J Occup Health 2017; 59: 74-80

Journal of Occupational Health

Field Study

Health status assessment of workers during construction phase of highway rehabilitation projects around lahore, Pakistan

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Abstract: Objective: The study focused on assessment of the health status of workers during construction phase of highway rehabilitation projects at six selected sites of N5 around Lahore, including Kala Shah Kaku, Muridke, Kamuki, Bhaipheru, Pattoki, and Okara. **Methods:** The study was based on multi-methods approach involving hazard identification through survey and checklist as well as a questionnaire for health status assessment and measurements of health parameters including peak expiratory flow rate (PEFR) and audiometric screening of 300 subjects. **Results:** The study revealed non-congenial working conditions at the sites. Noise, vibrations, dust, asphalt fumes, poor work postures, and injuries were found to be major health hazards. PEFR of most of the workers was found to be significantly lower than the reference value. Average PEFR ± SEM values were 187 ± 5.1 l/min, 178 ± 4.3 l/min, and 266 ± 5.3 l/min in ground preparation workers, asphalt workers, and heavy vehicle drivers, respectively. The highest rate (29%) of hearing loss was recorded among heavy vehicle drivers. Musculoskeletal problems were found to be more common among ground preparation workers. **Conclusion:** Data revealed unsatisfactory health status of most of the workers. Direct relationship between health outcomes and the type of construction activities were observed. The current study focuses on the importance of including occupational health and safety plan in the execution phase of every developmental project that involves construction activities.

(J Occup Health 2017; 59: 74-80)
doi: 10.1539/joh.16-0123-FS

Received May 22, 2016; Accepted September 30, 2016
Published online in J-STAGE November 16, 2016
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Key words: Expiratory Peak Flow Rate, Hearing Impairment, Level of Health

Introduction

The construction industry employs a large number of people. Construction workers are engaged in a wide range of activities and often become victims of different occupational diseases and injuries. Road construction workers include asphalt workers, ground preparation workers, and heavy vehicle operators who are directly or indirectly exposed to occupational hazards such as dust, noise, heat and cold, vibration, and chemicals[1)]. Noise induced hearing loss, respiratory diseases, musculoskeletal problems, skin and eye irritation are the prevalent health problems found among these workers[2)].

Health assessment studies provide evidence based link between causative agents and health outcomes. Road construction activities present variable occupational health hazards including exposure to hazardous substances including silica dust, asphalt, organic solvents, and agents, such as noise, vibration, and heat, affecting workers' health. Excessive exposure to these substances and agents may result in illness, injury, permanent disability, or even death. Fumes and vapors generated during the application of hot asphalt to the surface cause skin irritation, rashes, burns, and respiratory problems[3)].

Construction workers may face different occupational hazards. Extensive manual work, fatigue and loss of concentration at workplace are the reasons behind the increasing risk of accidents among workers[4)]. Ground construction workers are mainly exposed to silica dust, which can lead to the development of serious ailments such as tuberculosis, connective tissue damage, renal disease, and lung cancer[5)].

Asphalt mixing involves the mixing of bitumen with

mineral aggregates through heating. The mixing and its application process exert high risk of fatal and nonfatal injury and disease[6]. Construction workers operating heavy machinery during roads and highway construction operations are also exposed to fumes from diesel exhaust, vibration and high levels of noise. Most of the heavy vehicles are powered by diesel. Exposure to diesel fumes can cause eye and nasal irritation, asthma and chronic bronchitis[7]. Heavy machinery operations are associated with high levels of whole body vibrations[8]. Noise from heavy equipment is another occupational problem to which most of the road construction workers are exposed. Occupational noise leads to accidents specific to road construction activities[9].

The present study deals with the identification of potential health hazards and risks to highway construction workers associated with various construction activities and assessment of the workers' health status. The study will also provide a base for mitigation measure design to be considered during planning phase for the minimization of health risk to workers for future highway construction and reconstruction projects.

Objectives

The present study was designed to;

・Identify potential hazards and risks to health of highway construction workers using hazard identification checklist.

