25-60 years has recruited and separated into 2 groups.

Group 1: 100 non-exposed subjects of either sex.

Group 2: 100 Occupationally exposed subject of either sex.

Occupationally exposed group was sub grouped into.

(1) 60 occupationally exposed <10yrs subjects of either sex.

(2) 34 occupationally exposed 10-20 yrs subjects of either sex.

(3) 6 occupationally exposed 20-30 yrs subjects of either sex.

Exclusion criteria

Individuals with significant comorbidities was excluded from study.

Factory workers with tobacco smoking, alcohol intake, drug abuse and family history of liver disease of all individuals were excluded from the study.

Technique

Urine and blood specimen was obtained from both patients and control groups. 24-Hours Urine, was collected in appropriate containers. Serum was separated from the whole blood sample by incubating the vials containing blood sample for 10 minutes in water bath and then centrifugation at 3000 rpm for 5 minutes. The samples were brought to Pacific Medical University Udaipur in the Department of Biochemistry in thermocol box with ice box after maintaining strict universal safety precautions. All the biochemical parameters were analyzed in the Central Biochemistry, Department of Biochemistry, Pacific Medical University Udaipur. The separated serum sample was used for further biochemical analysis ERBA company reagent using fully automated clinical chemistry Analyzer ERBA EM 360-Transasia Bio Medicals Pvt. Ltd., Mumbai, India. Serum Total Protein was measured by Biuret method. Serum Albumin was measured by Bromocresol Green method. Serum Total Bilirubin was measured by Diazo method. Serum Alanine Transaminase, Aspartate Transaminase and Alkaline Phosphatase

were measured by (IFFC) International Federation of Clinical Chemistry. Serum Gamma Glutamyl Transpeptidase was measured by (GLUPA-C) L- γ -Glutamyl-3-carboxy-p-nitroanilide method. Serum Creatinine was measured by Jaffe's Method. Blood Urea was measured by GLDH - Urease Method. 24hrs urine PCR ratio test was measured by (Urine-Creatinine- Jaffe's Method and Urine Protein – Pyrogallol red method). Urine Bladder tumor Antigen test was used for further biochemical analysis NOVUS biologicals Biotechne brand NBP2-74985. Urine Bladder Tumor Antigen test, Urine Cytology & Urine Hematuria test was performed. Urine Bladder Tumor Antigen Test was analyzed using ELISA Reader, Urine Cytology was analyzed using compound Microscope and urine hematuria by using urine dipstick method.

Statistical analysis-

The statistical analysis was performed by using SPSS version 23. After analysis of data distribution patterns appropriate statistical tests was utilized for analyzing measures of central tendency, dispersion and odds ratio, P value using descriptive statistics and Logistic regression.

5. RESULT

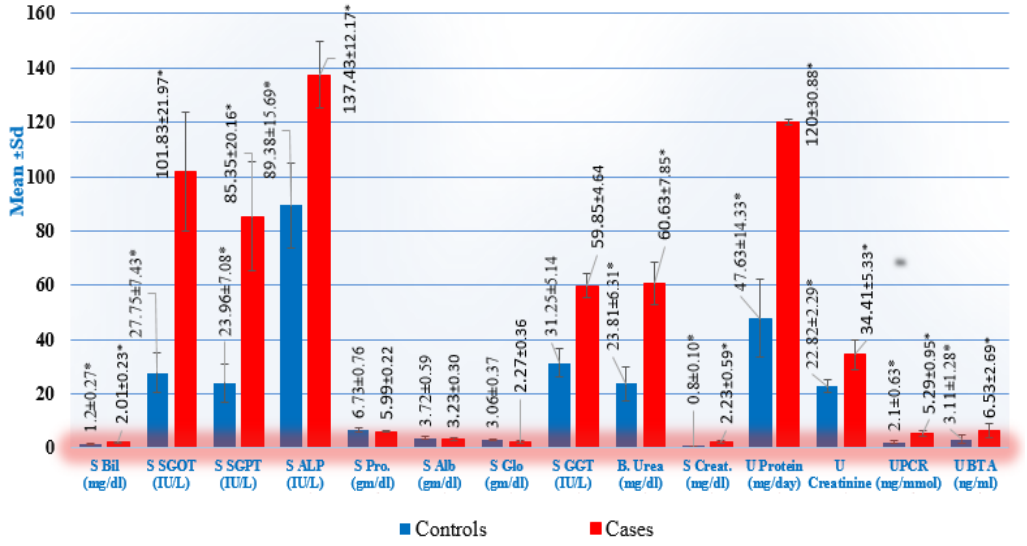
100 Healthy non-exposed participants were recruited and categorized as Group 1 and were considered as controls. 100 Occupationally dye and chemical exposed factory workers were recruited and categorized as Group 2. These participants were considered as cases and further categorized as <10 years (case group 1), 10-20 years (case group 2), 20-30 years (case group 3) occupational dye exposure in textile factory. Of the total participants included in the study 60% were <10 years, 34% had 10-20 years, and only 6% had 20-30 years exposed to occupational Dye and majority were male workers i.e. 68% while only 32% were female workers [Table 1].

Table 1: Duration of Occupational dyes and chemical exposure among Group 2 cases.

