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Epidemiological Studies in Workers Exposed to Steel Dust

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Abstract:

Context: Steel is crucial to the development of any modern economy and is considered to be the backbone of human civilization. Although studies on adverse health effects in steel industry workers were reported from European and other countries, studies of this nature are meager in Indian ethnic group, where the health problems in steel industry workers are very serious. In the present study, we focused on adverse health effects in steel industrial workers who were occupationally exposed to steel dust. To the best of our knowledge, this is the first investigation of its kind.

Methods: The study was carried out in 435 steel industry workers in the group of 20-60 years who are occupationally exposed to steel dust and in 426 subjects with no history of occupational exposure to steel dust or any other chemicals (control group). Information on the age, medical history, and habits like smoking, consumption of alcohol, surgical history, medication, and nature of the job, marital life and years of service were recorded in a standard questionnaire.

Results: The results have shown an increase in health problems particularly Hair loss, respiratory problems, diabetes, joint pains, followed by hypertension, headache, and eye problems. Their frequency of health problems was high in steel industrial workers compared to controls (71.03% vs 31.0%).

Conclusion: On the basis of the results obtained in the present study, definite conclusions were drawn on the nature of health problems in workers of the steel industry. The frequency of health problems was high in steel industrial workers compared to controls. This might be due to the undue exposure to steel dust at work place. Hence appropriate precautionary measures have to be taken to prevent or minimize the exposure of the workers to steel dust.

Keywords: Occupational Exposure, Health Problems, Steel Industrial Workers, Epidemiological Hypertension.

I. INTRODUCTION

A person spends, on an average, one third of his life at his workplace and therefore the environment in which he works can be a major factor in determining health. The steel and iron industry has been one of the world's most important industries ever since it was first founded. Steel industry workers are exposed to toxic compounds especially heavy metals like lead, nickel, cadmium, chromium, iron, and manganese. Long term exposure to steel dust causes health effects on humans such as genetic damages, damage to nerves, endocrine system. Stainless steel production gives rise to a mixture of airborne dust and fumes, which contain various metal oxides and other metal compounds that target the respiratory epithelium or bladder organ. Studies have shown the mutagenic effects, adverse respiratory health effects like lung cancer and increased risk of kidney cancer in the people exposed to steel dust (cameron et al., 2011).

Chemical factors like welding fumes containing manganese may result in neurological, neuropsychological and pulmonary adverse health effects (Bowler et al.,2006) and cardiovascular systems (Hobbesland et al.,1997). The lung cancer mortality among stainless steel welders was found to be higher than the general population (Bengt Sjogren et al., 1994).Noise induced hearing loss which is the most commonly observed condition in the workers of iron and steel industry. There was a positive association between duration of exposure and prevalence of hypertension. The prevalence of hearing impairment was significantly more in CEG (continuously exposed group) Occurrence of hearing impairment was also directly proportional to the duration of exposure. Neurodegenerative illnesses like Parkinson’s disease have seen in workers when they have been exposed to steel dust like manganese and iron. (MadhuVenkataraman; 2000). Nickel is the most observed cause of immediate and delayed hypersensitivity noticed in occupationally exposed as well in the general population (Das etal. 2008).

Sickness absenteeism has seen significantly higher among iron and steel workers when compared to other occupations and also they face health problems like the musculoskeletal system, gastrointestinal system and hypertension in higher proportions compared to their counterparts (Manjunatha et al., 2011).

Studies also showed that workers with the combination of the GSTM1 null, GSTT1 null, and GSTP1 Ile105/Ile105 genotypes were significantly associated with a higher risk of Hearing impairment. Workers are exposed to high level of noise, temperatures up to 1,800°C, toxic or corrosive substances, and respirable air-borne contaminants (Simon, 1992). The various processes carried out in the production of steel pipes result in the exposure of the workers to physical factors like heat, ionizing radiation, and noise (Khalkova, et al., 1986). Studies are also indicated that hypertension and hearing impairment are commoner in workers continuously exposed to high levels of occupational noise. Long-term exposure to occupational noise is itself a risk factor for occupational hypertension. U.W Narlawar., (2006) have reported that there was a positive association between duration of exposure and prevalence of hypertension exposure to these materials may lead to serious health problems.