・Collect data regarding socio-demographic indicators, health determinants, and health status of construction workers through interviews using questionnaire.

・Measure health surveillance parameters including PEFR and audiometric screening of workers.

Subjects and Methods

Study area

The national highway N5 is Pakistan's longest highway that extends from the port city of Karachi to Torkham at the border with the total length of 1819 km. The present study was conducted to determine health risks associated with workers of highway rehabilitation projects at six selected sites on N5 around Lahore including Kala Shah Kaku, Muridke, Kamuki, Bhaipheru, Pattoki, and Okara.

Subjects

The study involved 300 subjects including the three target groups of highway construction workers, i.e., ground preparation workers (n=75), asphalt workers (n=75), heavy vehicle drivers (n=75), and the control group (n=75) of workers not exposed to highway construction hazards. Written permission from the contractors were sought to conduct the survey. Visits were made to the sites and counseling sessions were conducted. Only those subjects were included who gave their consent to participate for questionnaire survey as well as for the measurement of various parameters. The study was conducted after obtaining the approval of the review board of the university. Approximately 800 workers were engaged in road construction activities at six different sites on N5. Variable numbers, i.e., between 200 and 240 workers were in each target group and approximately 100 personnel were in the control group. The number of workers selected for the study was random based on their consent and frequent availability from each representative group. These workers were involved in different road construction activities. Ground preparation workers at the study sites were involved in earth work including mounting and fine grading. These workers were involved in manually breaking and crushing the stones to prepare the aggregate base. Asphalt workers were involved in preparing the asphalt mix and its application on the road surface. Heavy vehicle drivers were found operating bulldozers and excavators used for clearing, paving, and compacting activities. Office boys and supervisors were considered in the control group for comparative study.

Hazard Identification

In order to assess health hazards at the selected sites, a hazard identification checklist was developed following the international labor organization (ILO) guidelines[10]. The checklist focused on the identification of factors and agents with the potential to cause health damage to workers including physical hazards (exposure to noise, vibration, and dust); ergonomical hazards (poor work postures, use of excessive force, repetitive movements, and handling of heavy objects); chemical hazards (exposure to toxic and irritating chemicals); and mechanical hazards (potential injuries due to falls, slips or trips, and confined spaces).

Health Assessment

In order to assess the health status of the workers, a questionnaire was designed. The questionnaire comprised three sections including socioeconomic information (age, education, monthly income, and family size), health determinants assessment (access to clean drinking water, safe food, first aid services, and provision of PPEs), and health status assessment (lung performance, hearing performance, prevalence of musculoskeletal disorders, and other health problems).

Measurement of Peak Expiratory Flow Rate

Lung performance of 300 subjects was measured using Mini-Bell Peak Flow Meter (Spain). Peak flow meter works on the simple principle of airflow measurement in the lungs[11]. Reading on the peak flow meter scale indicates how open the lung's airways are. Average PEFR values of construction workers were compared with normal values, i.e., 300-600 *l*/min[12].

Audiometric Screening

Hearing screening of all subjects was conducted using Ambco Field Audiometer 1500 (USA) to calculate the person's hearing efficiency. Test was performed in sound proof containers with background noise level of <20 dB. Audiometric test was performed for both the ears of the subject by setting frequencies of 500, 1000, 2000, and 4000 Hz. Hearing level dial on the audiometer was set at 5 dB. Results were compared with commonly used international classification system of hearing degrees provided by American Speech-Language-Hearing Association[13].

Data Interpretation and Analysis

Data collected through questionnaire and measurement of various parameters were computed and tabulated. Data analysis was performed using Microsoft excel and SPSS statistical package. Quantitative variables are expressed as mean, standard deviation, standard error of mean, and qualitative variables are described as percentage values after calculations based on various responses. The statistical differences in mean values according to job type for different parameters were tested using Student's t-test. P value of <0.05 was considered statistically significant to investigate the relationship between the job types of workers involved in various construction activities with their lung and hearing performance.