S.NO.	Exposure time	Male workers		Female workers		Total workers	
		No.	%	No.	%	No.	%
1	<10 years (Case group 1)	43	63%	17	53%	60	60%
2	10-20 years (Case group 2)	21	30%	13	40%	34	34%
3	20-30 years (Case group 3)	4	7%	2	7%	6	6%
	Total Cases	68	100%	32	100%	100	100

Peripheral blood was used to perform Liver, Renal, function, Bladder Tumor Antigen tests on all recruited participants. Serum bilirubin (3.067, P value 0.0069*), SGOT (OR 3553.276, P value 0.0083*), SGPT (OR 3.330, P value <0.001*), alkaline phosphatase (OR 3.235, P value 0.0091*), GGT (OR 9796.633, P value 0.0087), Blood Urea (OR 877.775 P value 0.00979*), Creatinine (OR 34.536 P value 0.0096*), Urine Protein (OR 2.363 P value 0.00988*), Urine Creatinine (OR 6.756 P value 0.0015*), Urine Protein Creatinine Ratio (OR 14.512 P value 0.0018*) and Urine Bladder Tumor Antigen (OR 28.321 P value 0.0065*) were found to be significantly increased in occupationally exposed cases as compared to controls [Figure 1].

Figure 1: Liver, Renal function, Bladder Tumor Antigen test values among cases and -controls.



Statistically significant (P value <0.05)

There was no significant change in serum proteins (OR 3.3210, P value 0.0001) and serum globulin (OR 3.234, P value 0.0001) levels but significant increase was seen in serum albumin (OR 3.106, P value <0.001) levels as compared to control [Table 2].

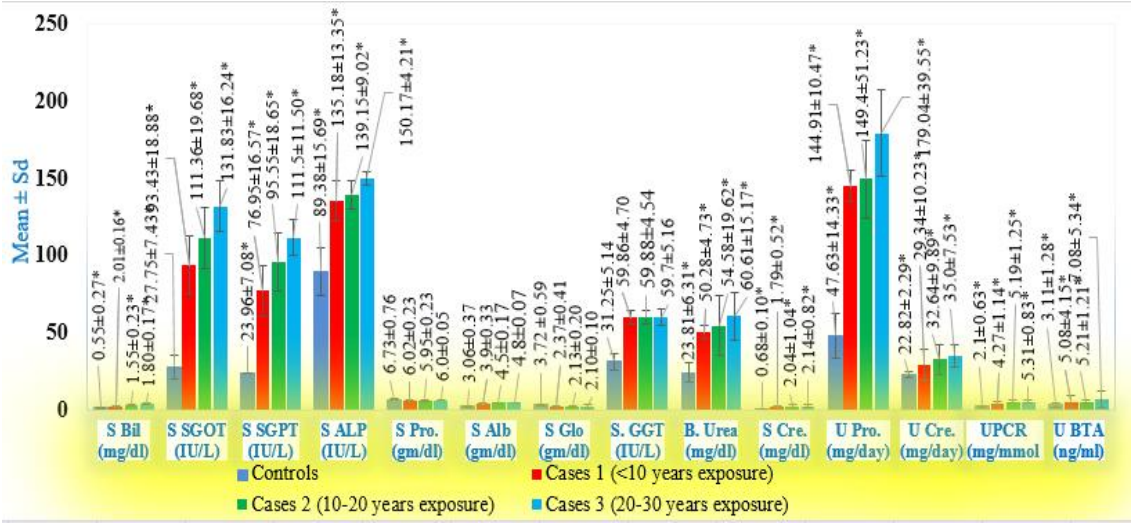
Table 2: Liver, Renal function, Bladder Tumor Antigen tests values among cases and controls.

S.No	Parameters	Mean ± SD Control(100)	Mean ± SD Case (100)	OR	P value
1	S.Bilirubin (mg/dl)	0.55±0.27	1.50±0.23	3.067	0.0069(*)
2	SGOT (IU/L)	27.75±7.43	101.83±21.97	3553.27	0.0083(*)
3	SGPT (IU/L)	23.96±7.08	85.35±20.16	3.330	<0.001(*)
4	Alkaline Phos. (IU/L)	89.38±15.69	137.43±12.17	3.235	0.0091(*)
5	S. Protein (gm/dl)	6.73 ± 0.76	5.99 ± 0.22	3.3210	0.0001
6	S. Albumin (gm/dl)	3.72±0.59	3.23±0.30	3.106	<0.0001
7	S. Globulin (gm/dl)	3.06 ± 0.37	2.27 ± 0.36	3.234	0.0001
8	S.GGT (IU/L)	31.25±5.14	59.85±4.64	9796.633	0.0087
9	Blood Urea (mg/dl)	23.81 ± 6.31	60.63 ± 7.85	877.775	0.00979
10	S. Creatinine(mg/dl)	0.68 ± 0.10	2.23 ± 0.59	34.536	0.0096
11	U. Protein (mg/day)	47.63 ± 14.33	179.69 ± 30.88	2.363	0.00988
12	U. Creatinine(mg/kg. body weight/ 24 Hrs)	22.82 ± 2.29	34.41 ± 5.33	6.756	0.0015
13	UPCR (mg/mmol)	2.10 ± 0.63	5.29 ± 0.95	14.512	0.0018
14	U BTA (ng/ml)	3.11± 1.28	6.53 ± 2.69	28.321	0.0065

Significant, P value <0.05 Considered significant, U = Urine, S= Serum.