II. MATERIALS AND METHODS

Study Design

Total 435 were enrolled for this study in the group of 20-60 years who are occupationally exposed to steel dust and in 426 subjects in the same age group belonging to the same socio economic status and not exposed occupationally to any chemical and physical agents was selected for comparison (control group). All the subjects of steel industrial workers and controls were clinically examined and information on age, nature, life style, duration of the job, socio economic status, income, occupational history, tobacco and alcohol use, health conditions, hours of work per day, medical history, personal safety measures taken, habits, health problems, living conditions, marital status, family history, and literacy were recorded using a standard questionnaire. The study was approved by the Institutional Ethics Committee of the Centre and written informed consent was obtained from all the participants of the study. The results were analyzed statistically using the appropriate t-test to find the significance of the differences in health problems between the two groups.

Results:

The details of health problems observed in the workers of the steel industry are presented in a (Figure 1, 2 and Table 1, 2).

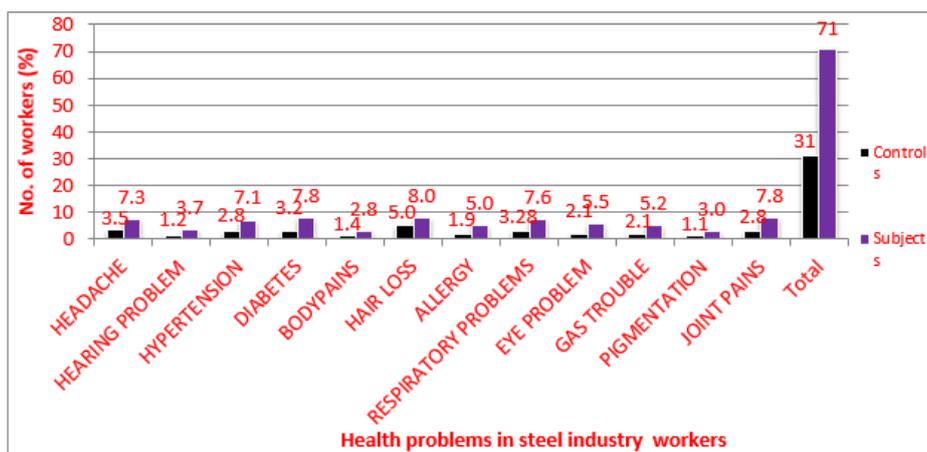


Fig.1: The Percentage of Health Problems in Steel Industry Workers

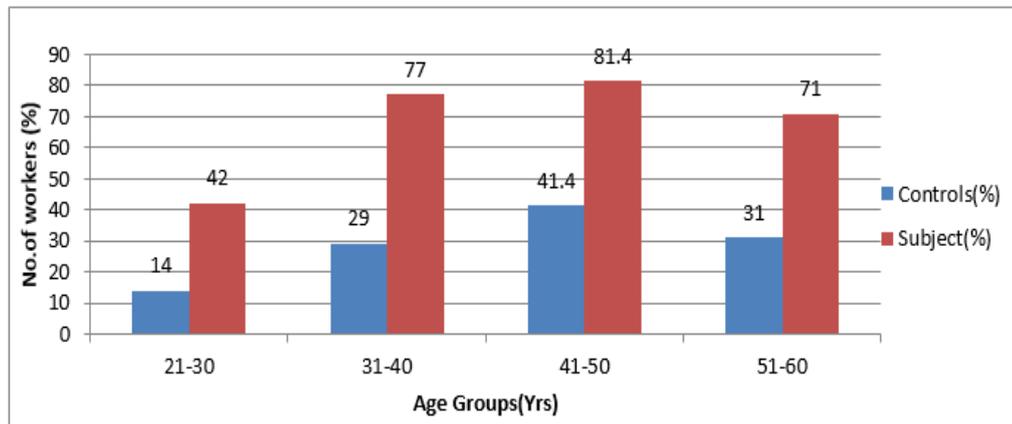


Fig. 2: Age Wise Health Problems in Steel Industry Workers of Different Age Groups

