Table 1: General characteristics of the studied groups.

Parameter	Exposed group (n=57)	Control group (n=59)	Test of significance	P-value
➢ Age (years) - Mean ± SD	44.9±10.03	41.5 ±10.07	t = 1.82	> 0.05
➢ Smoking habits				
Non smoker (No and %)	27 (47.4%)	16(27.1%)		
Ex-smoker (No and %)	9 (15.8%)	12(20.3%)	χ^2 = 5.133	> 0.05
Current smoker (No and %)	21 (36.8%)	31(52.5%)		
➢ SI* - Mean ± SD	145.16±255.73	169.75±215.8	t = 0.472	> 0.05
➢ BMI** (Kg/m^2) - Mean ± SD	29.8±4.4	27.6±4.8	t = 1.77	> 0.05
➢ Duration of exposure to organic solvents (years) Mean ± SD	19.18±9.9	----------		

***= Smoking Index**
****= Body Mass Index**

This table [1] shows that there was no statistically significant difference between the studied groups, as regards their ages, BMI and smoking habits (p>0.05).

Table 2: Distribution of the studied groups according to clinical manifestations.

	Exposed group (n=57)		Control group (n=59)		Test of significance χ^2	P-value
	No.	%	No.	%		
➢ **Gastrointestinal:**						
- Dyspepsia	4	6.8%	1	1.8%	0.766	> 0.05
- Nausea	5	8.8%	3	5.1%	0.174	> 0.05
- Diarrhea	3	5.3%	1	1.7%	0.296	> 0.05
- Constipation	4	7.0%	3	5.1%	0.002	> 0.05
➢ **Respiratory:**						
- Chronic Cough	17	29.8%	2	3.4%	12.9	<0.01**
- Expectoration	12	21.1%	2	3.4%	6.9	<0.05*
- Shortness of breath	13	22.8%	9	15.3%	0.641	> 0.05
- Allergic rhinitis	4	6.8%	1	1.8%	0.766	> 0.05
- Allergic conjunctivitis	4	6.8%	0	0%	2.23	> 0.05
- Urticaria	4	6.8%	0	0%	2.23	> 0.05
- Asthma	9	15.8%	3	5.1%	2.52	> 0.05
- Pallor	7	12.3%	5	8.5%	0.135	> 0.05
- Tremors	1	1.8%	0	-	1.044	> 0.05

***: P-value < 0.05 (significant)** **** p<0.01(highly significant)**

*****There were no subjects complained of Blood in stool, Haematemesis, Jaundice, Cyanosis or Lower limb oedema in both exposed and control groups.**

It is quite apparent this table that there were no significant difference between frequency of gastrointestinal manifestation in the exposed group and controls ($p>0.05$). Meanwhile, for respiratory manifestations, there was a statistically significant difference between both groups as regards cough and expectoration ($p< 0.01$ and $p<0.05$) respectively.

Table 3: Distribution of the studied groups according to mean and standard deviation of measured liver function tests.

Parameter	Normal Values	Exposed group (n=57)	Control group (n=59)	Test of significance	P-value
		Mean ± SD	Mean ± SD		
➢ TB(mg/dl)	< 12 mg/dl	3.97±2.6	3.5±2.4	t = 0.976	> 0.05
➢ DB(mg/dl)	< 3mg/dl	0.7±0.6	0.7±0.6	t =0.062	> 0.05
➢ ALT(U/L)	up to 12 U/L	9.95±1.93	9.19±2.29	t =1.93	> 0.05
➢ AST(U/L)	up to 12 U/L	10.07±2.01	9.41±1.91	t =1.82	> 0.05
➢ ALP(U/L)	73-207 U/L	107.81±47.95	94.56±31.06	t =1.77	> 0.05
➢ GGT(U/L) [a.]	10-50 U/L	26.7±24.8	24.4±11.9	z= 2.121	< 0.05*
➢ SBA (µmol /L) [a.]	Up to 8.1 µmol/L	50.2±47.9	5.4±2.7	z= 7.828	<0.01**

TB = Total bilirubin DB =Direct bilirubin
ALT= alanineaminotransferase AST= aspartate aminotransferase
ALP= Alkaline phosphatase GGT= Gamma –glutamyl transferase
SBA = Serum Bile Acids
* $p<0.05$ ** $p<0.01$ [a.] =Mann Whiteny test

As shown in this table, the mean levels of TB, DB, ALT, AST and ALP were slightly higher in exposed than the control but the differences were not statistically significant (P> 0.05)

Concerning GGT, there was a statistically significant difference between exposed and controls ($p<0.05$). As regards bile acids their mean levels were much higher in exposed compared with controls and the difference was highly statistically significant ($p<0.01$).

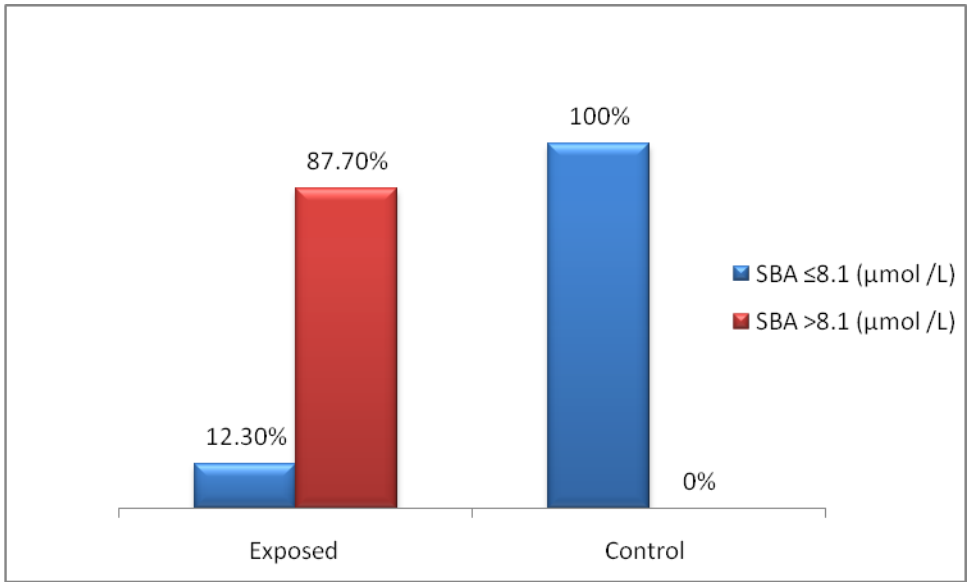
Table 4: Frequency of subjects above the upper limit of the reference range of measured hepatic biomarkers

