

Spirometry in Fuel Station Attendants: a Comparative Study

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Abstract

Introduction: Exposure to volatile fuel compounds and roadway motor vehicle exhaust leads to increased risk of chronic lung disease and carcinogenesis. Tobacco smoking further accelerates this process. Spirometry is an objective way of assessing lung function.

Aims: To infer whether fuel station attendants manifest a further decrease in lung function when compared to other full-time workers working outdoors and whether smoking tobacco manifest a further decrease in lung function among attendants.

Methodology: Lung function of 30 fuel station attendants (28.6 ± 6.24 years) was compared to 30 outdoor workers (27.53 ± 5.59 years) as control group via spirometry. Half of both exposed and control group consisted of participants who smoke tobacco.

Results: A statistically significant decrease in FEV_1 , FVC and FEV_1/FVC ratio in the exposed group when compared to the control (FEV_1 $78.84 \pm 7.19\%$ of predicted vs $87.97 \pm 8.32\%$ of predicted, $p < 0.001$; FVC $85.84 \pm 7.00\%$ of predicted vs $90.24 \pm 9.41\%$ of predicted, $p = 0.02$; FEV_1/FVC ratio ($76.28 \pm 4.72\%$ vs $81.15 \pm 4.31\%$, $p < 0.001$).

Conclusion: Fuel station attendants who smoke showed a significant drop in lung function when compared to non smoking attendants (FEV_1 $75.38 \pm 4.31\%$ of predicted vs $81.74 \pm 8.18\%$ of predicted, $p = 0.006$; FVC $89.93 \pm 5.43\%$ of predicted vs $88.75 \pm 7.34\%$ of predicted, $p = 0.01$).

Keywords

petrol pump workers, pulmonary function test, occupational hazards, tobacco smoking

Introduction

Air pollution is an ever increasing hazard due to the rapidly increasing number of motor vehicles. In Malta, with about 314,510 registered cars by the end of 2012, the demand for fuel stations in the Maltese islands has inevitably increased.¹ Although European policy on fuel compositions have lessened these risks², absence of personal protective equipment (PPE) and tobacco smoking are still factors which add up to health effects caused by volatile fuel compounds and roadway motor vehicle exhaust.³ The European Environment Agency (EAA) report that Malta is finding it difficult to control dangerous gas emissions with a sharp rise in pollution caused by traffic; in 2012 the island European Union (EU) established limit of nitrogen oxide was surpassed by 0.6 kilotons due to a 10 per cent increase in nitrogen oxides (NO_x) recorded in 2012 (EAA, 2013).⁴

The British Thoracic Society Standards of Care Subcommittee Guidelines on Occupational Asthma assert that the predominant hazardous health effects are seen on the lower respiratory system and such effects can be measured objectively via lung function tests in an occupational setting.

The aims of the study were to infer whether fuel station attendants manifest a further decrease in lung function when compared to other full-time workers working outdoors and whether fuel station attendants who smoke tobacco manifest a further decrease in lung function when compared to those who do not.

Methodology

All participants ($n=60$) were Caucasian males (age 28.27 ± 5.66 years).

The exposed group (EG) were 30 full-time fuel station attendants (age 28.77 ± 6.45 years) were randomly selected from all from the 2013 Malta Resources Authority fuel pump list⁵ from the different areas of Malta (Gozo was excluded) as presented on the 2010 Malta Demographic Review.⁶

The control group (CG) consisted of full-time recruits (age 27.77 ± 4.80 years) of the Armed Forces of Malta (AFM) based at the Hal Far Barracks in the southern part of the Maltese island and served various

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outdoor roles around the island.

Both groups were then divided into two subgroups and by service duration:

- **Tobacco smokers** 15 in each group: exposed (EGTS) and control (CGTS).
- **2-5 years service duration** 7 in EGTS and 7 in CGTS.
- **more than 5 years service duration** 8 in EGTS and 8 in CGTS
- **non smokers** 15 in each group: exposed (EGNS) and control (CGNS)
- **2-5 years service duration** 7 in EGNS and 8 in CGNS
- **more than 5 years service duration** 8 in EGNS and 7 in CGNS

AFM participants were approached via convenience sampling, i.e. randomly approaching recruits during daily routine. Fuel pumps were randomly chosen To implement further control on variables, inclusion and exclusion criteria were applied to the accessible population as shown in table 1.

Instrumentation

The spirometer model utilised was the Spiro-M PC® from Medical Econet GmbH, Germany. This model was then attached to an ASUS Eee PC® netbook via a USB port on which the spirometer software was installed. This setup ensured portability and ease of work.