Table: 1: SUMMARY OF HEALTH PROBLEMS IN CONTROLS AND STEEL FACTORY WORKERS

PARAMETERS	Age Wise Summary of Health Problems in Controls and Steel Factory Workers									
	Contro ls	Subjects	Controls	Subjects	Controls	Subjects	Controls	Subjects	Controls	Subjects
	21-30yrs		31-40yrs		41-50yrs		≥50Yrs		TOTAL	
	N=100	N=110	N=129	N=122	N=135	N=140	N=62	N=64	N=(426)	(N=435)
HEADACHE	3(3)	10(9.09)	5(3.87)	10(8.19)	6(4.44)	9(6.42)	1(1.61)	3(4.68)	15(3.52)	32(7.35)
HEARING PROBLEM	0(0)	0(0)	1(0.77)	5(4.09)	3(2.22)	8(5.71)	1(1.61)	3(4.68)	5(1.17)	16(3.67)
HYPERTENSIO N	1(0)	3(2.72)	4(3.10)	10(8.19)	5(3.70)	11(7.85)	2(3.22)	4(6.25)	12(2.81)	31(7.12)
DIABETES	2(2)	8(7.27)	4(3.10)	9(7.37)	5(3.70)	9(6.42)	3(4.83)	6(9.37)	14(3.28)	34(7.81)
BODYPAINS	0(0)	1(0.90)	1(0.77)	2(1.63)	3(2.22)	6(4.28)	2(3.22)	4(6.25)	6(1.40)	12(2.75)
HAIR LOSS	4(4)	7(6.36)	7(5.42)	12(9.83)	8(5.92)	12(8.57)	2(3.22)	4(6.25)	21(4.92)	35(8.04)
ALLERGY	1(1)	3(2.72)	3(2.32)	7(5.73)	3(2.22)	9(6.42)	1(1.61)	3(4.68)	8(1.87)	22(5.05)
RESPIRATORY PROBLEMS	1(1)	5(4.54)	5(3.87)	11(9.01)	7(5.18)	12(8.57)	1(1.61)	5(7.81)	14(3.28)	33(7.58)

EYE PROBLEMS	1(0)	3(2.72)	2(1.55)	7(5.73)	4(2.96)	9(6.42)	2(3.22)	5(7.81)	9(2.11)	24 (5.51)
GAS TROUBLE	1(0)	1(0.90)	2(1.55)	7(5.73)	4(2.96)	10(7.14)	2(3.22)	4(6.25)	9(2.11)	23(5.28)
PIGMENTATION	0(0)	0(0)	1(0.77)	3(2.45)	2(1.48)	6(4.28)	2(3.22)	4(6.25)	5(1.17)	13(2.98)
JOINT PAINS	1(1)	5(4.54)	3(2.32)	11(9.01)	6(4.44)	13(9.28)	2(3.22)	5(7.81)	12(2.81)	34(7.81)
TOTAL NO	14(14)	46(41.81)	38(29.45)	94(77.04)	56(41.48)	114(81.42)	21(33.87)	50(78.12)	130(30.51)	309(71.03)

Table: 2: Age (Yrs) Group Wise Related Health Problems in Steel Industry Workers

HEALTH PROBLEMS	21-30 Yrs			31-40 Yrs			41-50 Yrs			≥50 Yrs			Total		
	N=100		OR(95% Conf. Interval)	N=129		OR(95% Conf. Interval)	N=135		OR(95% Conf. Interval)	N=62		OR(95% Conf. Interval)	N=(426)		OR(95% Conf. Interval)
	C	S		C	S		C	S		C	S		C	S	
HEADACHE	3	10	3.23(0.78-15.3)	5	10	2.21(0.66-7.70)	6	9	1.47(0.46-4.82)	1	3	3(0.26-77.05)	15	32	2.17(1.11 - 4.28)
HEARING PROBLEM	0	0	0	1	5	5.47(0.61-125)	3	8	2.66(0.62-12.9)	1	3	3(0.26 -77.05)	5	16	3.21(1.09 - 10.1)
HYPERTENSION	1	3	2.77(0.25-70.4)	4	10	2.79(0.77-10.8)	5	11	2.21(0.68-7.55)	2	4	2(0.29 -16.42)	12	31	2.64(1.28 - 5.53)
DIABETIC	2	8	3.84(0.73-26.9)	4	9	2.48(0.67-9.90)	5	9	1.78(0.52-6.31)	3	6	2.03(0.42-10.86)	14	34	2.49(1.27 - 4.96)
BODYPAINS	0	0	0	1	2	2.13(0.14-60.2)	3	6	1.97(0.42-10.1)	2	4	2(0.29 -16.42)	6	12	1.98(0.68 - 5.99)
HAIR LOSS	4	7	1.63(0.41-6.87)	7	12	1.9(0.66-5.56)	8	12	1.48(0.54-4.14)	2	4	2(0.29 -16.42)	21	35	1.68(0.93 - 3.06)
ALLERGY	1	3	2.77(0.25-70.4)	3	7	2.55(0.57-12.8)	3	9	3.02(0.72-14.4)	1	3	3(0.26 -77.05)	8	22	2.78(1.16 - 6.88)
RESPIRATORY PROBLEMS	1	5	4.71(0.52-108)	5	11	2.45(0.75-8.4)	7	12	1.71(0.60-4.99)	1	5	5.16(0.55 - 120)	14	33	2.41(1.22 - 4.81)
EYE PROBLEM	1	3	2.77(0.25-70.4)	2	7	3.86(0.71-27.5)	4	9	2.25(0.61-8.92)	2	5	2.54(0.41-19.8)	9	24	2.70(1.18 - 6.35)