Parameter	Exposed (n=57)		Control (n=59)		Test of significance χ^2	P-value
	No.	%	No.	%		
TB(mg/dl)						
≤12	**57**	**100.0**	**59**	**100.0**	----------	---------
>12	---	-----	----	-----		
DB (mg/dl)						
≤3	**57**	**100.0**	**59**	**100.0**	----------	---------
>3	----	----	---	----		
ALT (U/L)						
≤12	**54**	**94.7**	**59**	**100.0**	**3.19**	**> 0.05**
>12	**3**	**5.3**	**0**	**0**		
AST (U/L)						
≤12	**53**	**93**	**59**	**100.0**	**4.29**	**> 0.05**
>12	**4**	**7**	**0**	**0**		
ALP (U/L)						
73-207	**54**	**94.7**	**59**	**100.0**	**3.19**	**> 0.05**
>207	**3**	**5.3**	**0**	**0**		
GGT (U/L)						
10-50	**51**	**89.5**	**58**	**98.3**	**3.99**	**> 0.05**
>50	**6**	**10.5**	**1**	**1.7**		
SBA (µmol /L)						
≤8.1	**7**	**12.3**	**59**	**100.0**	**90.96**	**0.005****
>8.1	**50**	**87.7**	**0**	**0**		

*** p<0.05** **** p<0.01**

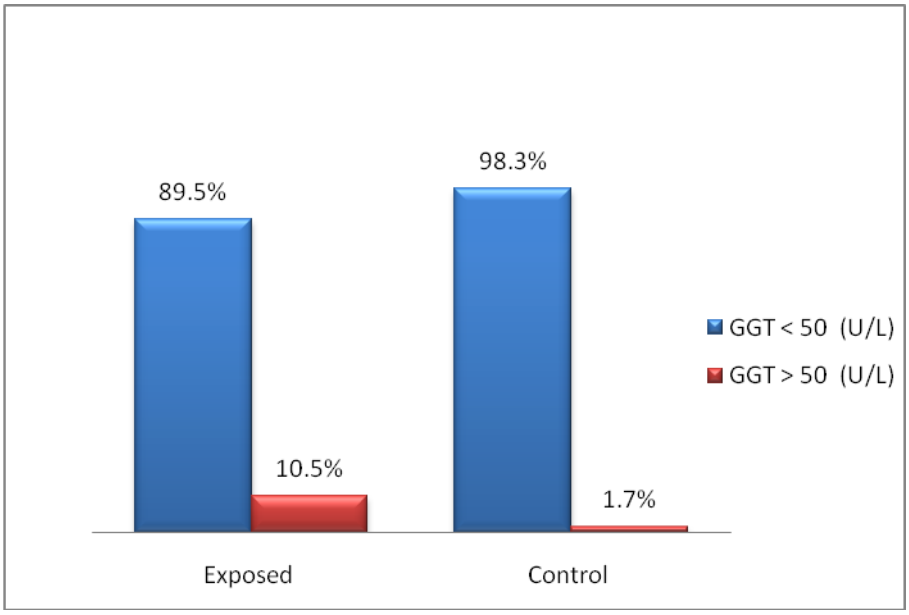
It is quite clear in this table that the number of individuals with increased SBA level above the upper limit of reference range was statistically significantly higher in the exposed group than in the controls ($p<0.01$). No significant difference between exposed and control individuals was observed for the other studied parameters.

(Figure 1): Distribution of SBA above the upper limit of the reference range



It is quite apparent in this figure that the level serum bile acids in (87.7%) of exposed groups was above the upper limit of reference range , meanwhile non of the controls had serum bile acids above the upper reference range.

(Figure 2): Distribution of GGT above the upper limit of the reference range



This figure shows that the level of GGT in (10.5%) of exposed groups was above the upper limit of reference range, meanwhile only (1.7%) of the controls had GGT level above the upper reference range.

Table 5: Distribution of liver function tests in the exposed groups according to exposure intensity.

Parameter	High exposure group (n=41) HES*32501-72500	Low exposure group (n=16) HES*2500-32500	Test of significance	P-value
	Mean ±SD	Mean ±SD		
➢ TB(mg/dl)	4.1 ± 2.4	3.9 ± 2.6	t = 0.224	> 0.05
➢ DB(mg/dl)	0.67 ± 0.66	0.69± 0.55	t = 0.094	> 0.05
➢ ALT(U/L)	10.10± 1.9	9.56± 2.03	t = 0.939	> 0.05
➢ AST(U/L)	10.15± 1.97	9.88± 2.16	t = 0.455	> 0.05
➢ ALP(U/L)	113.01 ± 54.03	94.47± 23.13	t = 1.32	> 0.05
➢ GGT(U/L) [a.]	30.25 ± 25.9	17.7 ± 13.05	z= 2.488	< 0.05*
➢ SBA (µmol /L) [a.]	63.7 ± 49.5	15.5 ± 15.4	z=4.706	<0.01**

HES = Life Time Hydrocarbon Exposure Score

*** p<0.05** **** p<0.01** **[a.] =Mann Whiteny test**

This table illustrates that the mean level of total bilirubin, direct bilirubin, ALT, AST and ALP showed no statistically significant difference between subjects with low exposure (LEG) and those with high exposure level (HEG). On the contrary, the mean levels of GGT and SBA were much higher in HEG than that in LEG and the difference was statistically significant between the two groups (P value were <0.05 and < 0.01) respectively.

