Environmentally Sustainable Occupational Exposure to Nanoparticles: A Pilot Study of Prevalence Symptoms and Truck Drivers Exposure to Diesel Ultrafine Particles

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Abstract

The aim of this pilot study is to investigate and examine the health risks associated with generational nano particles inhaled by truck drivers. The data for the pilot study was collected between May-November 2012 using a random sample survey of 50 Birmingham-area truck drivers that was selected from the Alabama Trucking Association membership directory and shipper's guide. Survey questions were designed to gather self-reported prevalence symptoms. The entire sample of respondents was 40; however, 15 cases could not be used because these respondents did not complete the questionnaire survey. The remaining 25 were used for the pilot study. The survey included questions on type of work and vehicle; exposure; symptoms such as frequency and severity of wheeze and chest tightness; and personal data, including age, gender, and smoking habits. Questions about cough and phlegm were based on the American Medical Research clinical definitions. The symptoms that were more prevalent in the sample of Birmingham, Alabama truck drivers were headaches, dizziness, and falling asleep unintentionally (perhaps factors other than exposure to diesel exhaust, e.g. stress, and noise contributes to falling asleep). Furthermore, truck drivers exposed to vehicle exhaust from diesel fumes experienced shortness of breath

with increasing years of driving. The results of the pilot study as indicated by truck drivers suggest diesel exhaust is an occupational health hazard to individuals who drive diesel vehicles. Furthermore, truck drivers exposed to diesel exhaust fumes experienced greater adverse health risks ranging from headaches and nausea to cancer and respiratory disease.

Keywords: Diesel exhaust, lung cancer, truck driver, occupational exposure, nano particles

Introduction

Sustainable development is a concept that captures the imagination of scholars, politicians, professionals and practitioners on all geographical scales (Oluwoye, 2012). Oluwoye (2012) reported that cities and towns face a wide variety of critical environmental problems (i.e., emission from automobiles, health-threatening pollution, and stratospheric ozone depletion). Furthermore, cities and towns face enormous human problems in the form of persistent poverty and human misery.

The World Commission on Environment and Development, established in 1987 by the United Nations, made a recommendation under 'Our Common Future' concluding that "a new developmental path was required, one that sustained human progress not just in a few places for a few years, but for the entire planet into the distant future." The question arises what is sustainable development? The Commission defined 'sustainable development as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs," (WCED, 1987). This definition is acceptable, except for the fact that the crucial little word 'need' is left undefined or unspecified. From the above definition one can see that sustainable development demands a creative process that replaces unsustainable practices with new sustainable practices that requires an understanding of future pattern of needs.

In an attempt to make the concept of sustainable development more specific, the author gives a narrow definition focused on the environmentally sustainable occupational exposure to nano particles. This means that we have to shift from our present modes of transport toward modes that are less energy consuming and less polluting.

Diesel exhaust is a complex mixture of gases and fine particles emitted by a diesel-fueled internal combustion engine. When diesel fuel burns in an engine, the resulting exhaust is made up of soot and gases that may contain thousands of different chemical substances. The soot consists of very small particles that can be inhaled and deposited in the lungs. Diesel exhaust contains 20-100 times more particles than gasoline exhaust. These particles carry cancer-causing substances known as polynuclear aromatic hydrocarbons (PAHs). Gases in diesel exhaust, such as nitrous oxide, nitrogen dioxide, formaldehyde, benzene, sulfur dioxide, hydrogen sulfide, carbon dioxide, and carbon monoxide can also create health problems.

