HEALTH STATUS OF GASOLINE STATION WORKERS IN PATHUMWAN AREA, BANGKOK, THAILAND, IN 2004 AND 2009

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ABSTRACT: This research characterized and compared health status of male gasoline station workers in Pathumwan District, Bangkok, in 2004 and 2009. Between these years, use of methyl tert-butyl ether (MTBE) in gasoline was banned in Thailand, and use of gasohol increased. Cross-sectional studies were conducted in each year. Each study included an interview for symptom prevalences, hematological tests and blood biochemical tests for kidney and liver function. Data were analyzed with multiple logistic regression for dichotomous outcomes and multiple linear regression for continuous outcomes. Independent variables included year of study, demographic characteristics, smoking, alcohol drinking, and duration of working at the gas station. Adjusted prevalence of abnormal red blood cell morphology decreased statistically significantly from 2004 to 2009 (modeled odds ratio for 2009 vs. 2004 = 0,34, $p=0.04$). Adjusted blood alkaline phosphatase level also decreased significantly (modeled decrease = -29.3 units/liter, $p<0.001$). These findings could plausibly be linked to removal of MTBE. Other health-related metrics did not differ significantly between 2004 and 2009. On balance, there was a limited tendency toward improvement of workers' health from 2004 to 2009. This could be attributable in part to removal of MTBE in gasoline. Further research, perhaps employing additional health metrics, is needed to fully characterize human health effects of MTBE exposure.

Keywords: health status, gasoline worker, Bangkok

INTRODUCTION

In recent decades, air pollution has become a serious environmental and occupational health problem in Bangkok. One group with substantial occupational ambient air pollution exposure is gasoline station workers. Previous research has shown statistically significant increase in DNA strand break ($p <0.001$) and decrease in DNA repair capacity ($p <0.001$) in petrochemical factory workers, gasoline workers and Bangkok school children [1]. Urban air pollution resulting from traffic is a major problem in many cities in a fuel combustion, e.g. transportation and the volatile organic compounds (VOCs) composition such as benzene of which is the one very complicate [2, 3]. Benzene is a carcinogenic agent in experimental animals and in man. The Land Transportation Department, Thailand, reported of heavy traffic congestion and rapid rise in the number of vehicles and gasoline stations were registered in Bangkok [4]. Leaded gasoline was completely phased out in 1996 and methyl tertiary butyl ether (MTBE) was substituted as an octane enhancer in unleaded gasoline. The concentration of ambient air benzene tended to be higher with used of MTBE in petroleum [5]. Thus, MTBE was banned in 2006. In an additional effort to reduce benzene, a gasoline-ethanol mixture (gasohol) was substituted for MTBE starting in 2001, and continues to be used at present. The current study measured and compared health status in male gasoline station workers in central Bangkok (Pathumwan District) in 2004, when MTBE was still in use, and 2009, when MTBE was no longer used.

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MATERIALS AND METHODS

Sample collection

Cross-sectional studies were conducted in 2004 and 2009. In 2004, data were collected from 44 male employees at 9 gas stations. In 2009, data were collected from 83 male employees at 11 stations, which included all 9 stations studied in 2004. Data included a standardized questionnaire interview for sociodemographic characteristics and presence of various symptoms, and blood tests. Blood tests included measurements of red cell-related and white cell-related parameters, abnormal hemoglobin composition, kidney function (blood urea nitrogen [BUN] and creatinine), and liver function (alkaline phosphatase [ALP], glutamic oxaloacetic transaminase [SGOT], glutamic pyruvic transaminase [SGPT] and hepatitis B surface antigen [HBsAg]).