Table 6: Distribution of liver function tests in the exposed groups according to duration of exposure to solvents.

Parameter	Exposure duration ≥ 15 years (n=37)	Exposure duration<15 years (n=20)	Test of significance	P-value
	Mean ±SD	Mean ±SD		
➢ TB(mg/dl)	4.2 ± 2.65	3.5 ± 2.4	t = 1.046	> 0.05
➢ DB(mg/dl)	0.76±0.69	0.54±0.48	t = 1.439	> 0.05
➢ ALT(U/L)	9.95 ± 2.03	9.95 ± 1.7	t = 0.007	> 0.05
➢ AST(U/L)	10.35 ± 1.9	9.55 ± 2.212	t = 1.378	> 0.05
➢ ALP(U/L)	112.6 ± 57.8	98.9 ± 18.1	t = 1.323	> 0.05
➢ GGT(U/L)[a.]	25.96 ± 18.25	28.15 ± 31.76	z= 2.468	> 0.05
➢ SBA (µmol /L) [a.]	63.8 ± 47.4	24.8 ± 38.3	z= 4.506	<0.01**

*** p<0.05** **** p<0.01** **[a.] =Mann Whiteny test**

The table above demonstrates that as regards, ALT, AST, ALP, GGT direct and total bilirubin their mean levels showed no significant difference between subjects with exposure duration less than 15 years and those with exposure duration equal or more than 15 years .

Meanwhile, the mean levels of serum bile acids were much higher among workers with longer duration of exposure to organic solvents (63.8 ± 47.4) than those with shorter duration of exposure (24.8 ± 38.3) and the difference was highly statistically significant ($p<0.01$).

Table 7: Validity of serum bile acid [SBA] levels of exposed against serum liver enzyme.

	Sensitivity (%)	**Specificity** (%)
➢ **Serum bile acid**	**77**	**94**
➢ **ALT**	**10**	**90**
➢ **AST**	**17**	**90**
➢ **GGT**	**30**	**83**
➢ **DB**	**3**	**100**

The relative sensitivity and specificity of SBA versus standard biochemical tests in detecting conditions connected with exposure to solvents is reported in the table above.

Concerning sensitivity, SBA showed the highest sensitivity when compared to ALT and AST, GGT and bilirubin. Regarding the specificity, SBA had higher specificity than ALT. AST and GGT.

Table 8: Correlation coefficient of exposure and effect indices in solvents exposed subjects:

Parameter	Age (years) r	BMI r	Duration of exposure (years) r	HES r	Smoking Index r
➢ TB(mg/dl)	0.113	-0.012	0.217	0.163	0.011
➢ DB(mg/dl)	0.096	0.150	0.178	0.092	-0.087
➢ ALT(U/L)	-0.003	0.259	0.045	0.112	-0.163
➢ AST(U/L)	0.030	0.040	0.058	0.165	0.195
➢ ALP(U/L)	0.233	-0.101	0.192	0.199	0.456**
➢ GGT(U/L)	0.376**	-0.131	0.044	0.047	0.051
➢ SBA (µmol /L)	0.001	0.111	0.393**	0.332*	-0.157

***. Correlation is significant at the 0.05 level (2-tailed).**

****. Correlation is significant at the 0.01 level (2-tailed).**

It is quite clear from this table that, there was a significant positive correlation between SBA and both duration and level of exposure ($p< 0.01$ and 0.05 respectively). On the other hand, GGT level showed significant positive correlation with age ($p< 0.01$). Also, ALP was positively correlated with smoking index ($p< 0.01$). The scatter diagrams of the significant correlations are present in Figure 3, 4 and 5.

Figure (3): Correlation coefficient between bile acids level and Life Time Hydrocarbon Exposure Score (HES).

