Original article

The association between kidney function and naphtha exposure among workers in the tyre industry

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Songkla Med J 2008;26(6):573-579

Abstract:

The objective of this paper is to present a study on the effect of naphtha exposure in relation to kidney function among workers in a selected rubber tyre factory. Data on respirable exposure of naphtha and kidney function were obtained from 60 exposed workers in the study. The level of naphtha exposure in an individual worker for one hour of working was 29.8 mg/m^3. Kidney functions in this study were assessed using a strip test and microscopic analysis of urine. Any associations between the naphtha level and kidney function parameters were assessed using the chi-square test. There was no significant association of naphtha exposure observed in all four kidney function parameters assessed in this study. However, smoking, which was a confounding factor in this study was found to have a strong correlation with a presence of protein in urine. Simple logistic regression and multiple logistic regression analysis showed that smoking workers were at higher risk of exhibiting protein presence. It was

Recieved January 28, 2008 **Accepted** October 30, 2008

shown that those who smoke have 1.84 times the odds of having protein presence compared to those who did not smoke. In conclusion, control measures are crucial to make sure that the concentration of naphtha exposure is below the exposure limit as exposure to naphtha may give rise to irreversible chronic health effects.

Key words: *kidney function, tyre industry manufacture, urine analysis*

Introduction

Due to the rapid development and innovation of transport technology the demand for the pneumatic tyre has increased dramatically In Malaysia. Production of a single tyre requires the use of a wide range of solvents; some of which may damage the liver, kidneys, heart, blood vessel, bone marrow and nervous system.[1] Harmful effects to the eyes, or skin may follow either inhalation of the vapour; contact with liquid or vapor, or ingestion.[2] The exposure to these solvents has, therefore, potential to produce major harmful effects and also common health risks for workers within the industry.[3] Determining the environmental working exposure by workers to airborne naphtha is made using active personal monitors.[4-5]

Naphtha-type solvent has been used in the manufacture of rubber tyres since the 1940s.[6-7] Naphtha is an organic solvent comprised of varying percentages of hydrocarbons. Its excellent lipid-soluble properties make it a highly used solvent.[8]

Naphtha has been known as rubber solvent, petroleum naphtha, coal tar naphtha, petroleum ether and n-hexane. Almost all the epidemiological studies and published which have appeared since 1964 on the effects on human chronic exposure to naphtha have been concerned with occupational exposure to mixtures of substances containing n-hexane. A large proportion of the gasoline and naphtha intoxications described in the literature are primarily of n-hexane intoxications.[9] There are no well-documented reports of industrial injury resulting from the inhalation of naphtha. However, naphtha is expected to be an irritant to human skin, eyes, and mucous membranes and also a central nervous system depressant.[10]

Naphtha toxicity has been reported following accidental or intentional dermal, oral, parental and inhalation exposure.[2] The objectives of this study are to identify naphtha exposure levels and whether there is any association between this exposure and kidney function in exposed workers by comparing the mean of naphtha exposure and the kidney function parameters assessed.

Materials and methods

This study was made in a rubber tyre plant in Kedah, Malaysia. The venue was selected on the assumption of the high level of solvent used during the manufacturing and processing of the rubber tyre. Thus, the exposure faced by the workers to the solvents used was probably high.

All workers followed the health and safety management guidelines and were mindful of health and welfare of all workers.

A study sample of 60 workers that met the requirements was selected from data given by the Safety and Health Unit at the Factory and had direct contact with naphtha during their routine job.

There were three major assessments done in this study: the measurement of naphtha exposure done via individual sampling; urine collection carried out for urine analysis according to Gribble et al.[11] and a questionnaire was given to respondents in order to get information on their health background, socio-demographic and economic data.

The inclusion criteria was worker years of working in factory more than 1 year, free from diseases , not on any type of kidney function treatment during the previous 12 months. The excluded criteria were the worker that had kidney diseases or taking medication to be effected kidney function.