FEV₁, FVC, FEV₁ / FVC ratio in each group were grouped in tables so as to create clear descriptive statistics via Microsoft® Excel® . FEV₁ and FVC were converted to a percentage of their predicted value via the *GLI2012 version 3.2.1 build 28* where lung function results are adjusted to age, height and ethnicity of the participants.⁷

GLI2012 also worked out lung function results which were considered as follows according to the percentage of the predicted value:

- normal FEV₁ and FVC 81-120% FEV₁ / FVC >70%
- borderline FEV₁ and FVC 76 - 80% FEV₁ / FVC 66-70%
- abnormal FEV₁ and FVC <76% FEV₁ / FVC <66%

Data collection was done by the researcher between February and May 2014. Consenting participants were instructed on how to use the PFM.⁸ The highest records of lung function and the ethnicity, height, age and years of employment were recorded in a Microsoft® Excel® spreadsheet.

A written informed consent was presented,

highlighting the aims of the study; the research process and the choice to stop their participation at any point of the study amongst other measures which ensured anonymity and confidentiality.

Permission from fuel station owners and the officer in charge of the Hal Far Barracks were obtained before conducting research.

The study was also approved by the University Research Ethics Committee (UREC).

Table 1: Inclusion and exclusion criteria

Inclusion Criteria	Exclusion Criteria
Both Subgroups	
1. Male	1. respiratory disease and conditions such as asthma, chronic obstructive pulmonary disease, bronchiectasis and lung neoplasms
2. 20 – 45 years of age	2. Previous cardiothoracic and upper spinal surgery
3. Understanding of either Maltese or English	3. Vertebral and thoracic disease and conditions such as ankylosing spondylitis and sever thoracic kyphosis
4. Ability to comprehend explanations regarding using the peak flow meter	4. Current upper respiratory tract infection, acute hay fever symptomatology or pneumonia
5. Employed for more than 2 years	
Tobacco Smoking (TS) Subgroup	
1. Currently smoke more than 15 cigarettes a day	1. Smoke less than 15 cigarettes a day
	2. Smoking methods other than cigarettes and tobacco
Non Smoking (NS) Subgroup	
	1. Smoking 1 to 14 cigarettes on any day of the week
	2. Ex-smoker

Results

A total of 42 fuel station attendants were approached out of which 3 refused to participate, 6 fuel station owners did not grant permission and 3 were not able to conduct lung function testing adequately. 30 Armed Forces of Malta (AFM) recruits were approached; all consented for participation and

conducted lung function properly. Overall response rate was 83.33%.

10 (33%) fuel pumps were located in the northern region of the island, 15 (50%) in the central part while 5 (17%) were in the southern region.⁶

Lung Function

Tables 2 through 5 show comparison of lung function between groups as follows:

- All exposed (EG) and all control (GG) participants (table 2)
- Smokers and non-smokers (table 3) in:
 - The exposed (EG) group
 - The control (CG) group

- Exposed and control non-smokers with:
 - 2 to 5 years employment (table 4)
 - More than 5 years employment (table 5)
- Exposed and control smokers with:
 - 2 to 5 years employment (table 4)
 - More than 5 years employment (table 5)

Table 2: Difference in Lung Function between the Exposed and the Control Groups

<i>N=60</i>	Exposed Group / % n=30	Control Group / % n=30	<i>p<0. 05</i>
%age of predicted FEV₁	78.84 ±7.19	87.97 ±8.32	<0.001
%age of predicted FVC	85.84 ±7.00	90.24 ±9.41	0.02
FEV₁ / FVC ratio	76.28 ±4.72	81.15±4.31	<0.001

Table 3: Intergroup difference in lung function between smokers and non-smokers

	Exposed Group n=30			Control Group n=30		
Subgroup	TS / %	NS / %	<i>p<0. 05</i>	TS / %	NS / %	<i>p<0. 05</i>
All (N=60)	<i>n=15</i>	<i>n=15</i>		<i>n=15</i>	<i>n=15</i>	
%age pred. FEV₁	75.38±4.31	81.74±8.18	0.006	89.04±8.81	86.89±7.95	0.24
%age pred. FVC	89.93±5.43	88.75±7.34	0.01	90.63±9.81	89.86±9.32	0.41
FEV₁ / FVC	75.80±2.92	76.76±6.10	0.29	81.63±4.29	80.66±4.42	0.27

Table 4: Difference in lung Function between smokers and non-smokers with 2 to 5 years of employment