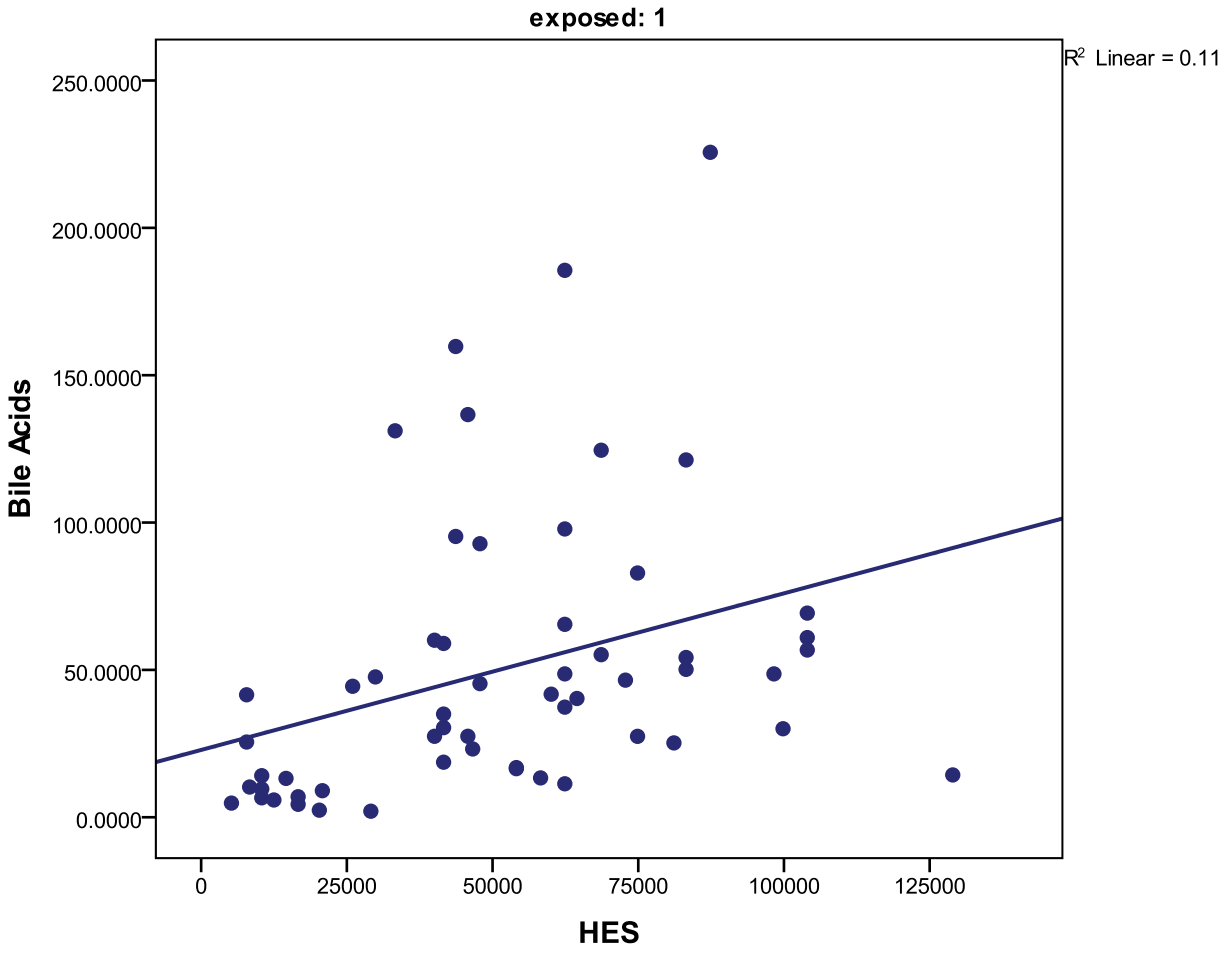


Figure (4): Correlation coefficient between bile acids level and exposure duration