Results and Discussion

Hazard Identification

Surveys of various sites using hazard identification checklist revealed concerning situations of highway rehabilitation work sites with reference to occupational settings. Physical health hazards observed during the survey of various sites were noise, vibration, and heat. Operations of mechanical excavators and bulldozers were found to produce high levels of noise. No control measures were observed at the sites to reduce noise exposure to workers.

Vibration was a major problem, and workers were found to be exposed to vibration hazards while working, especially when driving heavy vehicles. Another common physical health hazard found in these settings was the heat from the asphalt preparation, which is responsible for severe heat stress. The workers were found to be involved in preparing hot mixture of asphalt at temperatures 150-190℃, resultantly causing the generation of hot spots. This poses a potential risk of health effects either directly or indirectly that are likely to be aggravated with changing weather conditions. Direct and continuous exposure to high temperature can lead to disturbance in the temperature regulation mechanism in the human body. This can cause unconsciousness, hypothermia, and heat stroke.

Workers dealing with asphalt were also found to be exposed to chemical hazards. The equipment used for the preparation of hot asphalt was in poor conditions and workers were directly exposed to asphalt fumes. Hot asphalt is dangerous when it comes in contact with the skin and can lead to severe burns. Other hazardous chemicals found at the worksites were silica dust, gasoline, and diesel exhaust.

Numbers of ergonomical hazards were observed during the survey including poor work postures, handling of heavy hand-held tools, use of excessive work force, and repetitive movements. It was observed that ground preparation workers were exposed to these hazards in the daily work routine. These ergonomical hazards were found to be responsible for musculoskeletal problems and physical fatigue among the workers. Risk of injuries from passing traffic and other mechanical hazards were common safety issue at all sites. Heaps of construction wastes evidently blocking the passage way for workers were prevalent, thus presenting threats of slips, trips, and personal falls.

Health Status Assessment

Socio-demographic Information

All the workers assessed for health status were aged17-54 years. Average age ± SEM of construction workers of three occupational groups and control group was as follows, asphalt workers (31 ± 1.02 years), ground preparation workers (30 ± 0.98 years), heavy vehicle drivers (36 ± 0.92 years), and control group (33 ± 1.05 years). Data regarding socio-demographic factors such as education, family size, monthly income, earning members, and total monthly income of the family were also collected. Of the total workers, 28% were illiterate, whereas 49%, 8%, 12%, and 4% had education level up to primary, middle, matriculation, and intermediate, respectively. Most of these workers earn very little to support their families with average income level of 8000-24000 rupees per month; 48% of the workers had family size of 1-5 members, 50% had 6-10members, and 2% had 10-15 members, which evidently reflects the socioeconomic pressure on these workers.

Health Determinant Assessment

Analysis of data collected for health determinants was based on opinions of the respondents for various questions regarding the presence of hazards affecting their work efficiency and provision of public services at workplace. Table 1 shows the opinions of the respondents regarding workplace hazards affecting their ability to work. These workers were also asked about services provided by their employers at the workplace; 53% of the workers voiced their concerns that they had no access to safe drinking water at the workplace, 48% complained of access to safe food for eating during working hours, and 82% were not satisfied with the first-aid facilities and provision of personal protective equipment by the employer.

Peak Expiratory Flow Rate values of respondents (Table 2) depict significantly lower average values of PEFR

Table 1. Opinion of respondents about workplace hazards Affecting ability of work.

Target Group	Noise		Vibration		Extreme Temperature		Dust		Chemicals	
	n	%	n	%	n	%	n	%	n	%
Ground Preparation Workers	19	25	10	13	24	32	45	60	9	12
Asphalt Workers	16	21	2	3	36	48	18	24	55	73
Heavy Vehicle Drivers	62	82	27	36	16	21	12	16	16	21
Control Group	12	16	0	0	10	13	4	5	9	12

Table 2. Peak Expiratory Flow Rate (*l*/min) of total respondents of different target groups and controls (n=300).