GGT, Serum Albumin, Serum Protein and Serum Globulin levels were found to be non-significant in the occupationally exposed group 1, 2, 3 as compared to control group [Figure 2]

Figure 2: LFT, RFT, Bladder Tumor Antigen tests values among controls and exposed case groups.



* = Significant, P value <0.05 Considered significant.

Case Group 3 had most deranged Serum bilirubin (OR 2109120.18, P value 0.007), SGOT (OR 5179.44, P value 0.009), SGPT (OR 8.450, P value 0.009), alkaline phosphatase (OR 3.009, P value 0.009), Blood Urea (OR 920.285 P value 0.00991*), Creatinine (OR37.258 P value 0.0030*), Urine Protein (OR 1.487 P value 0.00995*), Urine Creatinine (OR 8.326 P value 0.0020*), Urine Protein Creatinine Ratio (OR 14.982 P value 0.0023*) and Urine Bladder Tumor Antigen (OR 42.695 P value 0.00430*) levels and were found to be significantly increased in progressive manner in the 20-30 years occupationally exposed cases group 3 as compared to case group 2 and 1.

There for we can say that cases group 3 which was for maximum exposure time duration had the highest Bladder Tumor Antigen tests, LFT, RFT derangement as compared to control and case group 1 and 2 [Table 3]

Table 3: LFT, Renal function, Bladder Tumor Antigen tests values comparison of prolonged exposed cases groups and controls.

S.No.	Parameters	Mean ± SD Control (100)	Cases (Group160, Group2-34, Group3-6)	Mean ± SD Cases	OR	P value
1	S.Bilirubin (mg/dl)	0.55±0.27	Group 1	1.40 ± 0.16	3053.152	0.000013*
			Group 2	1.55 ± 0.23	48682.610	0.000224*
			Group 3	1.80± 0.17	2109120.18	0.007*
2	SGOT (IU/L)	27.75±7.43	Group 1	93.43 ± 18.88	1.723	0.00969*
			Group 2	111.36± 19.68	3.552	0.00991*
			Group 3	131.83± 16.24	5179.443	0.00996*
3	SGPT (IU/L)	23.96±7.08	Group 1	76.95 ± 16.57	1.326	0.000267*
			Group 2	95.55 ± 18.65	1.899	0.00989*
			Group 3	111.50± 11.55	8.450	0.00995*
4	Alkaline Phosphatase (IU/L)	89.38±15.69	Group 1	135.18± 13.35	1.240	<0.0001*
			Group 2	139.15 ± 9.02	1.302	0.00292*
			Group 3	150.17 ± 4.21	3.009	0.00993*
6	S. Protein	6.73 ± 0.76	Group 1	6.02 ± 0.23	0.047	0.073
			Group 2	5.95 ± 0.23	0.042	0.981

	(gm/dl)		Group 3	6.0 ± 0.05	0.146	0.427
7	S. Albumin (gm/dl)	3.72±0.59	Group 1	3.9 ± 0.33	0.209	0.096
			Group 2	4.5 ± 0.17	0.074	0.544
			Group 3	4.8 ± 0.07	0.167	0.605
8	S. Globulin (gm/dl)	3.06 ± 0.37	Group 1	2.37 ± 0.41	0.026	0.7401
			Group 2	2.13 ± 0.20	0.002	0.841
			Group 3	2.1 ± 0.10	0.000127	0.233
9	S. GGT (IU/L)	31.25±5.14	Group 1	59.86 ± 4.7	12170.230	0.982
			Group 2	59.88 ± 4.54	25.072	0.992
			Group 3	59.70 ± 5.16	13.224	0.994

Renal function, Bladder Tumor Antigen tests values comparison of prolonged exposed cases groups and controls.

Table 3 Continued						
10	Blood Urea (mg/dl)	23.81 ±6.31	Group 1	50.28 ± 4.73	818.814	0.00982*
			Group 2	54.58 ± 19.62	897.202	0.00983*
			Group 3	60.61 ± 15.17	920.285	0.00991*
11	Serum Creatinine (mg/dl)	0.68 ± 0.10	Group 1	1.79 ± 0.52	32.452	0.004*
			Group 2	2.04 ± 1.04	36.260	0.009*
			Group 3	2.14 ± 0.82	37.258	0.0030*
12	Urine Protein (mg/day)	47.63 ± 14.33	Group 1	144.91 ±10.47	2.411	0.00989*
			Group 2	149.40 ±51.23	1.676	0.00994*
			Group 3	179.04 ±39.55	1.487	0.00995*
13	Urine Creatinine (mg/kg.body weight/ 24 Hrs)	22.82 ± 2.29	Group 1	29.34 ± 10.23	5.346	0.0004*
			Group 2	32.64 ± 9.89	5.849	0.007*
			Group 3	35 ± 7.53	8.326	0.0020*
14	Urine PCR (mg/mmol)	2.10 ± 0.63	Group 1	4.27 ± 1.14	12.450	0.0002*
			Group 2	5.19 ± 1.25	14.826	0.009*
			Group 3	5.31 ± 0.83	14.982	0.0023*
15	Urine BTA (ng/ml)	3.11 ± 1.28	Group 1	5.08 ± 4.15	20.425	0.00024*
			Group 2	5.21 ± 1.21	26.328	0.0069*
			Group 3	7.08 ± 5.34	42.695	0.00430*

* = Significant, P value <0.05 Considered significant.

