

Reproductive performance in wives of steel industrial workers

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Abstract

Background: Many factors such as exposure to physical and chemical agents, life style, smoking, and alcoholism habit may affect our reproductive health and ability to produce healthy children. We may be exposed to these factors at work, at home, or in the community, where they can cause reproductive or developmental problems such as infertility, miscarriage, birth defects, low birth weight, abnormal growth and development and childhood cancer. This study aims to investigate the reproductive outcome in spouses of the steel industry workers. Many studies have been carried out on health problems, cytogenetic damage but no studies have been carried out in spouses of workers exposed to steel dust. Hence a detailed study has been taken up to understand the hazards on reproductive system of male steel industrial workers, using reproductive performance as a parameter.

Methods: The study population consisted of 260 steel industry workers and 255 control subjects who belonged to the same age group and socio economic status for the reproductive performance. The information on reproductive history including the number of pregnancies, live births, abortions, still births, neonatal deaths, premature births, malformations etc. were analyzed. 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 for the differences in the reproductive outcome, between the two groups.

Results: A significant increase in the frequency of spontaneous abortions (3.86% vs 1.30%), premature births (3.40% vs 1.08%), neonatal deaths (2.27% vs 0.65%), malformations (1.81% vs 0.43%), still births (1.13 vs 0.21%), was observed in the spouses of the steel industrial workers compared to the control group.

Conclusion: The findings of this study indicated adverse reproductive outcome in the spouses of steel industrial workers. This might be due to the undue exposure to steel dust at work place. Appropriate precautionary measures have to be taken to prevent or minimize the exposure of the workers to steel dust.

Keywords: Spontaneous Abortion, Reproductive Dysfunction, Occupational Exposure, Birth defects.

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. Men are forced to work anywhere under the influence of economic gain, to earn and meet the financial needs of the family. Therefore male reproductive health that faces various risks during his working life should be considered as a pain factor. The emitted material coming from steel industry contains heavy metals such as nickel, chromium, iron, manganese, cobalt, tungsten, molybdenum and vanadium etc. and hence workers exposed to steel dust are at high risk for health and reproductive problems.

Human exposure to heavy metals has risen dramatically in the last 50 years in the use of heavy metals in steel industries. In this aspect many

international and national studies, related to reproductive performance have been carried out in industrial workers. Many studies have shown a decrease in semen quality which has increased the focus on male reproductive health. Studies have shown that heavy metals like lead (Pb), cadmium (Cd), and mercury (Hg) have toxic effects on reproductive outcome and are also associated with miscarriages (Gerhard, *et al.*, 1998).

Semen abnormalities correlated with the number of years of exposure to chromium Cr (VI) (Elbetieha, *et al.*; 1997). Hong lif *et al.*, (2001) observed occupational exposure to Cr (VI) reduced sperm counts and sperm motility in electroplating workers. Long exposure to some of the metals has been documented to cause disruption in the fetal developmental process and pregnancy outcome (Kumar 2011). Astrid Sigel *et al.*, (2011) showed adverse effects of metals on male fertility that include altered genetic material of sperm, altered spermatogenesis, pregnancy loss, genetic diseases in

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offspring. Nordberg *et al.*, (2005) reported adverse male reproductive functions that include size of testis, semen quality, seminal vesicles, reproductive endocrine function, impotency, and fertility. Welding fumes typically include many agents with potential reproductive toxicity, e.g. hexavalent chromium, nickel, cadmium, manganese, and carbon monoxide which have been reported to cause an increased risk of infertility and reduced semen quality among male welders. However, the studies have shown that spouses of stainless steel welders have an increased risk of spontaneous abortions (Hjollund, *et al.*, 2000). Here we report cross-sectional data concerning the reproductive performance in spouses of steel industry workers who are occupationally exposed to steel dust.

Materials and methods

260 spouses of steel industry workers and 255 spouses of normal subjects who belonged to the same age group and

socio- economic status were studied for the reproductive performance.

Subjects for the present study were selected among the workers of the steel industry situated at Patancheru, Hyderabad, India. After informed consent was obtained, information on age, years of service, socio economic status, life style, income, occupational history, tobacco and alcohol use, health conditions, etc. and details on the reproductive history including fertility, number of pregnancies, live births, abortions, still births, neonatal deaths and congenital malformations in their offspring etc were collected following the criteria set by Danforth (1977). The results were analyzed statistically using the appropriate t-test to find the significance in the differences between the two groups for the reproductive parameters studied and the differences were found to be significant.