GAS TROUBLE	1	2	1.81(0.12-51.9)	2	7	3.86(0.71-27.5)	4	10	2.51(0.70-9.80)	2	4	2(0.29 -16.42)	9	23	2.58(1.12 - 6.10)	-
PIGMENTATION	0	0	0	1	3	3.22(0.29-81.6)	2	6	2.97(0.53 - 21.7)	2	4	2(0.29 -16.42)	5	13	2.59(0.85 - 8.40)	-
JOINT PAINS	1	5	4.71(0.52-108)	3	11	4.16(1.04-19.3)	6	13	2.2(0.75 - 6.72)	2	5	2.54(0.41-19.79)	12	34	2.92(1.43 - 6.06)	-
Total	14	46	4.41(2.13-9.25)	38	94	8.03(4.39-14.7)	56	144	6.18(3.46-11.1)	21	50	6.97(2.94-16.75)	130	309	5.58(4.12 - 7.56)	-

OR= Odds ratio (95% CI), P value <0.05

The health problems both in study group and controls were summarized and the results were presented in (Fig -1) indicated that out of 436, (71.03%) industrial workers showed different types of health problems as against (31.0%) in controls. Health problems like respiratory problems, joint pains, hearing problem, eye problems and diabetes, hypertension, respiratory problems, hair loss were observed in industrial workers and controls, but the industrial workers show a high incidence of these health problems. The results further showed an increased the percentage of Hypertension(7.12% vs 2.81%), Diabetes (7.81% vs 3.28%).In controls, respiratory problems were observed in (3.28%) and it has increased to (7.58%) in the study group. Similarly, joint pains were observed in (2.81%) of controls and it has increased to (7.81%) in the study group. Hair loss problem showed (8.04%) more in steel industry workers when compared to controls (4.92%).The eye related problems showed (5.51%) more when compared to controls (2.11%).Similarly, (1.17%) of hearing problems in controls were observed which have increased to (3.67%) in workers exposed to steel dust, Body pains were observed (2.75%) in steel industry workers compared to controls (1.40%).Health problems have increased to 40% in steel industry workers as shown in(table1).

Age wise analysis of health problems observed in the workers indicated that high incidence of health problems was observed in (51 – 60) years age group followed by age group (41-50), age group(31-40), (21-30) as shown in(fig- 2).

The differences in health problems between the control and the study subjects were subjected to statistical analysis to find the significance. The increase in all the health problems in the study group was found to be significant. The OR and 95% CI to age group ≥60yrs were OR=6.97, 95% confer. Interval (2.94-16.75) compared to the controls and the least risk for health problems to the age group (21-30) yrs. were OR=4.07, 95% CI :(1.99-8.40) as shown in (table 2).

III. DISCUSSION

Epidemiological studies in industrial workers are important to understanding health problems and genetic effects in workers exposed to heavy metals in the work environment. Studies carried out all over the world established ill health effects, cytogenetic and DNA damage in the industrial workers. Thus also highly pertinent to understand these health problems in steel industrial workers.

Despite concern about the harmful effects of industrial and agricultural chemicals very little attention has been paid to generate data on health problems of men working in the steel industry. In the present study, we mainly focused on the health problems of the steel industry workers involved in various processes in the steel industry. The study revealed a high incidence of health problems such as respiratory problems, hair loss, skin related problems, blood pressure, headache, blood sugar, and joints pain in the steel industry workers when compared to the non-industrial workers. This might be due to the occupational exposure of the workers through inhalation, cutaneous contact, and ingestion of the steel dust in the work environment.