Exposure to diesel exhaust particulates is *reasonably anticipated to be a human carcinogen,* based on limited evidence of carcinogenicity from studies in humans that indicates elevated lung cancer rates in occupational groups exposed to diesel exhaust (IARC, 1989, Cohen & Higgens, 1995, &Bhatia et al., 1998) and supporting animal and mechanistic studies. An increased risk of lung cancer is found in the majority of human studies. The overall relative risk is approximately 1.3 and higher risks are found in more heavily exposed subgroups in some studies. The increased risk is not readily explained by confounding by either smoking or asbestos exposure. However, the increased risk cannot always be clearly ascribed to diesel exhaust exposure. Although some studies employed semi-quantitative estimates of diesel exhaust exposure (Steenland *et al*., 1998), most studies used inadequate measures of exposure.

Kittelson et al. (2002) reported that diesel exhaust is a complex mixture of particulate matter (PM) and gases and includes particles ≤ 1.0 µm diameter (PM1) with mutagenic and polycyclic aromatic hydrocarbon (PAH) carcinogenic compounds adsorbed to a carbon core and ultra fine particles made up of condensed organics). Approximately 40 epidemiologic studies have described an association between lung cancer risk and occupations with some degree of diesel exhaust exposure, including railroad workers, construction workers, port workers, and truck and other professional drivers (Bhatia et al., 1998; Diesel Working Group 1995; Lipsett & Campleman, 1999; & Office of Research and Development, 2002). However, this association has been questioned (Bunn et al., 2004; Hesterberg et al., 2006; & Valberg& Watson, 2000) because of uncertainties regarding the link between the occupational records used to assess work history, specific job duties, and exposure. In particular, the likelihood that

truck drivers and other workers in trucking industry jobs were exposed to diesel exhaust depends on job duties and historical driving patterns. Previous studies in the trucking industry lacked detailed work records identifying specific trucking industry–related jobs and had a limited ability to assess job-related exposure differences.

The purpose of this paper is to examine the association of truck drivers' exposure to diesel ultra fine particles with their self-reported illness.

Methodology

The data for the pilot study was collected between May-November 2012 using a random sample survey of 50 Birmingham-area truck drivers that was selected from the Alabama Trucking Association membership directory and shipper's guide. Survey questions were designed to gather self-reported prevalence symptoms. The entire sample of respondents was 40; however, 15 cases could not be used because these respondents did not complete the questionnaire survey. The remaining 25 were used for the pilot study. Survey questions were designed to gather self-reported prevalence symptoms. The survey included questions on type of work and vehicle; exposure; symptoms such as frequency and severity of wheeze and chest tightness; and personal data, including age, gender, and smoking habits. Questions about cough and phlegm were based on the American Medical Research clinical definitions.

The survey was undertaken as a pilot to a more detailed objective four of (The investigation and examination of health consequences associated with generation of nano particles inhaled by truck drivers) current research topics entitled "Developing Sensors and the Testing of Adverse Health Effects of Nano particles on Individuals in the Environment." The intention of the survey was to give a broad understanding of truck drivers' self-reported illnesses toward exposure to diesel exhaust.

Descriptive analysis frequency distributions were performed. Linear associations between continuous variables were assessed using the non-parametric spearman with correlation coefficient using SPSS Windows.

Results and Discussion

Analysis of Frequency Distribution

Of the 25 truck drivers surveyed, 9% were age 60 and over, 24% were between the ages of 50-59, 36% were between the ages of 40-49, 20% were between the ages of 30-39, and 12% were between the ages of 20-29. The survey of truck drivers revealed that 30.5 of the truck drivers drive an average of 52,000 miles per year, 20% of them drive 62,400 miles, and 78,000 miles respectively. It should be noted that the respondents start at 6:00a.m. and stop driving at 6:00p.m. The majority of the truck drivers worked 12 hours per day while spending 80% of the time behind the wheel.

Table I: Age of Respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid					
	20-29	3	12	12	12
	30-39	5	20	20	32
	40-49	9	36	36	68
	50-59	6	24	24	92
	60+	2	8	8	100.0
	Total	25	100.0	100.0	

The range of the salary of the truck drivers surveyed per month is from $3,200.00 to $8,000.00. Eighty percent of the respondents suffered from headaches, while 20% of them never got headaches (See Table 2). However, Table 2 below shows that 100% of the respondents suffered dizziness.