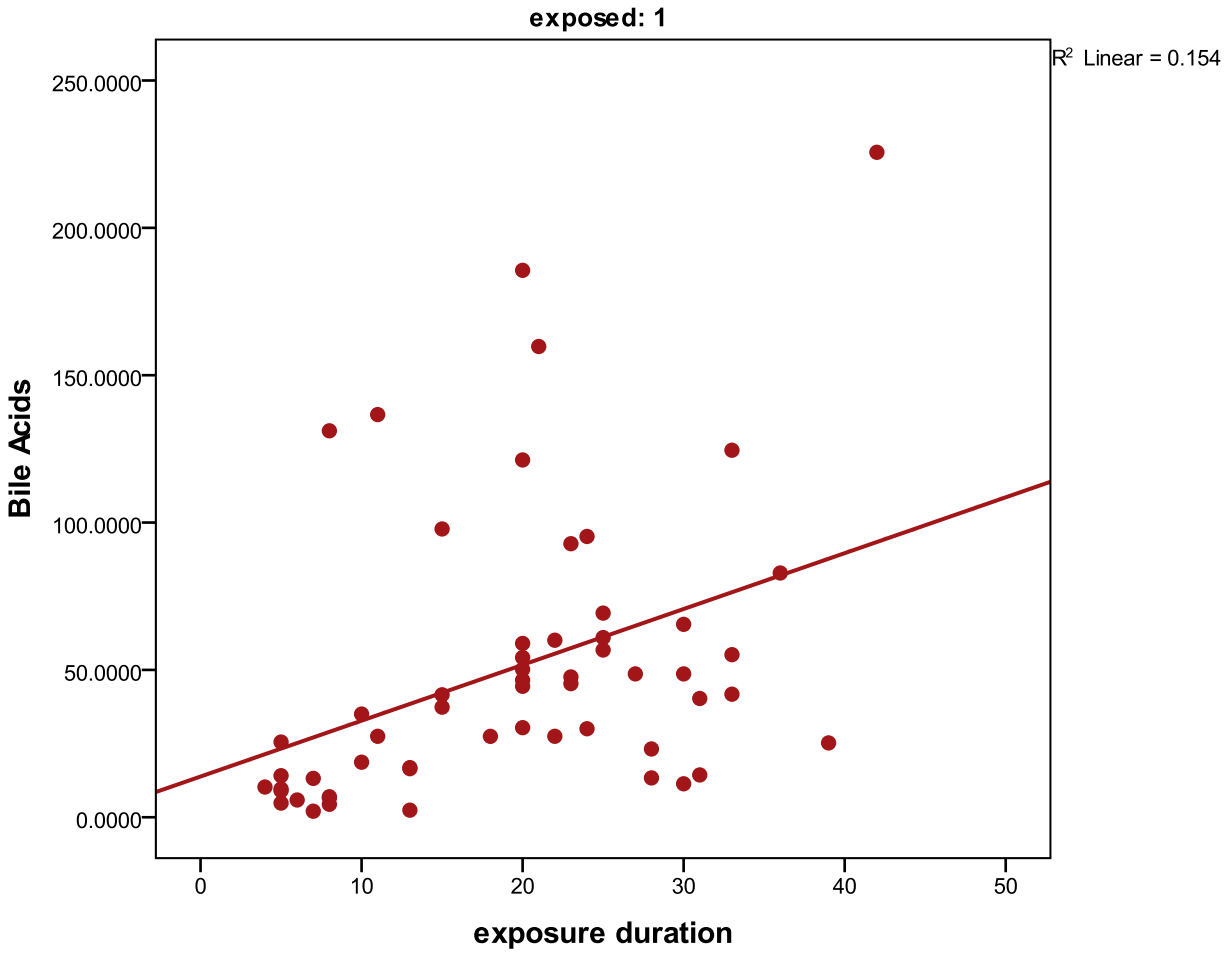


Figure (5): Correlation coefficient between ALP level and Smoking Index

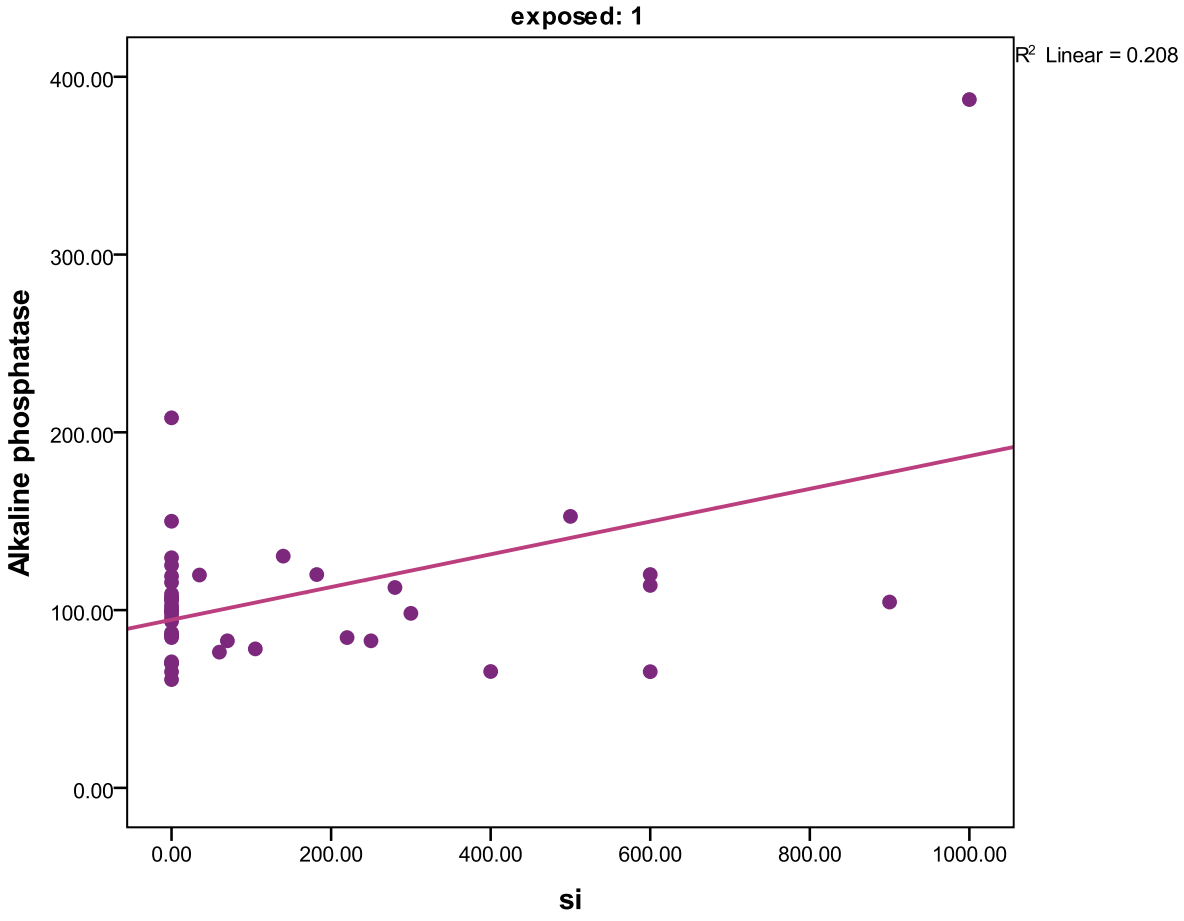


Table 9: Distribution of the studied groups according to mean and standard deviation of ventilatory functions tests.

Parameter	Exposed group (n=57)	Control group (n=59)	Test of significance (t- test)	P-value
	Mean ± SD	Mean ± SD		
➢ FVC(% predicted value)	80.39±24.03	80.98±21.9	0.140	>0.05
➢ FEV_1(% predicted value)	80.30±17.79	89.97±22.48	2.56	<0.01**
➢ FEV_1 /FVC ratio	98.83 ±16.89	111.84±14.24	3.66	<0.01**
➢ PEF(% predicted value)	85.25±22.31	96.24±32	2.14	<0.05*
➢ FEF	98.26±30.93	109.32±32.21	1.88	>0.05

FVC = Forced Vital Capacity
FEV1% = Forced Expiratory volume in first second
PEF = Peak Expiratory Flow
FEF= forced expiratory flow
*** p<0.05 ** p<0.01**

It is clear from the table above that there was no significant difference between the mean values of FVC between both exposed and controls. FEF decreased in exposed than controls but the decrease was not significant between both groups. On the other hand, FEV_1, FEV_1/FVC and PEF showed statistically significant difference between both groups ($p< 0.01$, 0.01and 0.05) respectively.

Table (10): Frequency distribution of ventilatory functions impairment among the studied groups.