Table 4 refers to as these participants were considered as cases and further categorized as <10 years, 10-20years, 20-30 years (case group 1, 2, 3). Significant results were found using years of exposure as a categorical variable. Urine hematuria and malignant cytology diagnoses globally increased. With increasing duration of exposure, the risk of showing a Urine hematuria (<10 years 11.66%, 10-20 years 29.41%, 20-30 years 33.33%) and malignant cytology increased linearly (<10 years 3.0 %, 10-20 years 11.76 %, 20-30 years 50.0%). Case Group 3 had most deranged Urine Hematuria (OR 15.143, P value 0.004) and Urine Cytology for malignant cell (OR 58.0, P value 0.00031) levels and were found to be significantly increased in progressive manner in the 20-30 years occupationally exposed cases group 3 as compared to case group 2 and group first is Reference category.

Table 4: Analyses of risk for urine cytology for malignant cell Urine Hematuria in relations with occupational sectors in prolong exposed cases group.

S.NO.	Parameters	Cases (Group1-60, Group2-34, Group3-6)	Numbers of workers	% of workers	OR	P value
1	Urine Hematuria	Group 1	07	11.66%	Reference category	
		Group 2	10	29.41%	3.155	0.037
		Group 3	03	33.33%	15.143	0.004
2	Urine Cytology for Malignant cell	Group 1	02	3.33%	Reference category	
		Group 2	04	11.76%	3.867	0.131
		Group 3	03	50.0%	58.0	0.00031

* = Significant, P value <0.05 Considered significant.

6. DISCUSSION

The Indian textile industry is a significant contributor in the Indian economy, in terms of its contribution to industrial production, employment and exports. Extensive scientific and industrial development have resulted in the destruction of the environment, as well as adverse effects on human health [30, 31]. Dying is one of the critical procedures in textile industry in which the workers can expose to a wide range of chemicals that are utilized in the working environment. Little information is available about possible toxic effect in workers from textile dyeing plants [32].

The liver performs multiple diverse functions essential to life, such as synthesis, excretion, and detoxification are major among the others. Exposure to organic solvents may induce liver toxicity because most of the chemicals are metabolized in the liver and toxic metabolites generated through the metabolism are main cause of liver damage [33].

Bilirubin is the end product of heme catabolism. Bilirubin is bound to albumin in the plasma and is delivered to the liver in the form of albumin-bound bilirubin. A significant increase was observed in the serum Bilirubin levels of occupationally exposed subjects when result was compared with non-exposed subjects [Table 2]. Our observations are similar with previous studies which reported that lead content of dye used in textile industry have hepatotoxic effect [34, 35].

SGOT and SGPT are the most frequently used indicators of hepatic cell necrosis. A significant increase was observed in the serum SGOT and SGPT levels of occupationally exposed subjects when results were compared with non-exposed subjects [Table 2]. Our results were similar to this study serum SGOT, SGPT significantly increased in workers involved in the dying processes for 6-10 years [36, 35].

The elevation in the concentration of serum SGOT and serum SGPT suggest the existence of hepatic damage which may develop a mechanism of cytotoxicity against hepatocytes with the passage of enzymes into blood stream. The significant elevation of SGOT and SGPT may be due to necrosis of hepatocytes under influence of xenobiotics. [37] Benzanthrone (BA) and 3-bromobenzanthrone (BBA) are the contents of dye intermediates used in the production of textile and dye processing may also be responsible for disturbance of membrane integrity. The significant elevation of these enzymes was attributed to disturbance of membrane integrity by both BA and BBA [38, 39].

Alkaline phosphatase is present in all tissues of the body and its concentration is high in liver, bones, intestine, kidney and placenta. There was significant change in serum ALP of occupationally exposed subject when result was compared with non-exposed subject [Table 2]. A significant increase in serum ALP in rats administered with a green-coloring dye [40].

There was significant change in serum GGT of occupationally exposed subject when result was compared with non-exposed subject [Table 3]. Our observation is similar with previous study of many researchers of different countries [41-43]. Serum proteins, play many different functions, including transport of lipids, hormones, vitamins and minerals in the circulatory system and the regulation of cellular activity and functioning of the immune system. Serum Protein, Globulin, levels were found to be non-significant in the occupationally exposed group 1, 2, 3 as compared to control group. However, no significant change in GGT was found by some authors [44-45]. Observed the inhibition of protein synthesis in animals exposed to azo dyes [46].

The lower serum albumin levels of in textile industry workers may indicate a reduction in the synthetic function of the liver relative to exposure of harmful organic solvents [47].

The blood urea and creatinine are good indicator for impairment in renal functions. Majority of solvents used in textile and dyeing industry; the early critical effects are still speculative. The high serum levels of creatinine, uric acid and blood urea considered to be indicators for the damaging of the tubular epithelium. Nephrotoxicity caused by organic solvents is reversible once the exposure has increased [48, 49]. A significantly increased was observed in the Urine Proteins Creatinine Ratio of occupationally exposed subject when result was compared with non-exposed subject. [Table 1]. The term Urinary microalbumin is now considered obsolete as there is no such biochemical molecule; the condition is now referred to only as increased urine albumin. Albuminuria is used as a marker to detect marker for chronic renal impairment [50].