Table 2 below also reveals that 92% of respondents experienced nausea, while 8% did not experience nausea. Furthermore, 60% felt tired after a day's work and 40% were not tired. It should be noted that 92% of respondents experienced nausea, while 8% did not experience nausea.

Table 2: Perceived Prevalence of Symptoms of Truck Drivers

Symptoms	Frequency		Valid Percent	
	Yes	No	Yes	No
Headaches	20	5	80	20
Dizziness	25	0	100	0
Nausea	23	2	92	8
Felt Tired	15	10	60	40
Fell Asleep	16	9	64	36
Experienced Cold	16	9	64	36
Stuffy or Runny Nose	19	6	76	24
Hoarse or Sore Throat	22	3	88	12
Red Eyes at Work	15	10	60	40
Dryness or Nose Smarting	22	3	88	12
Dryness or Irritation in the throat	22	3	88	12
Breathing Difficulties without Physical Exertion	15	10	60	40
Strange taste in the Mouth	20	5	80	20
Coughed in the morning upon rising	21	4	84	16
Coughed during the day or night	22	3	88	12
Coughed most of the days for more than 3 months	8	17	32	68
Coughed up Phlegm from the chest	22	3	88	13
Coughed up Phlegm most days	15	10	60	40
Past 3 years increased cough and Phlegm last 3 weeks	6	19	24	76

Sixty-four percent fell asleep unintentionally, while 36% of them did not fall asleep. However, 64% of the truck drivers experienced a cold while 36% did not (See table 2). Table 2 above reveals that 76% of the respondents experienced a stuffy or running nose, while 24% were not. It should be noted that 88% of the truck drivers also experienced hoarseness or a sore throat while 12% did not experience these symptoms. The question on experience of having eyes swart or red eyes when at work revealed that 60% experienced having eye irritation or red eyes, while 40% were not (table 2). Notwithstanding, 88% of the respondents experienced dryness or nose smarting and 12% did not have dryness or nose smarting.

Table 2 above reveals that 88% of the respondents suffered from dryness or throat irritation, while 12% did not experience these symptoms. Furthermore, 60% of the truck drivers had difficulty breathing without

physical exertion, while 40% did not experience these symptoms. As one can see from the above Table 2, 80% of the subjects reported a strange taste in the mouth, while 20% did not experience this symptom. However, 84% of the subjects usually coughed in the morning after waking up, while 16% did not cough upon waking.

As shown in Table 2 above, 88% of the respondents indicated they usually coughed during the day or night, while 12% did not. But, 32% of the respondents indicated they coughed most of the day for more than three months, while 68% did not cough.

Furthermore, 88% of the subjects coughed up phlegm from the chest during the day or night more than two times, while 12% did not cough up phlegm. Notwithstanding, 60% of the drivers coughed up phlegm most days for more than 3 months per year, while 40% did not as indicated in Table 2.
For the past 3 years, 24% of the respondents had increased coughing and phlegm that lasted three weeks or longer, while 76% did not experience these symptoms.

As one can see from the above table, 88% of the respondents indicated they coughed during the day or night, while 12% did not cough. However, 32% of the respondents indicated they coughed most of the day for more than three months, while 68% did not cough.

Table 2 above reveals that 88% of the subjects coughed up phlegm from the chest during the day or night more than two times, while 12% did not experience this symptom. Furthermore, 60% of the drivers coughed up phlegm most days for more than 3 months per year, while 40% did not as shown in Table 2. For the past 3 years, 24% of the respondents had increased cough and phlegm lasting three weeks or more, while 76% did not experience these symptoms (See Table 2).

Spearman's rho Correlation Analysis on Prevalence Symptoms

The Spearman's rho correlation coefficient was calculated to give an indication of suggested relationships between variables.