Data analysis

The primary purpose of data analysis was to compare workers' health status in 2009 to that in 2004. To

Table 1 Characteristics of gasoline station workers, by study year

Characteristic	2004 (n=44) Mean ± S.D. or percentage	2009 (n=83) Mean ± S.D. or percentage	Overall Mean ± S.D. or percentage	*p*-value (2009 vs. 2004)
Age (years old)	25.4 ± 10.8	29.5 ± 9.4	28.1 ± 10.0	0.030
Income (baht/month)	5708 ± 1340	7185 ± 1713	6673 ± 1738	<0.001
Years worked at gas station	4.6 ± 5.4	4.9 ± 6.0	4.8 ± 0.5	0.778
Days worked per week	6.2 ± 0.6	6.2 ± 0.5	6.2 ± 0.6	0.982
Hours worked per day	11.4 ± 1.5	10.4 ± 1.7	10.6 ± 1.7	0.027
Body Mass Index (kg/m^2)	20.9 ± 3.0	22.5 ± 4.3	21.9 ± 4.0	0.021
HBsAg or illness (%)	15.9	18.8	17.7	0.808
Smoking (%)	52.3	44.6	47.2	0.458
Alcohol drinking (%)	75.0	67.5	70.1	0.421
Abnormal hemoglobin composition (%)	72.7	48.8	57.3	0.013

Table 2 Symptoms of gasoline workers

Symptom	Unadjusted prevalence		Logistic regression results*		
	2004 (%)	2009 (%)	Odds ratio for 2009 vs. 2004	95% CI	*p*-value
Headache	36.4	32.5	1.06	0.41 to 2.74	0.910
Dizziness	36.4	26.5	1.33	0.47 to 3.72	0.590
Fatigue	20.5	18.1	0.75	0.23 to 2.41	0.628
Sore throat†	13.6	10.8	1.82	0.34 to 9.87	0.488
Skin irritation	11.4	7.2	0.32	0.07 to 1.53	0.151
Eye irritation	11.4	4.8	0.27	0.04 to 1.62	0.150
Nausea	9.1	3.6	0.29	0.04 to 2.30	0.242
Depression	4.5	9.6	9.91	0.94 to 104.78	0.057

* Adjusted for age, BMI, monthly income, smoking, alcohol drinking, HBsAg or illness, years working at gas station, days per week working at gas station, and hours per day working at gas station.
† For sore throat, the logistic model did not include the variable for HBsAg or illness, because inclusion of this variable greatly inflated standard errors for some independent variables.

accomplish this, multiple regression analysis was conducted, with health-related endpoints as dependent variables. Logistic regression was used for dichotomous dependent variables, such as presence or absence of symptoms. Linear regression was used for continuous endpoints, including most of the hematologic and biochemical parameters. All regression models included a zero-one independent variable for year of study (reference group=2004), as well as independent variables for age, body mass index (BMI), smoking (smoker vs. non-smoker), alcohol drinking (drinker vs. non-drinker), years working at the gas station, days worked per week, and hours worked per day, Models for all dependent variables except sore throat also included a combined variable for presence vs. absence of HbsAg or chronic illness (e.g., diabetes, hypertension). Models for red cell-related parameters included a variable for presence vs. absence of abnormal hemoglobin composition.

RESULTS

Participant characteristics are presented and compared by study year in Table 1. Mean age, income, and BMI were statistically significantly higher in 2009 than 2004. In contrast, mean hours worked per day, and percentage of participants with abnormal hemoglobin composition, were significantly higher in 2004. Other characteristics did not differ significantly between study years.

Unadjusted symptom prevalences in 2004 and 2009 are shown in Table 2, as are results of multiple logistic models comparing prevalences in 2009 to those in 2004. Reported prevalences of headache, dizziness, and fatigue were substantial. Unadjusted prevalences of 7 of 8 measured symptoms were higher in 2004 than 2009. However, modeled odds ratios were less than 1 in 2009 for only 4 of 8 symptoms. Modeled prevalence of depression was marginally significantly higher in 2009 than 2004, although the 95% confidence interval was very wide.