The results of this study sound an alarm about the major occupational health hazards that have not received adequate attention so far. No studies have been carried out on various health problems in steel industrial workers in south India population. However similar studies elsewhere provided evidence for the health problems and genotoxic effects in workers occupationally exposed to steel dust. Parameswarappa et al., (2015) have shown that hypertension and hearing impairment are commoner in steel industry workers continuously exposed to high levels of occupational noise. Zamanian et al., (2015) reported the effect of occupational noise exposure on blood pressure and heart rate among workers of a steel industry and observed that blood pressure of the exposed workers was increased and heart rate was decreased. Our results are in agreement with that of Roberto Cappelletti et al., (2016) who have shown a significantly increased risk of lung tumors, diabetes, rheumatoid arthritis, hypertension and cardiovascular diseases in male steel industry workers as compared to the general population.

The steel industry workers are exposed to complex mixtures of large varieties of heavy metals such as nickel, chromium, iron, manganese, cobalt, tungsten, molybdenum and vanadium and their byproducts whose combined effect maybe greater than their individual effects on health. Human exposure to heavy metals has risen dramatically in the last 50 years as a result of an exponential increase in the use of heavy metals in industrial processes and products.

Metallic dust is a heterogeneous substance with respiratory sensitizing properties. Its long term exposure may adversely affect lung functions leading to acute or chronic respiratory diseases (Nurul et al., 2016). Biswas et al., (2014) conducted a study to find out the morbidity pattern among iron and steel workers and reported that commonest morbidity in the iron and steel workers was lumbago (musculoskeletal pain), followed by occupational dermatitis. Obtulowicz et al., (2000) observed nickel, chromium, iron, and copper metals dust were the main allergic factors in steel industry workers. Azwan et al., (2006) have reported the exposure-response relationship between occupational agents and lung function impairment among steel industrial workers. Hamzah et al., (2015) and Nurul et al., (2014) showed exposure to metal dust and fumes are leading cause of respiratory problems among steel industrial workers. Most of the symptoms observed were a chronic cough, chronic phlegm, chest tightness, and shortness of breath, however wheezing among them was not observed. Exposure to cobalt, chromium, and nickel showed a dose-response relationship with a chronic cough, chest tightness, chronic phlegm and shortness of breath. Gomes et al., (2016) showed an increased risk of impaired lung function from chronic exposure to dust and fumes in iron and steel factories. Park et al., (1994) and Cruz et al., (2006) have reported occupational exposures to metal dust are known to be an important factor in the causation of respiratory symptoms and lung diseases.

Metals interfere with many cellular reactions. Hayes (1997) and Sabine Martin (2009) have reported that exposure to metals like cadmium, cobalt, nickel, and chromium compounds are carcinogenic to humans. Cadmium is the most dangerous metal ion characterized by high stability and toxicity. It is not degradable in nature and will thus, once released in to the environment, stay in circulation. Cadmium is known to bind to essential respiratory enzymes (Nies et al., 2003) causing oxidative stress and cancer (Banjerdkji et al., 2005). Cadmium induced renal dysfunction and osteopenia (Kido et al., 1990).

Eman Alissa et al. (2011) showed dysfunction the blood and cardiovascular, eliminative pathways (colon, liver, kidneys, skin), endocrine (hormonal), gastrointestinal, immune, nervous (central and peripheral), reproductive, and urinary problems. Das et al. (2008) reported nickel induced carcinogenicity, haematotoxic, immunotoxic, neurotoxic, genotoxic, reproductive toxic, pulmonary toxic, nephrotoxic and hepatotoxic in exposed industrial workers. (Chuang et al., 2015, Tawichascri et al., 2015) have indicated safety behaviors played a role in the accumulation of airborne steel dust among steel industry workers. It is evident that combinations of poor work practices and safety behaviors among workers, and the limited training and education on safety procedures, may have immensely contributed to health problems in steel industrial workers when exposed to steel dust. Majority of the health problems are due to inadequate protective measures. Hence improvements in control measures are needed to reduce the metal dust exposure and workers should be encouraged to use respiratory protection devices during their working hours. Finally providing a safe working environment and adopting safe work practices can minimize exposure to the harmful effect of metal dust. Both management and regulatory authority should take initiative to comply with occupational health regulations.

IV. CONCLUSIONS

The results clearly indicated an increase in health problems in steel industry workers. This might be due to the continues exposure of workers to steel dust that contains a mixture of heavy metals. Occupational health management, as well as safety measures, should be improved to reduce the metal dust exposure in the workplace thereby minimize or control health problems in the steel industry workers.

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CONFLICT OF INTEREST

None of the authors of this paper had any personal or financial conflicts of interest.

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