Association between age and past 3 years of cough + phlegm for 3 weeks or more

A negative rank correlation existed between age and past 3 years ($r = -0.333$, $p < .052$). The rank correlation is significant at the 5% level for a one-tail test, which suggests that H0 be rejected in favor of H1, such that one can conclude that there is a significant similarity in the ranking of the truck drivers with yes and no symptoms. As the age of the truck drivers increases, the prevalence symptom of cough and phlegm for 3 weeks or more decreases.

Association between years of driving and shortness of breath

A significant relationship emerged between years of driving and shortness of breath ($r = 0.368$, $p < .032$). It should be noted that 0.032 is less than 0.05; the rank correlation is significant at the 5% level for a one-tail test, which suggests that H0 be rejected in favor of H1. The rank correlation suggests that as years of driving increases the more truck drivers experience shortness of breath.

Association between miles driving per year and cough through the day vs. coughing up phlegm from chest

A positive Spearman's rho correlation existed between miles driving per year and cough through the day ($r = 0.376$, $p < .032$). This is a one-tail test t-test, since the significance is 0.032 which is less than 0.05; the rank correlation is also significant at the 5% level. Furthermore, the Spearman's rho correlation emerged between miles driving per year and coughing up phlegm from chest ($r = 0.290$, $p < .080$). It should be noted that 0.080 is higher than 0.05, the rank correlation is significant at the 10% level for a one-tail test.

***Association between Driving Hours behind the wheel and (i) Catch Cold once a Year* (ii) Suffer from Dryness or Irritation in the Throat (iii) Shortness of Breath without having exerted yourself (iv) Cough in the morning when rising up.**

A significant positive relationship emerged between driving hours behind the wheel and exposure to catching a cold once a year ($r = 0.300$, $p < .072$); driving hours behind the wheel and exposure to getting a hoarse or sore throat ($r = 0.285$, $p < .083$); driving hours behind the wheel and suffer

from dryness or irritation in the throat ($r = 0.329$, $p < .054$); driving hours behind the wheel and shortness of breath without having exerted yourself ($r = 0.326$, $p < .025$); driving hours behind the wheel and exposure to cough in the morning when rise up ($r = 0.397$, $p = .025$) As driving hours increased, the truck drivers had a greater chance of catching a cold once a year, getting hoarse or a sore throat, and suffering from dryness or irritation in the throat, shortness of breath, and coughing in the morning. The rank correlation of the above symptoms is significant at the 5% level for a one-tail test.

Association between Start work time and Fall asleep

A negative correlation existed between start work time and fall asleep ($r = -0.464$, $p = .010$). The rank correlation is significant at the 1% level for a one-tail test that suggests that as start work time increases the chances of falling asleep at work decreases.

Association between End work time and Catch cold once a Year

A negative correlation existed between end work time and catching a cold once a year ($r = -0.320$, $p < .059$). The rank correlation is significant at the 5% level for a one-tail test that suggests that as end-day work time increases chances of catching cold once a year decreases.

Association between Start work time and Phlegm from the chest

A significant relationship emerged between the two variables ($r = 0.287$, $p < .082$). The rank correlation shows there is a positive relationship between work start time and symptom of coughing up phlegm from the chest. The earlier drivers started work, the greater their chances of coughing up phlegm from their chest.

Conclusion and Recommendations

The results of the pilot study emphasized that exposure to diesel exhaust is an occupational health hazard among individuals driving diesel vehicles. Furthermore, truck drivers exposed to diesel exhaust face adverse health effects ranging from headaches and nausea to cancer and respiratory disease.

Furthermore, the data obtained from the truck drivers suggests that the health effects of diesel exhaust are likely to be greater for cough and shortness of breath symptoms than for lower respiratory symptoms. Some uncertainty about the causality of the observations arises from the small samples response rates and conflicting trends in respiratory and nasal symptoms, together with the lack of reliability inherent in comparisons between successive questionnaires.

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