2-5years n=30	Non-Smokers n=15			Tobacco Smokers n=15		
	Exposed n=7	Control n=8	<i>p<0. 05</i>	Exposed n=7	Control n=8	<i>p<0. 05</i>
%age pred. FEV₁	77.63±5.59	87.26±8.53	0.01	73.86±4.42	92.89±7.28	>0.001
%age pred. FVC	87.29±9.40	88.39±9.34	0.42	82.43±7.30	96.36±8.11	0.003
FEV₁ / FVC	74.64±6.27	83.29±4.01	0.003	76.00±3.58	81.61±4.93	0.02

Table 5: Difference in lung function between smokers and non-smokers with more than 5 years of employment

> 5 years <i>n</i> =30	Non-Smokers <i>n</i> =15			Tobacco Smokers <i>n</i> =15		
	Exposed <i>n</i> =8	Control <i>n</i> =7	<i>p</i> <0. 05	Exposed <i>n</i> =8	Control <i>n</i> =7	<i>p</i> <0. 05
%age pred. FEV ₁	85.33±8.67	86.47 ±7.88	0.40	76.71±4.02	85.68±9.06	0.001
%age pred. FVC	90.04±5.29	91.54±8.44	0.34	83.38±3.61	85.61±8.65	0.26
FEV ₁ / FVC	78.61±5.68	77.66 ±2.66	0.35	75.62±2.45	81.65±4.00	0.01

Table 6: Case-control studies analysing lung function among fuel station attendants
FSA – Fuel Station Attendants

No	Author / Location	Year	Participants	Cases	Controls	Findings
			FSA's	non FSA		
1	Alam et al. Karachi, Pakistan	2014	160	130	130 unidentified	VC indirectly related to work hours decrease in VC,FVC,FEV1 in cases
2	Sadiqua & Rathna Mysore, India	2012	56	28	28 college personnel	decrease in FEV1 and FVC
3	Sharma, Gupta and Gupta Jammu, India	2012	133	100	33 hospital personnel	decrease in FEV1, FVC, MVV, PEFR
4	Aprajita, Panwar and Sharma Amritsar, India	2011	200	150	50 hospital personnel	decrease in FEV1,FVC,PEFR
5	Madhouri et al. Kanchipuram, India	2010	30	30	30 hospital personnel	decreased FVC,FEV1 and PEFR
No	Author	Year	Participants	Cases	Controls	Findings
				Smoking FSA's	Non-Smoking FSA's	
6	Chawla & Lavania India	2008	58	35	23	a. decrease in FVC,FEV1 and PEF proportion to years of work b. smoking attendants had significantly lower FEV1 only

Discussion

Overview of findings

A statistically significant reduction in all lung function parameters, FEV₁, FVC and FEV₁/FVC ratio, resulted when comparing all exposed participants ($n=30$) to controls ($n=30$). FEV₁ and FEV₁/FVC ratio differences were highly significant ($p<0.001$).

Exposed participants, i.e. fuel station attendants (FSAs) showed a decrease in lung function. Mean FEV₁ ($78.84\pm7.19\%$ of predicted) fell below the normal range (81 – 120% of predicted) and is classified as a borderline result as per the Global Lung Initiative ranges.⁷ Mean FVC ($85.84\pm7.00\%$), despite being significantly less ($p=0.02$) than the control mean still fell in the normal range. Mean FEV₁/FVC ratio ($76.28\pm4.72\%$) is within normal range; however, since FEV₁ is in the borderline range, this would be considered a borderline obstructive pattern of lung function.⁷

Table 6 shows six studies which all report a marked decrease in all 3 lung function parameters. The difference in this study is that FVC seemed not be significantly lower: both when compared to the normal conventional ranges and when comparing groups within the study itself.⁹⁻¹⁴

Smoking as a contributory factor to a decrease in lung function

Tobacco smokers (TS) and non-smokers (NS) were independently compared in each group.

In the control group (CG), despite a lower mean result in all lung function parameters was registered for TS participants, no statistically significant difference was found when compared to NS control participants and all 3 parameters were in the normal value range.

On the other hand, tobacco smokers in the exposed group (EGTS) showed a statistically significant drop in all 3 lung function parameters when compared to the control group (CGTS). The 3 parameters for EGNS were in the normal range while mean FEV₁ ($75.38\pm4.31\%$ of predicted) in EGTS was in the abnormal range. FEV₁/FVC ratio fell in the normal range but since FEV₁ is abnormally low this is to be considered as an obstructive pattern of lung function.⁷

Similarly, Chawla and Lavania¹⁴ compared lung function between 35 FSAs who smoked and 23 who did not. While there was no significant intergroup difference between FVC and FEV₁/FVC parameters, a significantly lower FEV₁ was registered among participants who smoked. This goes in line with this study.