Samples of naphtha exposure were collected using a Spectrex personal air sampling pump (PAS 500) according to the NIOSH method 1550. The personal air sampling pump is equipped with a charcoal tube (intake flow 0.2l/min) and is capable of producing constant flow rates to allow time for contact between the gas and absorbent or the vapor with the absorbent. The pump is attached to each worker within their breathing zone for one hour of working activity. In this study, each worker was measured twice an hour at the beginning of the shift and during the last hour of their shift.

The standard acceptable limit for personal air sample naphtha and recommended exposure limit (REL) for naphtha is 400 mg/m^3 as a time weighted average (TWA) for a 40-hour a week.

Absorbed naphtha levels was determined by the method recommended by the National Institute of Occupational Health and Safety.[12-13] The sample was treated with 99:1, carbon disulfide: dimethylformamide. Analysis was conducted using gas chromatography with a flame ionization detector (GC/FID). The sample aliquot was injected manually using the solvent flush technique or with an auto sampler. The peak area could then be measured. The peak of the analysis was divided by the peak area of the internal standard on the same chromatogram. The calculation began by determining the mass, mg (corrected for DE) of naphtha found in the sample front (W_f) and back (W_b) sorbent section, and in the average media blank front (B_f) and (B_b) Sorbent sections. The concentration, C, of naphtha in the air volume sampled, V(L) is calculated using this formula:

$$C = \frac{(W_f + W_b - B_f - B_b)\,10^3}{V} \quad mg/m^3$$

This method is described in the OSHA Computerized Information System [OSHA 1994][14] and NIOSH Method No. 1550 [NIOSH 1994b].[15]

Two urine samples were collected from the respondents: one in the early morning before starting their shift and the second just after completing their shift. Using the midstream method each worker was given a labeled specimen container to collect their urine. Midstream involves collecting urine excluding the first and last voided urine. The urine was then refrigerated below 4°C until analysis. A simple chemical analysis using a dipstick (a commercial reagent strip for urine chemistry testing along with its container with colour comparison chart) was then performed to detect abnormal levels of each of following and. The strip was immersed into the sample and the chemical reaction caused the reagent pad to change colour. The edge of the strip was drawn along the specimen container and tapped to remove any excess sample. The strip was placed on a sheet of tissue to remove further excess fluid to give a better reading. After approximately 30 seconds the strip was analysed by comparing the colour of the reagent strip with the color comparison chart. In order to achieve a more dependable result, microscopic examination was subsequently carried out. Meanwhile, microscopy was detect cellular and non cellular elements of urine. A 12 ml sample of the collected urine was centrifuged at 1,500 rpm for five minutes after which the supernatant was removed and the remained sediment used. A drop of the sediment was poured onto a slide and scanned with a low power (10x) and then a high power objective (40x).

The demographic and job history information on the respondents, such as household income, education level, years of working in the industry were obtained through the self administered survey forms. The supervisors of the respondent's workstations were responsible for the collection and return of all the distributed forms.

Results

Table 1 shows the descriptive statistics of the selected socio-economic variables of the study respondents. The total number of respondents was 60 male workers of which 59 (98.3%) was Malays and one (1.7%) was Chinese. Most of them have been educated up to secondary school level with the mean years of education being 11 years. Most of them was grouped in the lower middle income group with a mean monthly household income of RM 1,314. Most of the respondents had been working in the factory for about nine years.

Table 1 shows that the selected respondent's frequency of smoking, alcohol and medicine consumption. For smoking more than half of the respondents smoked (66.7%) but only a few drank alcohol.

Table 1 Demographic data of respondents

Variable	Mean	n	S.D.	%
Years of education	10.9		±1.68	
Monthly house income (RM)	1,313.6		±860.06	
Years of working	9.0		±5.98	
Smoking				
Yes		40		66.7
No		20		33.3
Alkohol consumption				
Yes		4		6.7
No		56		93.3

N=60, S.D.=Standard deviation

Table 2 Distribution of respondent according to workstation

	Respondent	
	Number (N)	Percentage (%)
Making 10A	33	55
Moulding technical	10	16.7
Extruder	7	11.7
Repair	7	11.7
Solution house	2	3.3
Test house	1	1.7