Parameter	Exposed group (n=57)		Control group (n=59)		Test of significance χ^2	P-value
	No	%	No	%		
➢ FVC impairment	11	19.3%	14	23.7%	0.126	>0.05
➢ FEV_1 impairment	29	50.9%	12	20.3%	10.53	<0.01**
➢ Both FEV_1 and FVC impairment	5	8.8%	5	8.5%	13.8	>0.05
➢ No impairment	12	21.0%	28	47.5%	13.7	<0.05*
➢ FEV_1/FVC impairment	10	17.5%	3	5.1%	3.36	<0.05*

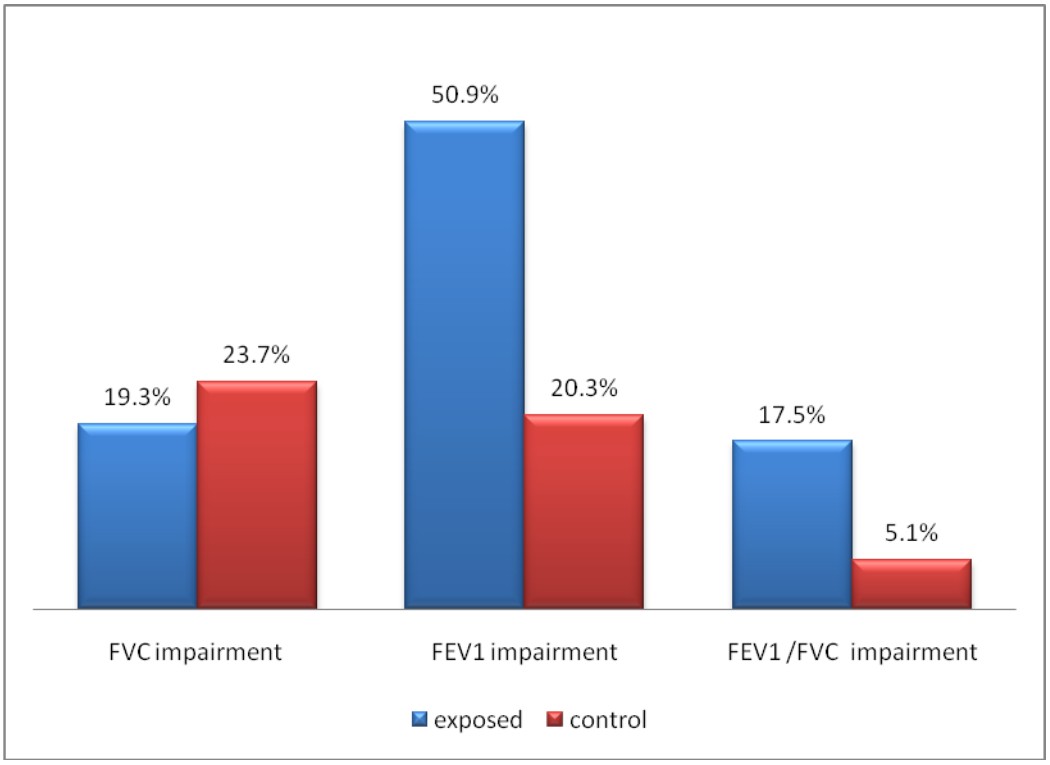
FVC = Forced Vital Capacity

FEV_1% = Forced Expiratory volume in first second

*** p<0.0** **** p<0.01**

As seen in this table, FVC impairment did not differ between exposed and controls. Meanwhile, FEV_1 and FEV_1 /FVC ratio impairment were more obvious in exposed than controls and the difference was statistically significant ($p< 0.05$ and $p< 0.01$) respectively.

Figure (6): Frequency distribution of ventilatory functions impairment in studied groups



This figure shows apparent difference between percentage of exposed subjects with FEV_1 impairment and controls followed by FEV_1/FVC ratio impairment.

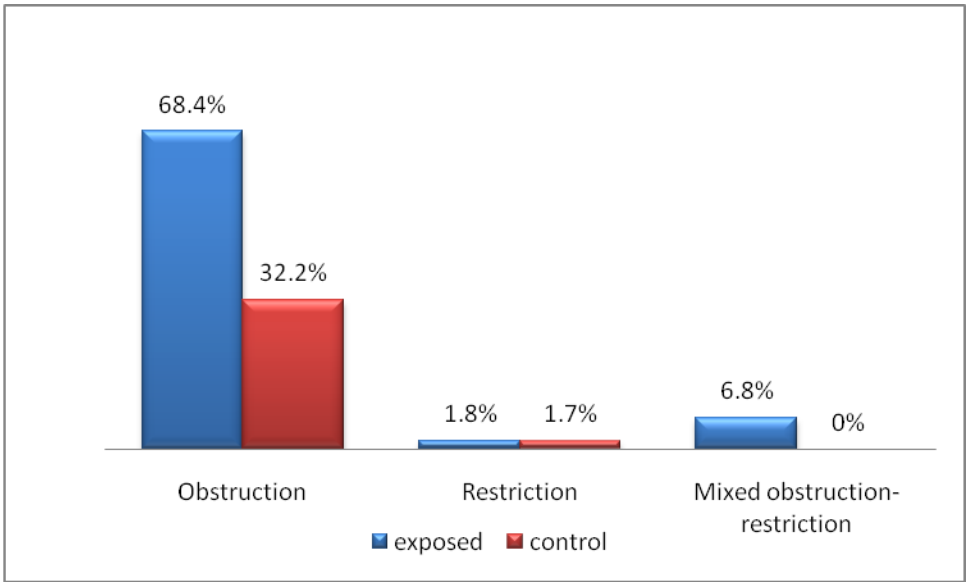
Table (11): Patterns of ventilatory impairment among studied groups

	Exposed (n=57)		Control (n=59)		Test of significance χ^2	P-value
	No.	%	No.	%		
➢ Obstruction	39	68.4%	19	32.2%	17.1	<0.01**
➢ Restriction	1	1.8%	1	1.7%		
➢ Mixed obstructive-restrictive	4	6.8%	0	0%		
➢ No impairment	13	33%	39			

**** p<0.01**

As clear from this table, the obstructive pattern was the most prevalent abnormality in exposed than in controls while restriction was nearly the same for both groups.