In light of the above results, fuel station attendants (FSAs) who actively smoke tobacco manifest a further decrease in lung function when compared to FSAs who do not.

Duration of employment

Results for exposed and control non-smokers, and exposed and control tobacco smokers were stratified by duration of employment: 2 to 5 years and more than 5 years.

2 to 5 years employment

Exposed non-smokers (EGNS) exhibited a statistically lower FEV₁ and FEV₁/FVC ratio when compared to non-smokers in the control group (CGNS). Since mean EGNS FEV₁ ($77.63\pm5.59\%$ of predicted) was in the borderline range of values with FEV₁/FVC ratio being in the normal range, a borderline obstructive pattern resulted.⁷

EGTS showed a statistically significant drop in all 3 lung function parameters when compared to CGTS; the latter had all 3 parameters in the normal range while the former had only FEV₁ in the abnormal range and its difference was of high significance (<0.001).

More than 5 years employment

No statistical significance was found between non-smokers who were employed more than 5 years in both groups (EGNS and CGNS) and all 3 parameters were in the normal range.

Control smokers had all lung function results in the normal range. Exposed smokers have mean FEV₁ ($76.71\pm4.02\%$ of predicted) in the borderline range and FEV₁/FVC ratio in the normal range: both were statistically significantly low when compared to CGTS. EGTS results show a borderline restrictive pattern.

Chawla and Lavania have also found a drop in lung function which is inversely proportion to the years of employment as fuel station attendant; this study has not been able to detect such correlation with those who have worked more than 5 years actually showing a better result.¹⁴ Similarly, Alam and colleagues compared 160 FSAs with 130 unidentified control participants and found that, apart from declining FVC and FEV₁, vital capacity (VC) also decreased with the number of hours worked in a week.⁹

It is interesting to note that control participants in all studies but one were hospital or college personnel who all classify as indoor workers.⁹⁻¹³ This study has opted for outdoor personnel and therefore it is assumed that a better control population was chosen since indoor environment could be a confounding variable in all the other studies.

Conclusion and Limitations

According to the study results, fuel station attendants manifest a further decrease in lung function when compared to other full-time workers working outdoors, and fuel station attendants who smoke tobacco manifest a further decrease in lung function when compared to those who do not.

However, the study carries numerous limitations

with a small sample size being the major one. This study had a very small cohort: 30 exposed participants and 30 control participants. This limited the generalisation of results and also the validity and reliability of statistical data.

The age range of the participants was 28.27 ± 5.66 years – this means that the sample does represent the whole population of fuel station attendants. A narrow age range, despite helping internal validity, was not enough to give as much validity as when participants are matched.

Observer and operational bias might have occurred since the researcher was the only individual involved in the whole process that is data collection, analysis and interpretation.

The study was compared to overseas studies in non-EU, developing countries (India and Pakistan); a comparison with European (or better, local) studies would have given a better interpretation should such other studies been available.

The Southern region of Malta was underrepresentation vis-à-vis number of FSAs where only 5 out of 30 were from the region. The results might therefore not be generalisable in that region of Malta.

Finally this was one of the first experiences of the research in both spirometry and statistics; moreover time restraints, lack of access and resources have definitely impacted the robustness of the results.

Therefore the results cannot be generalised to the study population. However, it can be suggested that fuel station attendants might have worse lung function when compared with other outdoor workers and that tobacco smokers further deteriorates lung function.

Recommendations

As a result, the study limitations and the poor availability of other studies on the topic should encourage further research in the field. This should especially be the case locally now that a baseline study has introduced the professional community with an idea of the needed awareness, policy and legislation related to fuel stations attendants (FSAs).

Sole use of Automated Fuel Pump – the way of the future?

In the opinion of the researcher, and in line with the large study that Lynge and colleagues conducted in Scandinavia, having more automated fuel pumps will prevent the long hours of exposure to FSAs.³ In reality, and in light of the health hazards that a FSA faces, this job can be made redundant as in many regions in first world countries since every motor vehicle driver can operate an automated pump.

Research Recommendations

Apart from this, the remaining recommendations

address the research community with the following recommendations:

- Conducting the same study with a larger sample.
- Conducting an adjunct questionnaire on symptomatology which relate to disease reflected by a drop in lung function (e.g. asthma).
- Study the effect of other respiratory hazards apart from the fuel distribution industry.
- Qualitative study looking into the experience of fuel station attendants.

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