Urine cytology screening can provide relevant epidemiological data for earlier detection of urothelial cancer caused by to occupational exposure to urinary tract carcinogens. Occupational sectors with an increased risk of urothelial cancer in textile industry workers. A significantly increased was observed in the Urine cytology for malignant cell and hematuria of occupationally exposed subject when result was compared with exposed groups. [Table 1]. we included 2020 workers over a period of 20 years from 1993 to 2013: 606 worked in rubber manufacturing, 692 from metal processing, 245 in chemical industry and 477 in roadwork and building industry. 6478 cytology were normal, 462 suspicious and 13 malignant. Suspicious and malignant cytology occurred in 4.8% of workers exposed for 1–10 years, 6.2% for 11–20 years of exposure, 7.6% for 21–30 years and 8.6% for >30 years (p30 years of exposure. Using metal processing as reference, the risk of pathological urine cytology results increased for rubber manufacturing (OR=1.32, 95% CI 1.05 to 1.65, p=0.02), with a trend for roadwork and building industry (OR=1.39, 95% CI 0.98 to 1.97, p=0.07) and for chemical industry (OR=1.34, 95% CI 0.94 to 1.93, p=0.11) [51, 52]. A significantly increased was observed in the Urine bladder Tumor antigen of occupationally exposed subject when result was compared with non-exposed subject. [Table 1]. The risk is particularly elevated (OR = 4.41; 95% confidence limits: 1.15–16.84) for subjects who worked in dyeing or printing and who were most probably exposed to azo-dyes. Exposure in the textile industry may be responsible for 16% of the bladder cancers in the Mataro area. A list of dyes commonly used in the Mataro textile industries was compiled and cross-checked with lists of substances tested or evaluated for carcinogenesis [53].

Presented results from a case control study carried out in the county of Mataro, Spain. The study was based on 57 cases that were hospitalized for or died from bladder cancer between 1978 and 1981. An increased risk for past employment in the textile industry (Odds ratio, OR = 2.2; p = 0.038) was found among a group of common occupational sectors. Further analyses in the study indicated that the risk for subjects who worked in dyeing or printing sectors and who were exposed to azo-dyes was particularly elevated (OR = 4.41; 95 % confidence limits; 1.15–16.84) [54]. Similarly, Zheng et al. conducted a study on 1,219 incident bladder cancer cases based on gender which were diagnosed during the period 1980 to 1984. [55] High carcinogenic potential of benzidine to the urinary bladder is also fundamental to elevation of bladder cancer risks in workers exposed to benzidine – based dyes and colorants with much lower exposure (You et al., 1990) [56].

More recent study conducted by the National Institute for Occupation Safely and Health found high relative risks 4- Chloro -O- toluidine production is highly carcinogenic and is associated with increased bladder cancer risk 1988 (Stasik, 1998) [57]. Studies have found a positive association between exposure to PAHs and bladder cancer when the commutative exposure index restricted to exposure received thirty or more years before observation (Romundstad et al., 2000) [58]. From Analyzes of 11 case control studies in six European countries, the results concluded that about 5-10% of bladder cancer in European men could be attributed to occupational exposure, including but not specifically aromatic amines and that the results indicated that improvement in working decades in Western Europe preventing a significant number of bladder cancer cases caused by exposure to occupational carcinogens, particularly aromatic amines (Kogevinas et al., 2003) [59-62].

7. CONCLUSION

Bladder cancer is a highly lethal malignancy and the increasing trends of bladder cancer are alarming, especially in the developing countries including India, and thus, there is a strong need to identify and implement effective prevention and treatment strategies. There by reducing long term morbidity and mortality among workers. Very few studies have been done on Bladder cancer in dye exposure in textile industrial workers of Pali region. Bladder Tumor Antigen tests are in vitro immunoassays that detect human complement factor H-related protein (hCFHrp) in the urine samples of patients with urothelial carcinoma and Urine cytology screening can provide relevant epidemiological data for earlier detection of urothelial cancer caused by to occupational exposure to urinary tract carcinogens. Severe/Long-Term exposure (20-30 years group) of toxic dyes and chemicals had caused increased Bladder Tumor Antigen levels and severe Hepatic and Renal functional health derangement in Textile Industry workers of Pali District.in Rajasthan, India These results suggest that the risk factor for development of bladder cancer is occupational exposure to aromatic amines (2-naphthylamine, 4-aminobiphenyl and benzidine) and 4,4'-methylenebis (2-chloroaniline), which can be found in the products of the chemical, dye. The recommendations to screen workers exposed to urothelial carcinogens 20 years after the beginning of occupational exposure. However, we demonstrated a significant linear dose–response relationship between duration of exposure and detection of a suspicious or malignant cytology. Thus, early screening will result in best prognosis along with improved industrial hygiene. We also strengthen the evidence to support new guidelines for an early screening of urinary tract cancer by urine cytology screening, starting with initial exposure, reassessed during years of working life. As early screening was

associated with best prognosis and industrial hygiene improvements, we strengthen the evidence to support new guidelines for an early screening of urinary tract cancer by urine cytology screening, starting with initial exposure, reassessed during years of working life. Provide protection for industrial workers and other workers where there is more exposure like dyes will probably help in reducing the burden of bladder cancer. Creating awareness of early signs and symptoms of bladder cancer and subsequently organizing screening camps for the high-risk groups will probably be key for better outcomes in terms of control of bladder cancer.