Figure (7): Patterns of ventilatory impairment among studied groups



It is apparent from this figure that Pulmonary Obstruction represents the highest abnormality in exposed group (68.4%) followed mixed obstruction-restriction (6.8%).

Table 12: Frequency distribution of ventilatory function impairment in the exposed group by smoking status

Parameter	Smokers (n=30)		Non smokers (n=27)		Test of significance χ^2	P-value
	No	%	No	%		
➢ FVC impairment	6	22.2%	5	16.7%	0.038	>0.05
➢ FEV_1 impairment	21	70%	8	29.6%	7.7	<0.01**
➢ Both FEV_1 and FVC impairment	2	6.7%	3	11.1%	0.015	>0.05
➢ No impairment	1	1.1%	11	42.6%	3.8	<0.01**
➢ FEV_1/FVC impairment	8	26.7%	2	7.4%	2.4	>0.05

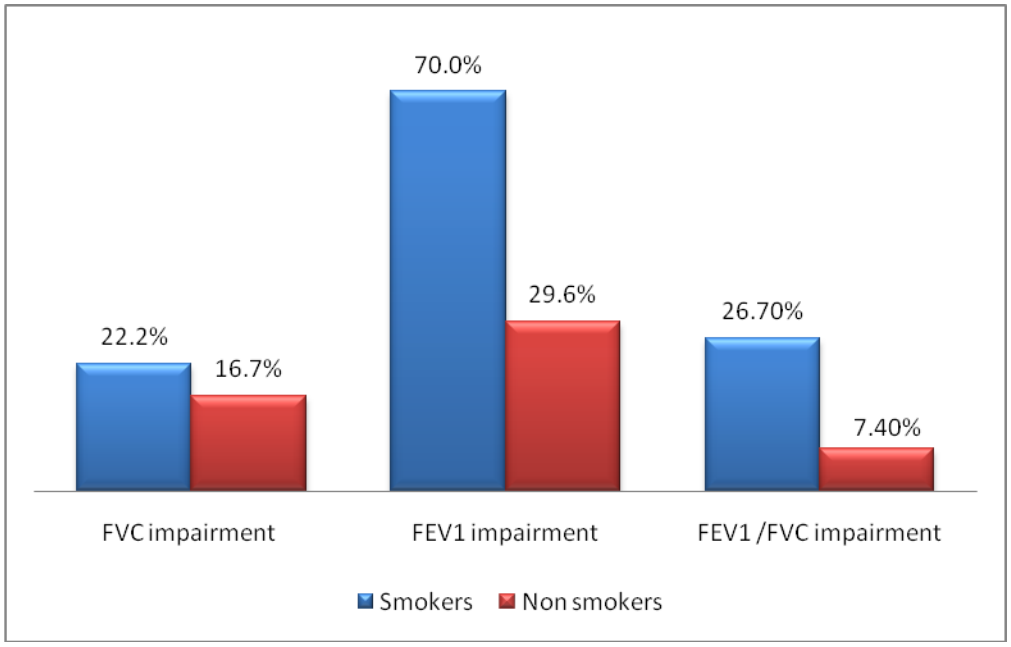
FVC = Forced Vital Capacity

FEV_1% = Forced Expiratory volume in first second

**** p<0.01**

This table indicates that within the exposed group, FVC and FEV_1/FVC impairment showed no significant difference between smokers and non-smokers. On the contrary, FEV_1 impairment was statistically significantly different between both groups ($p<0.01$).

Figure (8): Frequency distribution of ventilatory function impairment in exposed group by smoking status



This figure shows that impairment in FEV_1 was significant in smokers (70%) versus (29.6%) in non-smokers.

Table 13: Frequency distribution of ventilatory functions impairment according to the exposure intensity.

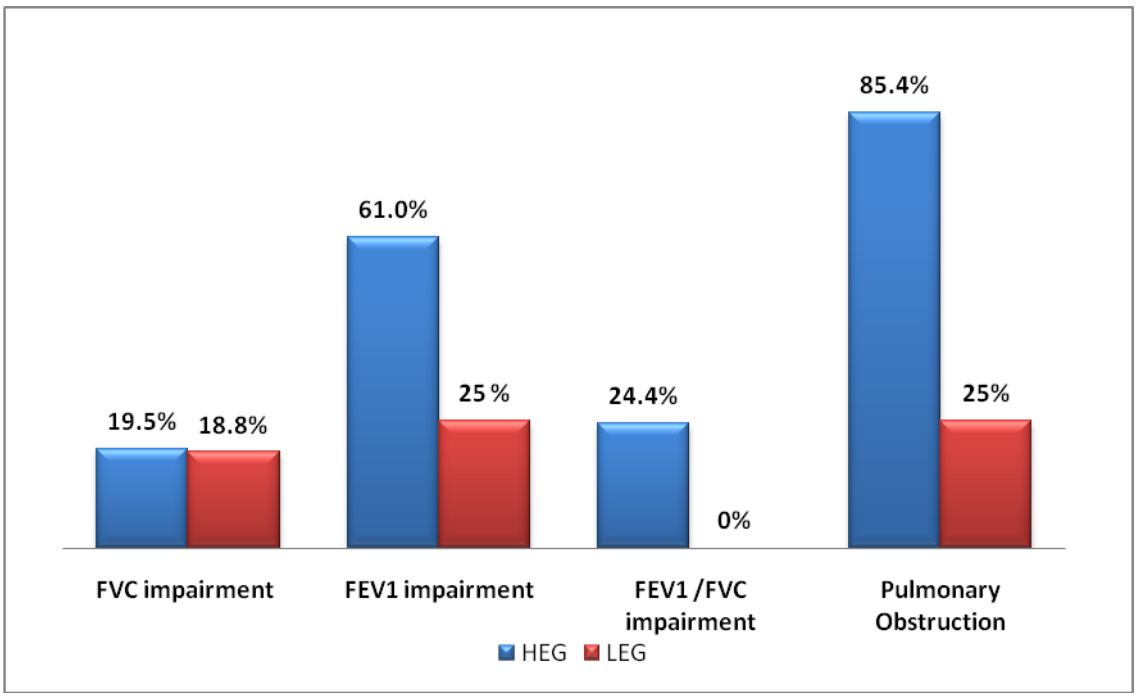
Parameter	High exposure group (n=41) HES*32501-72500		Low exposure group (n=16) HES*2500-32500		Test of significance χ^2	P-value
	No	%	No	%		
➢ FVC impairment	8	19.4%	3	18.8%	0.004	>0.05
➢ FEV_1 impairment	25	61%	4	25.0%	4.61	<0.05*
➢ Both FEV_1 and FVC impairment	4	9.8%	1	6.2%	0.177	>0.05
➢ No impairment	4	9.8%	8	50%	3.3	<0.01**
➢ FEV_1/FVC impairment	10	24.4%	0	0%	3.12	<0.05*
➢ Pulmonary obstruction	35	85.4%	4	25%	21.28	<0.01**