Results of hematologic tests are summarized in Table 3. In multiple linear regression models, no white cell-related endpoint differed significantly between 2004 and 2009. The same was true for total hemoglobin, hematocrit and red cell volume. Modeled prevalence of abnormal red cell structure was significantly lower in 2009 than 2004 (OR=0.34, 95% CI 0.12 to 0.95, *p=0.040*). Modeled prevalence of low hemoglobin did not differ significantly between the two study years.

Table 3 Hematological tests of gasoline workers

Tests of White Blood Cells ($X10^9$/L)	Reference[a]	Mean ± S.D		Linear regression results*		
		2004	2009	Coefficient for 2009 vs. 2004	95% CI	*p*-value
Total	5.0 - 10.0	8.4 ± 2.1	7.8 ± 1.7	-0.31	-1.10 to 0.48	0.435
Neutrophils	4.0 - 7.5	4.2 ± 1.6	4.1 ± 1.3	-0.07	-0.68 to 0.54	0.819
Lymphocytes	2.0 - 4.5	2.7 ± 0.8	2.7 ± 0.8	0.19	-0.16 to 0.54	0.274
Monocytes	0.2 - 1.0	0.5 ± 0.2	0.5 ± 0.1	-0.03	-0.10 to 0.05	0.488
Eosinophils	0.1 - 0.6	0.6 ± 0.5	0.5 ± 0.5	-0.07	-0.28 to 0.14	0.516
Basophils	0.00 - 0.10	0.04 ± 0.02	0.03 ± 0.04	-0.00	-0.02 to 0.01	0.590
Platelets	50.0 - 400.0	249.5 ± 50.5	246.7 ± 65.3	-0.48	-27.08 to 26.13	0.972
Tests of Red Blood Cells	Reference	Mean ± S.D		Linear regression results†		
		2004	2009	Coefficient for 2009 vs. 2004	95% CI	*p*-value
Hemoglobin (gm%)	13.0 - 17.0	14.0 ± 1.0	14.4 ± 1.8	0.09	-0.59 to 0.77	0.788
Hematocrit (%)	39.0 - 51.0	43.4 ± 3.2	42.7 ± 4.5	-1.19	-2.99 to 0.60	0.190
MCV (ft)	80.0 - 98.0	77.3 ± 8.8	81.7 ± 9.0	0.99	-2.57 to 4.54	0.583
		Mean ± S.D		Logistic regression results†‡		
Abnormal RBC (%)	-	68.2	28.7	0.34	0.12 to 0.95	0.040
Low hemoglobin (%)	-	15.9	8.8	0.66	0.16 to 2.71	0.561

* Models were adjusted for age, BMI, monthly income, smoking, alcohol drinking, HBsAg or illness, years working at gas station, days per week working at gas station and.hours per day working at gas station.
†Models were adjusted for age, BMI, monthly income, smoking, alcohol drinking, HBsAg or illness, years working at gas station, days per week working at gas station, hours per day working at gas station and abnormal hemoglobin.
‡ For logistic regression models, modeled odds ratios, not coefficients, are given.
[a] Standard reference labolatory of Faculty of Allied Health Sciences, Chulalongkorn University.

Table 4 Blood biochemical tests of gasoline workers

Biochemical Test	Reference[a]	Mean ± S.D		Mean ± S.D		
		2004	2009	Coefficient for 2009 vs. 2004	95% CI	*p*-value
BUN (mg%)	6.0 - 20.0	12.8 ± 2.7	12.4 ± 3.1	-0.48	-1.74 to 0.79	0.457
Creatinine (mg%)	0.5 - 1.5	0.9 ± 0.2	1.0 ± 0.2	0.04	-0.03 to 0.12	0.279
SGOT (U/L)	0.0 - 40.0	27.4 ± 10.0	28.1 ± 20.9	-0.60	-8.00 to 6.79	0.872
SGPT (U/L)	0.0 - 40.0	28.5 ± 21.0	34.0 ± 28.1	-0.23	-10.45 to 1.00	0.965
ALP (U/L)	26.0 - 117.0	118.9 ± 42.9	78.1 ± 40.7	-29.28	-45.46 to -3.09	0.001