To address this issue, there is a critical need for multicenter prospective studies to develop standardised protocols. These efforts could significantly improve in factory workers outcomes by addressing the current shortcomings in the management of this prevent urological cancer.

8. ADDITIONAL INFORMATION

Disclosures

Human subjects: Consent for treatment and open access publication was obtained or waived by all participants in this study. Institutional ethics committee, Pacific Medical College and Hospital, Udaipur, Rajasthan issued approval PMU/PMCH/IEC/2023/15. Ethical approval for the project approved by Institutional ethics committee, Pacific Medical College and Hospital, Udaipur, Rajasthan via letter reference number PMU/PMCH/IEC/2023/15 on 01/04/2023. Informed written patient consent form for treatment and publication in open access journal has been obtained from each study participant prior to enrollment in study and sample collection. **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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REFERENCES

[1] Farling & K.B: Bladder cancer Risk factors, diagnosis, and management. Nurse Pract. 2017, 42, 26–33.

[2] Jemal, A. Bray, F.; Center, M.M.; Ferlay, J.; Ward, E.; Forman, D: Global cancer statistics. CA Cancer J. Clin. 2011, 61, 69–90.

[3] Antoni, S.; Ferlay, J.; Soerjomataram, I.; Znaor, A.; Jemal, A.; Bray, F: Bladder Cancer Incidence and Mortality: A Global Overview and Recent Trends. Eur. Urol. 2017, 71, 96–108.

[4] Botteman, M.F.; Pashos, C.L.; Redaelli, A.; Laskin, B.; Hauser, R: The health economics of bladder cancer: A comprehensive review of the published literature. Pharmacoeconomics. 2003, 21, 1315–1330.

[5] Bochenek, K.; Aebisher, A.; Międzybrodzka, A.; Cieślar, G.; Kawczyk-Krupka, A: Methods for bladder cancer diagnosis—The role of autofluorescence and photodynamic diagnosis. Photodiagnosis Photodyn. Ther. 2019, 27, 141–148.

[6] International Agency for Research on Cancer. Globocan. Lyon, France: International Agency for Research on Cancer; 2018.Available from: http://www.gco.iarc.fr. [Last accessed on 2020 Jun 03.

[7] Koka, Vinita and Srivastava, Meenu: Occupational health hazards of textile workers of Pali district. Asian J. Home Sci. 2012, 7 (1): 152-155.

[8] Sargunar CG & Ravishankar S: Occupational Disease in textile dyers A brief review. Journal of research in Biology. 2012; 2(7):626.

[9] Wernli KJ, Astrakianakis G, Camp JE, Ray RM, Chang CK, Li GD, et al.: Development of a job exposure matrix (Jem) for the textile industry in shanghai. China. J. Occup. Environ. Hyg. 2006, 3: 521-529.

[10] Hoet PHM, Bruske-Hohlfeld I, and Salata OV: Nanoparticles – known and unknown health risks. Journal of Nanobiotechnology. 2004, 2: 12.

[11] Westhoff E, Maria de Oliveira-Neumayer J, Aben KK, Vrieling A, Kiemeney LA: Low awareness of risk factors

among bladder cancer survivors: new evidence and a literature overview. Eur J Cancer. 2016, 60:136–45. https://doi. Org/ 10. 1016/j. ejca. 2016. 03. 071.

[12] Van Hoogstraten LMC, Vrieling A, van der Heijden AG, Kogevinas M, Richters A, Kiemeney LA: Global trends in the epidemiology of bladder cancer: challenges for public health and clinical practice. Nat Rev Clin Oncol. 2023, 20 (5):287–304. https:// doi. Org/ 10. 1038/ s41571-023-00744-3.

[13] Jubber I, Ong S, Bukavina L, Black PC, Comperat E, Kamat AM, et al.: Epidemiology of bladder cancer in 2023: a systematic review of risk factors. EurUrol. 2023, 84(2):176–90. https:// doi. org/ 10. 1016/j. eururo. 2023. 03. 029.

[14] Chavan S, Bray F, Lortet-Tieulent J, Goodman M, Jemal A: International variations in bladder cancer incidence and mortality. Eur Urol. 2014, 66 : 59-73.

[15] WHO: Disease and injury country estimates. World Health Organization. 2009.

[16] Arnulf Stenzl G: Tumour markers in bladder cancer. Euro Oncol Rev. 2005, 3: 1-7

[17] Lokeswar VB: Urinary bladder tumor markers. Uro Oncol. 2011, 6:528-37.

[18] Harris L: American society of clinical oncology update of recommendations for the use of tumor markers in breast cancer. J Clincial Oncol. 2007, 25: 5287-312.5

[19] Wu X, Ros MM, Gu J, Kiemeney L: Epidemiology and genetic susceptibility to bladder cancer. BJU Int. 2008, 102: 1207-15.

[20] Li HT, Duymich CE, Weisenberger DJ, Liang G: Genetic and epigenetic alterations in bladder cancer. Int Neurourol J. 2016, 20: 84-94.

[21] Yamamoto Y, Matsuyama H, Kawauchi S, Furuya T, Liu XP, Ikemoto K, et al.: Biological characteristics in bladder cancer depend on the type of genetic instability. Clin Cancer Res 2006; 12:2752-58.