Results

Table1 Reproductive outcome of spouses of steel industry workers

Parameter	Subjects (%)	Controls (%)	OR(95%CI)
No. Of couples	N= 260	N= 255	
Infertile couples	30(11.53)	12(4.70)	2.6(1.26-5.60)*
Fertile couples	230(88.46)	243(95.29)	0.37(0.17-0.79)
No. Of pregnancies	440	460	
Live children	408(92.72)	450(97.82)	0.28(0.12-0.60)*
Abortions	17(3.86)	6(1.30)	3.04(1.11-8.70)*
Premature birth	15(3.40)	5(1.08)	3.21(1.08-10.1)*
Neonatal death	10(2.27)	3(0.65)	3.54(0.89-16.3)*
Stillbirths	5(1.13)	1(0.21)	5.27(0.60-119)*
Malformation	8(1.81)	2(0.43)	4.24(0.83-29.0)*

OR-Odds ratio, CI-95% Conf. interval, P value <0.05 *-Significant

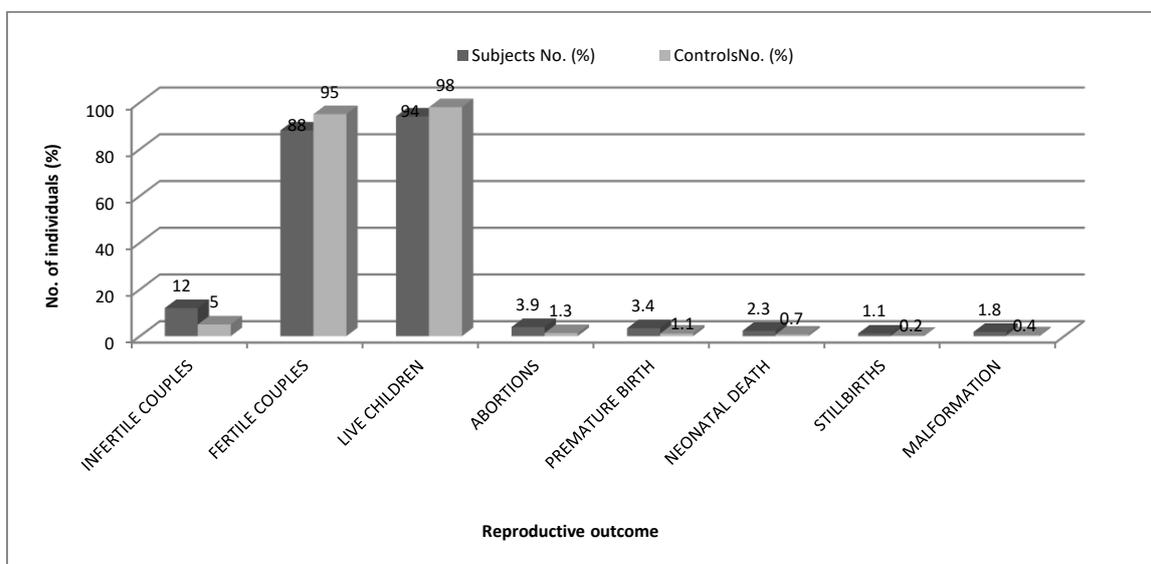


Figure 1 Reproductive outcome of spouses of steel industry workers

The results on reproductive outcome of spouses of workers of steel industry and that of spouses of control subjects not exposed occupationally to any physical, biological and chemical agents are presented in Table 1.

260 couples in the study group and 255 couples in the control group were studied for the reproductive outcome. In the study group 11.53% were found to be infertile as against 4.70% in the control group ($p<0.05$). The results

further showed a significant increase in the percentage of abortions (3.86% vs 1.30 %), premature births (3.40 % vs 1.08%), neonatal deaths (2.27% vs 0.65%), still births (1.13% vs 0.21%) and malformation (1.81% vs 0.43%) and a significant decrease in the live births (93% vs 98%).

Discussion

Despite concern about the harmful effects of industrial and agricultural chemicals very little attention has been paid to generate data on reproductive performance of steel industry workers. The study presents evidence for impaired reproductive performance in spouses of steel industry workers.

Our results showed a significant increase in the frequency of abortions, stillbirths, neonatal deaths and decrease in fertility rate and a significant decrease in fertility rate and live births suggesting adverse reproductive outcome in spouses of the male steel industry workers as a result of occupational exposure to steel dust at work place. The results of this study sound an alarm about the reproductive outcome that has not received adequate attention so far. No studies have been carried out on reproductive outcome in steel industry. However similar studies have been carried out in some industrial workers. Baranski *et al.*, (1993), have shown that exposure of welding workers to agents like lead, manganese, and other welding operations including heat and noise cause an effect on male genital system, leading to sperm abnormalities, hyperestrogenism, impotence, infertility and increased spontaneous abortion rate in their wives of the exposed workers. Our results are in agreement with that of Sreedevi *et al.*, (2000) who have shown an increased frequency of abortions and decreased infertility rate in traffic police due to exposure to- vehicular exhaust.