* Adjusted for age, BMI, monthly income, smoking, alcohol drinking, HBsAg or illness, years working at gas station, days per week working at gas station, and hours per day working at gas station.
[a] Standard reference labolatory of Faculty of Allied Health Sciences, Chulalongkorn University

Table 4 presents results of blood biochemical tests. Mean alkaline phosphatase (ALP) exceeded normal limits in 2004 and was within normal limits in 2009. Modeled ALP was significantly lower in 2009 than 2004. Other biochemical endpoints did not differ significantly between study years.

DISCUSSION

Gasoline is a complex mixture of many constituents in varying proportions. Not only does its composition of whole gasoline vary from company to company and season to season, but it also changes over time. The composition of gasoline vapors is dominated by volatile hydrocarbons such as alkanes, alkenes, and aromatics. Other substances such as alcohols, ethers, and additives, may also be present. Starting in 1996, MTBE was used as an octane enhancer after lead was banned from gasoline. MTBE was used until 2006. Gasohol was also introduced as an octane enhancer, and continues to be used at present. Gasoline station workers have been exposed to all of these compounds via inhalation and dermal exposure.

Removal of MTBE in 2006 resulted in an important change in gasoline station workers' exposures between 2004 and 2009. We observed statistically significant reductions in abnormal red blood cell prevalence and in alkaline phosphatase level from

2004 to 2009. These changes could plausibly be related to reduction in MTBE exposure. We also observed a marginally significant increase in symptoms of depression from 2004 to 2009. It seems unlikely that this could be attributed to increased gasohol levels, although alcohol has been associated with depression in previous research [6]. There was also a significant reduction in prevalence of abnormal hemoglobin composition between 2004 and 2009. This probably reflects a reduction in the proportion of study participants from Northeast Thailand, where the prevalence of thalassemia carriers is high [7]. Specifically 36 of 44 participants in 2004 (81.8%) were born in Northeast Thailand, whereas the corresponding proportion in 2009 was 45 of 83 (54.2%).

Otherwise, we observed no appreciable change in health-related metrics between 2004 and 2009. This suggests that overall, MTBE exposure did not exert a consistent effect on the health parameters measured in the current study. Even so, occupational exposure to gasoline has been associated with numerous signs of neurotoxicity [8, 9], and previous studies have shown that the concentration of benzene tends to higher with the use of MTBE in gasoline [10]. MTBE studies in animals have shown mild perturbations in hormone testosterone and prolactin in male Sprague-Dawley Rats [11] and mutagenicity in the Ames bacterial assay [12]. MTBE effects in humans remain unclear [13, 14]. In toxicokinetic studies of laboratory animals, MTBE concentrations have been higher, and study procedures have been more invasive, than in human studies [15].

Epidemiologic studies in Thailand have shown that the incidence of aplastic anemia in Bangkok during 1989 - 2002 was higher than European and North American cities [16]. The WHO indicated that long term benzene inhalation exposures as low as 0.0003 ppm can lead to acute leukemia [17]. Elevated serum enzyme values are often the earliest indicators of liver injury in asymptomatic patients. Abnormal SGOT and SGPT point to a hepatocyte disorder; abnormal ALP suggests a biliary tract disorder [18]. This study found that SGOT and SGPT were not significant difference between 2004 and 2009 but ALP was significantly decreased from high level in 2009. This results might be decreased of toxicity. A previous study suggested that six VOCs (benzene, toluene, ethylbenzene, m,p-xylene, o-xylene and MTBE) may influence biochemical liver tests [19].

In summary, the current study showed a limited tendency toward improvement of gasoline station workers' health between 2004 and 2009. Removal of MTBE in 2006 may have contributed to this improvement, although this cannot be asserted with confidence. At the same time, the studied health metrics may not be optimal for detection of MTBE effects. On balance, further research is needed to characterize human health effects of ambient MTBE exposure.

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