Target Group	n	Average	Range	SD
Ground Preparation Workers	75	187	103-290	43.9
Asphalt Workers	75	178	102-240	37
Heavy Vehicle Drivers	75	266	186-393	46
Control Group	75	366	259-490	51.8

among these workers, whereas average PEFR value of control group was significantly higher ($P<0.05$) than that of the three occupational groups of highway construction workers. The lowest PEFR was measured to be in the range of 102-240 *l*/min among the asphalt workers. This was below the normal range of 300-600 *l*/min. Presence of reduced lung performance measured through PEFR is depictive of the likelihood of occupational respiratory diseases that are usually caused by extended exposure to irritants or toxic substances that may result in acute or chronic respiratory ailments.

These workers were found to be exposed to asphalt fumes when preparing hot mixture of asphalt. Exposure to asphalt fumes over long periods of time may lead to severe disease and in some cases, even lung cancer. Common route of exposure to asphalt fumes is inhalation. These fumes have irritant properties and are responsible for increased risk of reduced lung performance. The present study is in agreement with the study by Tepper and Burr in 2006. They regarded asphalt fumes to be responsible for low PEFR among pavers[14].

The presence of other hazardous chemicals at the workplace such as gasoline and diesel exhaust was generated from wide spread vehicular and mechanical activities at these sites. Sources of these chemicals were fuels used to power the heavy vehicles. Diesel exhaust is found to be responsible for health problems including shortness of breath, coughing, and lung-related illness among many of the heavy vehicle drivers.

Ground preparation workers also showed lower level of PEFR within the range of 103-290 *l*/min because they were found to be exposed to high levels of aerosols such as silica dust particles, which are evident causes of respiratory diseases among these workers. Road rehabilitation activities involve clearing of road surface material to enable repair. The dust generated by this operation is usually in the form of very fine particles, which are hazardous to respiratory health and are difficult to control[15]. Although specific data were not collected with reference to smokers and non-smokers and the number of cigarettes per day, it was observed that majority of the workers of older age groups were found smoking during break hours and in certain cases during the work. These observations are complementary to the findings of the lower PEFR of those workers.

Musculoskeletal problems were found to be common among workers. Table 3 shows fatigue and other musculoskeletal problems in workers among different occupational groups. According to the collected data, the highest rate (61%) of fatigue was recorded among ground preparation workers. A study conducted by Roja et al in 2006 for the assessment of skeletal muscle fatigue of road construction workers provided evidence that workers in ground construction operations are often exposed to ergonomical factors of awkward postures, use of excessive force, and repetitive movements, leading to significant health hazards including musculoskeletal problems[16].

Fifty-one percent of ground preparation workers who were involved in manual crushing and grinding of the stones for the preparation of even road surface suffered from back pain. It was noted that these workers use excessive force to hit the stones for grinding and were in very awkward postures by putting excessive stress on the back, thus resulting in back pain. Forty percent of the workers faced problems with bending knees, 20% and 25% had difficulty in moving head and arms, respec-

Table 3. Musculoskeletal Problems of workers from different occupational groups of highway construction workers and control group.

Target Group	Musculoskeletal Problems									
	Back pain		Difficulty in moving arms		Difficulty in bending knees		Difficulty in moving head		Fatigue	
	n	%	n	%	n	%	n	%	n	%
Ground Preparation Workers	38	51	19	25	30	40	15	20	46	61
Asphalt Workers	10	13	5	7	12	16	8	11	33	44
Heavy Vehicle Drivers	34	45	18	24	25	33	19	25	41	55
Control Group	8	11	3	4	5	7	3	4	20	27

Table 4. Percentage of degree of hearing loss among highway construction of different job types.