[22] Schlomer, B.J.; Ho, R.; Sagalowsky, A.; Ashfaq, R.; Lotan, Y: Prospective Validation of the Clinical Usefulness of Reflex Fluorescence In Situ Hybridization Assay in Patients With Atypical Cytology for the Detection of Urothelial Carcinoma of the Bladder. J. Urol. 2010, 183, 62–67.

[23] Ng, K.; Stenzl, A.; Sharma, A.; Vasdev, N: Urinary biomarkers in bladder cancer: A review of the current landscape and future directions. Urol. Oncol. Semin. Orig. Investig. 2021, 39, 41–51.

[24] Ellis, W.J.; Blumenstein, B.A.; Ishak, L.M.; Enfield, D.L: Clinical evaluation of the BTA trak assay and comparison to voided urine cytology and the bard BTA test in patients with recurrent bladder tumors. Urology. 1997, 50, 882–887.

[25] Wiener, H.G.; Mian, C.H.; Haitel, A.; Pycha, A.; Schatzl, G.; Marberger, M: Can urine bound diagnostic tests replace cystoscopy in the management of bladder cancer. J. Urol. 1998, 159, 1876–1880.

[26] Leyh, H.; Marberger, M.; Conort, P.; Sternberg, C.; Pansadoro, V.; Pagano, F et al: Comparison of the BTA statTM test with voided urine cytology and bladder wash cytology in the diagnosis and monitoring of bladder cancer. Eur. Urol. 1999, 35, 52–56.

[27] Pode, D.; Shapiro, A.; Wald, M.; Nativ, O.; Laufer, M.; Kaver, I: Noninvasive detection of bladder cancer with the BTA stat test. J. Urol. 1999, 161, 443–446.

[28] Liaqat I, Arshad M, Arshad N: Changes in selected blood biochemical components of industrial workers occupationally exposed to textile dyes: A preliminary study. Pakistan J. Zool. 2009; 41(1):65-9.

[29] Voss J, Roller M, Brinkmann E: Nephrotoxicity of organic solvents biomarkers for early detection. Int Arch Occup Environ Health. 2005; 78: 475-485.

[30] Ragunathan I and Panneerselvam N: Antimutagenic potential of curcumin on chromosomal aberrations in Allium cepa. J Zhejiang Univ. Sci. B. 2007, 8: 470-5.

[31] Kwon P, Lundin J, Li W, Ray R, Littell C and Gao D: Night shift work and lung cancer risk among female textile workers in Shanghai, China. J Occup Environ Hyg. 2015, 12:334-41.

[32] Donbak L, Rencuzogullari E, Topaktas M and Sahin G: A Bio monitoring study on the workers from textile dyeing plants. Russian Journal of Genetics. 2006; 42 (6):613-618.

[33] Keith G, Tolman MD, Robert R. Liver function. In: Burtis CA, Ashwood ER: editors. Tietz Textbook of Clinical Chemistry. 3 rd ed. WB Saunders Company: Philadelphia. 1999, 1125-77

[34] Constantin M, Choi AJS, Cloonan SM and Stefan WR: Therapeutic Potential of Heme Oxygenase-1/Carbon Monoxide in Lung Disease. International Journal of Hypertension. 2012, 1-18.

[35] Abdou ZA, Attia MH and Raafat MA: Protective effect of citric acid and thiol compounds against cadmium

and lead toxicity in experimental animals. J Biol Chem Environ Sci. 2007; 2(2):481–497.

[36] Letasiova S, Medveova A, Sovcikova A, Dusinska M, Volkovova K,Mosoiu C et al.: Bladder cancer, a review of the environmental risk factors. Environ Health. 2012, 111:11.

[37] Kazmi MP, Shakoori AR, Hafeez MA, and Ali SS: Short term effects of chlorpyrifos on hematology and biochemical components of blood of the Sprague-Dawley rat. Pakistan J. Zool. 2003, 35: 237-243.

[38] Soyinka OO, Adeniyi FA and Ajose OA: Biochemical parameters of liver function in artisans occupationally exposed to "vat dyes". Indian. J. occup. Environ. Med. 2007, 11: 76-79.

[39] Singh RP, Khanna R, Kaw JL, Kanna SK and Das M: Comparative effect of benzanthrone and 3-bromobenzanthrone on hepatic xenobiotic metabolism and antioxidative defense system in guinea pigs. Arch Toxicol. 2003, 77: 94– 9.

[40] Peti-Peterdi, János, Harris, Raymond C: Macula Densa Sensing and Signaling Mechanisms of Renin Release. Journal of the American Society of Nephrology. 2010, 21(7): 1093-1096. | DOI: 10.1681/ASN.2009070759.

[41] Ibrahim KS, Amer NM, El-dossuky EA, Emara AM, El- Fattah AES, Shahy EM: Hepatic dysfunction and immune suppression among Egyptian workers occupationally exposed to benzene. Int Public Health Forum. 2014, 1:1-6.

[42] Sancini A, Caciari T, Chighine A, Gioffre PA, Andreozzi G, Sacchi L, et al.: Workers of the printing industry and hepatic damage . Ann Ig. 2014, 26:321-9.

[43] Hussein ASA, AbdallaMSh, Hussein JS, WafaaGh. ShoushaWGh, Mohamed AH: Antioxidants in shoemakers exposed to organic solvents. J Appl Sci Res. 2008, 4:1107-17.