FVC = Forced Vital Capacity

FEV_1% = Forced Expiratory volume in first second

The table above shows that there was no significant difference in FVC impairment between high and low exposure groups. Meanwhile, high exposure group showed statistically significant difference than low exposure group as regards FEV_1 and FEV_1/ FVC ratio impairment ($p < 0.05$). Furthermore, pulmonary obstruction was more obvious in HEG than LEG ($p<0.01$).

Figure (9): Frequency distribution of ventilatory function impairment according to the exposure intensity



Regarding the intensity of exposure, (61%) of high exposure group versus (25%) of low exposure group had FEV_1 impairment. 85.4% of highly exposed had pulmonary obstruction.

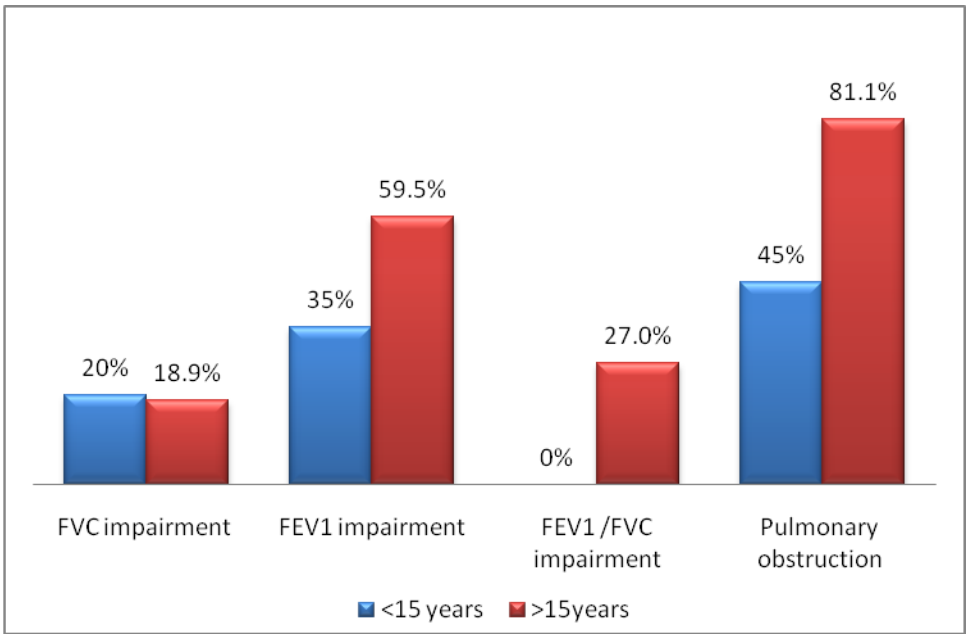
Table 14: Frequency distribution of ventilatory functions impairment in exposed according to the duration of exposure

Parameter	Exposure duration ≥ 15 years (n=37)		Exposure duration<15 years (n=20)		Test of significance χ^2	P-value
	No	%	No	%		
➢ FVC impairment	7	18.9%	4	20%	0.01	>0.05
➢ FEV1 impairment	22	59.5%	7	35%	3.12	>0.05
➢ Both FEV_1 and FVC impairment	3	8.1%	2	10%	0.06	>0.05
➢ No impairment	5	12.5%	7	35%	1.9	>0.05
➢ FEV_1/FVC impairment	10	27%	0	0%	6.56	<0.01**
➢ Pulmonary obstruction	30	81.1%	9	45%	9.56	<0.01**

FVC = Forced Vital Capacity
FEV1% = Forced Expiratory volume in first second

This table illustrates that FVC and FEV_1were not affected. On the contrary, the group whose exposure duration was longer than 15 years showed significant impairment in the FEV_1/FVC ratio than those with shorter duration of exposure ($p<0.01$). Furthermore, (81.1%) of those with longer duration versus only (45%) of those with shorter duration of exposure showed obstructive pattern and the difference was statistically significant between them ($p<0.01$).

Figure (10): **Frequency distribution of ventilatory functions impairment in exposed according to the duration of exposure**



The above figure shows that (81.1% and 59.5%) of exposed with longer duration of exposure showed pulmonary obstruction and FEV_1/FVC ratio impairment respectively versus (45% and 35%) in those with shorter duration of exposure.