Target Group	Degree of Hearing Loss					
	Slight hearing loss		mild hearing loss		Moderate hearing loss	
	n	%	n	%	n	%
Ground Preparation Workers	5	7	8	11	0	0
Asphalt Workers	7	9	5	7	0	0
Heavy Vehicle Drivers	9	12	7	9	6	8
Control Group	3	4	0	0	0	0

Cut off values of degree of hearing loss (ASHA, 1981)

Degree of hearing loss	Hearing loss (dB)
Normal hearing	–10 to 15
Slight hearing loss	16-25
Mild hearing loss	26-40
Moderate hearing loss	41-55
Moderately severe hearing loss	56-70
Severe hearing loss	71-90
Profound hearing loss	Above 90

tively, 45% of heavy vehicle drivers had back pain as a common musculoskeletal problem. These drivers were found to be exposed to vibration hazards during work. It was observed that most of the workers were driving the vehicles on uneven road surfaces which poses additional hazards and likely multiplied the risk of back pain. A research study was conducted showing relationship between working as a heavy vehicle operator and development of musculoskeletal disorders. Whole body vibration and working postures are linked to lower back and neck disorders[17]. The rate of back pain was comparatively lower in asphalt workers because they were not directly exposed to vibration hazards and awkward postures.

Another peculiar observation was the prevalence of hearing loss. Hearing loss was recorded in 29% of the heavy vehicle drivers, whereas 18% of ground preparation and 16% of asphalt workers also had low hearing efficiency. Results of Audiometric Screening of the respondents shown in Table 4 revealed that 7% of ground preparation workers were found to have slight hearing loss and 11% had mild hearing loss; 9% of asphalt workers were found with slight hearing loss and 7% with mild hearing loss. Among heavy vehicle drivers, 12% had slight hearing loss, 9% had mild hearing loss, and 8% had moderate hearing loss, according to standard categories of degree of hearing loss by American Speech-Language-Hearing Association. Only 4% of individuals of the control group showed slight hearing loss. Highway construction workers are exposed to potentially hazardous levels of noise resulting in noise-induced hearing loss[18]. The operation of heavy equipment including excavators, diggers, bulldozers, and rollers on these reconstruction sites was found to generate high levels of noise exceeding the ambient noise levels. It was alarming that most of the heavy vehicles were not properly maintained and produced much higher level of noise exceeding well beyond the permissible limit.

According to Legris and Poulin in 1998, an 8-h average noise exposure levels for heavy equipment operators were recorded as 97, and 95dB in case of vibration road roller and asphalt road rollers, respectively. The study also assessed the relationship between hearing loss with person's

ability to drive. It was observed that slight to mild hearing loss may not affect a person's ability to drive safely but further longer exposure due to same occupation may result in moderately severe and severe hearing loss[19]. It is noteworthy that workers driving heavy vehicle were more exposed to noise than ground preparation and asphalt workers because of multiple reasons, including activities around them coupled with the noise of heavy machinery operations. These findings are similar to those reported by Elizabeth et al (2013), in which they categorized the road construction industry as one of the most hazardous occupations in terms of high noise exposures and high risk of noise-induced hearing loss[20].

Conclusion

An evident link of hazard identification with the results of health status assessment of workers of three occupational groups was observed. Workers at the sites were exposed to similar types of hazards but occupational health hazards linked with specific job are of particular significance. Data collected with reference to the prevalence of various health problems among highway construction workers were directly related to the nature of the job performed by the workers. Results revealed that cough, asthma, and skin rashes were major health problems of asphalt workers due to continuous exposure to chemical fumes. Ground preparation workers mostly complained of back pain, leg cramps, and cough. Lung diseases were found to be more prevalent in asphalt and ground preparation workers. Highest rate of hearing problem due to heavy noise was found among heavy vehicle drivers. Musculoskeletal problems were prevalent among ground preparation workers and heavy vehicle drivers as a result of awkward posture and repetitive muscular activity, whereas fatigue was the common complaint by all the workers under study. The socioeconomic status such as low monthly income, and education level, as well as inadequate health determinants such as inadequate access to clean drinking water and safe food and unavailability of first aid are the additional factors causing deteriorated health conditions among workers. Noncompliance of ILO guidelines for working hours, non-use of PPE, and attitudes of contractors towards workers are also important factors that need to be addressed. The findings of the present study are of significance not only in the context of occupational health and safety studies for academic and research reasons but also are important with reference to the need for health policy planning of developmental projects during construction phase.

Conflicts of interest: The authors declare that there are no conflicts of interest

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