Table 2 As stated earlier, this study has been carried out among 60 workers who were directly exposed to naphthar in their daily work routine. The respondents worked at five main workstations: Making 10A, Moulding, Extruder, Repair and Testing. Making 10A employs the largest percentage of respondents who work in making 10A and were responsible for sticking rubber sheeting around the unmoulded light truck and motorcycle tyres. These workers use naphtha as a glue solution to stick the rubber sheet around the tyre. Moulding or moulding technical is a section where the tyre is moulded according to its specific specification. The Extruder Section is responsible for producing the tread and sidewall of the tires. Naptha based solutions was used to improve adhesion. The extruders operators may be exposed to volatile naphtha used at the tread-end cement station. After the rubber thread is cut into specified length and the tread ends tackified. Tackification involves applying a cement containing dissolved naphtha.

The Repair section and Test House have the responsibility to inspect faults in the tyres that may appear during the manufacturing processess. In this section, naphtha is particularly used for cleaning, patching and painting blemishes. The solution House is effectively a warehouse where all the solvents used during the tyre manufacturing processes are stored and mixed according to the usage.

The personal air sampling pump assessment of naphtha levels was collected from their breathing air. Figure 1 shows a graph of the level of naphtha exposure for individual workers. As the graph indicates, the level of naphtha exposure among all the respondents is not normally distributed. A normality test was carried out after the data was logge but the data was still abnormal. Thus, the original data was used and was used in all subsequent statistical analysis. The mean of the naphtha level was 29.8 mg/m^3 with a median value of 12.82 mg/m^3 (Table 3).

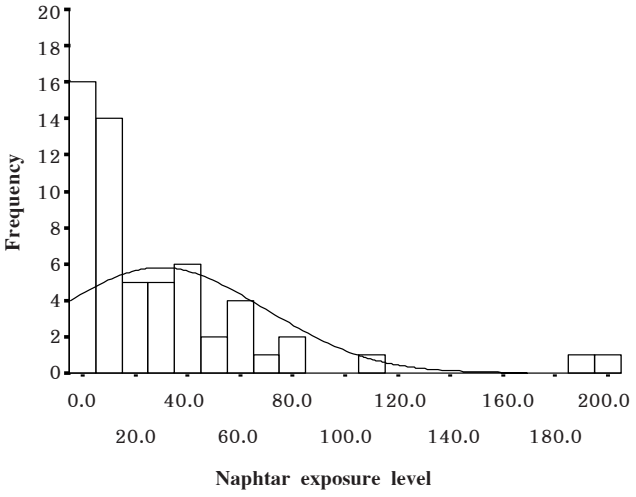

Figure 1 Level of naphtha exposure in individual workers

Table 3 Naphtha exposure in individual workers

Mean (S.D.)	Naphtha concentration in the air (mg/m^3)		
	Median (IQR)	S.E.	Range
29.80 (39.77)	12.82 (40.83)[a]	5.22	0.19-200.51

p<0.05 is significant, N=60, Missing values = 2, S.D.=Standard deviation, IQR=Inter quartile range, S.E.=Standard error, a=The distribution skewed to the right

One of the objectives in this study was to determine the level of kidney function in workers exposed to naphtha. Protein, blood, uric acid and calcium oxalate were selected as the main parameters to be measured from the urine using strip tests and microscopic analysis made in this study. The median naphtha concentration on air samples which was 12.82 mg/m^3 has been used as the cut off point in determining a high and low level of exposure. The chi-square test was conducted to see if there was any association between naphtha concentration and kidney function parameters (Table 4). The study revealed no significant association between naphtha exposure and the four kidney function parameters used.

Using simple logistic regression and multiple logistic regression analysis and controlling for selected con-founding kidney functions, it was observed that the smoking influenced the presence of protein in the kidney, which was higher than the naphtha exposure level. It was shown that those who smoked had 1.84 times the odds of having a presence of protein compared to those who were non-smokers (OR=0.39, 95% CI).