[44] Padmanaban P, Deept GN, Sarkar G, Sarkar M: Biochemical parameters of paint workers in Puducherry . Chron Young Sci. 2011, 2:59-60.

[45] Vasudev Sankhla , Don Mathew , Seema Jawalekar , Shrikant Sharma , Suraj Pal Singh , Disha Sahi , Prasad khodke , Aman Deep : Assessment of Hepatotoxicity in Textile Industry Workers Exposed to Occupational Hazards. Cuestiones De Fisioterapia. 2025, 54(3), 2992-3005. https://cuestionesdefisioterapia.com/index.php/es/article/view/1522

[46] Lack, A., Yeoman, A. & Wendon, J: Renal dysfunction in chronic liver disease. Crit Care 14, 214 (2010). https://doi.org/10.1186/cc8855

[47] Oluwatosin O. Soyinka, Francis A. Adeniyi, and Olabamiji A. Ajose: Biochemical parameters of liver function in artisans occupationally exposed to “vat dyes”. Indian Journal of Occupational and Environmental Medicine. 2007, 11(2): 117-247.

[48] Singh Z & Chadha P: Textile industry and occupational cancer. Journal of Occupational Medicine and Toxicology. 2016; 11: 39

[49] Jyothi K, Kalyani D and Nachiappan V: Effect of acute exposure of N, N-Dimethylformamide, an industrial solvent on lipid peroxidation and antioxidants in liver and kidney of rats. Indian Journal of Biochemistry & Biophysics. 2012; 49(4): 279-84

[50] Haider MZ & Aslam A: StatPearls [Internet]. StatPearls Publishing; Treasure Island (FL) 2023, Proteinuria. [PubMed].

[51] Dutheil F, Rouanet L, Mulliez A, et al: Urine cytology screening of French workers exposed to occupational urinary tract carcinogens: a prospective cohort study over a 20-year period. BMJ Open. 2017, 7: 16238. doi :10.1136/ bmjopen-2017-016238.

[52] Carreón T, Hein MJ, Hanley KW, et al: Bladder cancer incidence among workers exposed to o-toluidine, aniline and nitrobenzene at a rubber chemical manufacturing plant. Occup Environ Med. 2014, 71: 175–82.

[53] Serra C, Kogevinas M, Silverman DT, Turuguet D, Tardon A, Garcia-Closas R, et al: Work in the textile industry in Spain and bladder cancer. Occup Environ Med. 2008, 65 (8):552-9. doi: 10.1136/oem.2007.035667. Epub 2007 Nov 28. PMID: 18045847.

[54] Gonzales CA, Riboli E, and Lopez-Abente G: Bladder cancer among workers in the textile industry: results of a Spanish case–control study. Am J Ind Med. 1988, 14: 673–80

[55] Zheng W, McLaughlin JK, Gao YT, Silverman DT, Gao RN, Blot WJ: Bladder cancer and occupation in Shanghai, 1980–1984. Am J Ind Med. 1992, 21: 877–85

[56] You XY, Chen JG, Hu YN: Studied on the relation between bladder cancer and benzidine or its derived dyes in Shanghai. Br J Ind Med. 1990, 47: 544 32.

[57] Stasik MJ: Carcinomas of the urinary bladder in a 4-chloro-o-toluidine cohort. Int Arch Occup Environ Health.

1988, 60:21-24.

[58] Romundstad P, Haldorsen T, Andersen A: Lung and bladder cancer among workers in a Norwegian aluminium reduction plant. Occup Environ Med. 2000, 57: 495–499.

[59] Kogevinas M, T Mannetjt, A., Cordier S, Ranft U, Gonzale Z , C.A, Vineis P, et al: Occupation and bladder cancer among men in Western Europe. Cancer causes and control. 2003, 14: 907-14.

[60] Shrikant Sharma, Don Mathew, Ashish Kumar Sharma , Vasudev Sankhla , Suraj Pal Singh , Neelam Bhatia , Disha Sahi: Metabolic consequences of hypothyroidism: impact on glycemic regulation, liver health and lipid metabolism. Cuestiones De Fisioterapia. 2025,54(3),4226_4252.https://cuestionesdefisioterapia.com/index.php/es/article/view/1731

[61] Suraj Pal Singh , Don Mathew , Mukesh Chand , Shrikant Sharma , Vasudev Sankhla , Neelam Bhatia , Disha Sahi: Analysing the association between Serum Parathyroid Hormone, Osteocalcin, and TRACP 5b in Bone Mineral Disease among Chronic Kidney Disease Patients before and after dialysis. Cuestiones De Fisioterapia.2025, 54(3), 3018-3030. https://cuestionesdefisioterapia.com/index.php/es/article/view/1523

[62] Suraj Pal Singh, Don Mathew, Mukesh Chand, Vasudev Sankhla, Shrikant Sharma, Neelam Bhatia, Disha Sahi: Correlation of Serum Parathyroid hormone, Serum Osteocalcin and Serum Tartrate resistant acid Phosphatase (TRACP) 5b with Bone mineral disease in Chronic Kidney Disease patients . Cuestiones De Fisioterapia.2025, 54(3), 2180-2191. https://cuestionesdefisioterapia.com/index.php/es/article/view/1408