There was not any statistical association between the dependent variable (age, alcohol, smoking and naphtha) and presence of blood, uric acid crystal and oxalate crystal. The Mann-Whitney test was conducted to see if there was any comparison between the mean naphtha level and kidney function parameters. The results, however, showed there was no significant association between naphtha exposure and the four kidney function parameters chosen for assessment in this study.

Table 4 Association between naphtha concentration and kidney function in respondents.

Variable	n	High (>12.82)	Low (<12.82)	X^2 statistic[a] (df)	p-value
		Freq (%)	Freq (%)		
Protein					
Yes	22	14 (48.3)	8 (27.6)	1.6 (1)	0.206
No	36	15 (51.7)	21(72.4)		
Blood					
Yes	52	25 (86.2)	27 (93.1)	0.88 (1)	0.344
No	6	4 (13.8)	2 (6.9)		
Uric acid					
Yes	50	24 (82.8)	26 (89.7)	0.74 (1)	0.389
No	8	5 (17.2)	3 (10.3)		
Calcium oxalate					
Yes	35	19 (65.5)	16 (55.2)	1.192 (1)	0.275
No	25	10 (34.5)	15 (44.8)		

p<0.05 is significant, a=chi square test for independence

Discussion

The determination of naphtha exposure in the study location clearly indicates that the factory was a moderate polluted area. In an industrial plant an atmospheric naphtha source was only one of many sources of contamination faced by workers. Exposure to organic solvents was one of the most common chemical health risks in the work place. Solvents, their vapors and mists had various effects on human health. Many of them had a narcotic effect, causing fatigue, dizziness and intoxication.[10]

The study revealed no significant association between naphtha exposure and the four kidney function parameters used. This may due to the level of naphtha exposure in individual workers in the plant being lower than the actual recommended safe exposure limits. According to the United States Department of Labour's current Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) for naphtha is 400 mg/m^3 as over an 8-hour time weighted average (TWA). The mean level of naphtha exposure in one hour at the plant was only 29.76 mg/m3 giving an 8-hour TWA level for naphtha exposure within the plant of 238.08 mg/m^3, which is also below the recommended exposure limit (REL) for naphtha of 400 mg/m^3 as a TWA for up to a 40-hour a week. Moreover, the exposure duration of the respondents in this study is within the eight hours legal limit per shift with almost half the respondent's exposures being under seven hours per shift.

The con-founding factors studied were age, alcohol consumption and smoking. A strong correlation was found between smoking and presence of protein in the urine ($p< 0.05$). The results showed that the smoking factor influenced the presence of protein in the kidney. It was shown that those who smoked had 1.84 times the odds of having a presence of protein compared to those who did not smoke. This result shows that instead of naphtha exposure the smoking factor has a significant impact on the kidney function as evidence by presence of protein. This result was not surprising as the renal effects of smoking have been extensively reviewed recently. As mentioned by Marie et al., 2002, smoking has been implicated in the progression of renal disease in type 1 diabetes because it increases the risk of microalbuminuria and proteinuria and subsequent end-stage renal failure.[14]

Other than that, there were no strong associations found between the confounding factors and any of the kidney parameters assessed. Among the limitations of this study are the small number of respondent and only one plant, which may not be very representative of the whole worker population working in the rubber tyre industry whom are exposed to naphtha. This study does not include all the workstations in the plant that might have bigger exposure to naphtha as there is a bias introduced outside the study control. The respondents were selected by the management of the factory. There may bias in the selection of the respondents. This study as a pilot study only used small sample size and simple methods of assessing the kidney function which are those often used as the first test administered if kidney problems are suspected. This study may make a contribution as baseline data to perform additional tests in future research to analyses transferring, β_2-microglobulin and N-acetyl-β-D-glucosaminidase(NAG)[17-18] as biomarkers for early detection of organic solvents and diagnose the cause and the level of decline in kidney function.

Conclusion

Even though the concentration of the naphtha exposure is below the accepted limit, attention still needs to be given because exposure to naphtha may give rise to irreversible chronic health effects, in this case workers who are exposed to naphtha exposure may experienced various kind of effect. Therefore, some control measure is crucial to protect them.

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