The steel dust contains nickel, chromium, iron, manganese, cobalt, tungsten, molybdenum and vanadium which are carcinogenic and mutagenic (Cornelia 2002). Thus the adverse effects might be due to exposure to complex mixtures of these heavy metals whose combined effect may be greater than the sum of their individual effects on reproductive health. The earlier studies carried out in the workers exposed to nickel, chromium, iron, manganese, lead showed adverse effects on both male and female reproductive systems.

Sunil Kumar (2004) showed occupational exposure to lead, nickel, iron and chromium was associated with reproductive dysfunction like abortion and reduction in fertility. Studies have shown effects on Semen quality of industrial workers occupationally exposed to chromium (Kumar *et al.*, 2005). Piotr Rzymiski *et al.*, (2015) showed an increased risk of spontaneous abortions, pre-term deliveries, still births and hypotrophy in man exposed to heavy metals. Das (2009) showed an increase in the rate of spontaneous abortions among a group of 356 women who worked in a nickel hydrometallurgy refining plant. Inhorn *et al.*, (2008) observed a decreased sperm count,

cryptorchidism, hypospadias, miscarriages, endometriosis, impaired fertility and infertility in workers occupational exposure to heavy metals. Metals not only influence male reproductive health and fertility but also cause ill effects on the developing foetus (Agrawal *et al.*, 2012). Sengupta (2012) summarized studies carried out on the effects of more than 20 metals and concluded that many metals have potential toxic effects on the male reproductive systems. Sengupta *et al.*, (2013) also showed an altered sexual behavior, altered fertility and fertility problems in workers occupationally exposure to metals. Studies carried out in animal models also showed evidence for adverse reproductive outcome in workers exposed to heavy metals. Elbetieha *et al.*, (1997) have shown that fertility was significantly reduced in males exposed to the trivalent chromium compounds in experimental animal models. Kakela *et al.*, (2008) conducted a study to determine the reproductive effects of nickel in both female and male Wistar rats in which one or both genders were exposed to nickel and they observed induced shrinkage of seminiferous tubules and decreased number of spermatogonia in the tubules. Aruldas *et al.*, (2004) reported Cr (VI) induced detrimental effects on fertility in experimental animal models. Das and Dasgupta (2009) also reported decreased sperm count, sperm motility in nickel treated rats.

Tina *et al.*, (2000) have shown a reduced quantity and quality of semen in man exposed to welding metals. Kumar (2004) reported occupational exposure associated with reproductive dysfunction in males as well as in females. The problem of infertility has increased from 8 to 15% over the past two decades in industrialized countries (Dondero *et al.*, 1991, Runnebaum *et al.*, 1997). All these studies suggest there is an increase in the environmental pollution as a result of industrialization and urbanization.

The ultimate aim and purpose of reproductive epidemiology is to promote, protect, and restore good health and reduce incidence of reproductive problems by understanding the risk factors in the steel industry workers. Many studies are based on workers exposed to a variety of metals that may be reproductive toxin. Their occupational exposure may also include such confounding exposures as heat, vibration, or noise. It is therefore difficult to attribute specific observed toxic effects in a workplace study to any single hazard, and difficult to define interactions that may increase or diminish the reproductive toxicity of a single metal. Both management and regulatory authority should take initiative to comply with occupational health regulations to control adverse reproductive health.

Conclusions

The result of study suggest adverse reproductive outcome in the spouses of steel industrial workers and this might be due to the undue exposure of male steel industrial

workers to steel dust at work place. Appropriate precautionary measures have to be taken to prevent or minimize the exposure of the workers to steel dust.

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References

- [1]. Ahmed Elbetieha, Mohammed H. Al-Hamood. Long-term exposure of male and female mice to trivalent and hexavalent chromium compounds: effect on fertility. *Toxicology* 116 (1997); 39-47.
- [2]. Anju Agrawal. Toxicity and Fate of Heavy Metals with Particular Reference to Developing Foetus. *Advances in Life Sciences* 2012; 2(2): 29-38 DOI: 10.5923/j.als.20120202.06.
- [3]. Astrid Sigel, Helmut Sigel, Roland K. O. Sigel. Metal Ions in Toxicology: Effects, Interactions, Interdependencies. *Royal Society of Chemistry* 2011; Science - 422 pages.
- [4]. Boguslaw Baranski. Effects of the Workplace on Fertility and Related Reproductive Outcomes. *Environmental Health Perspectives Supplements* 1993; 101 (Suppl. 2): 81-90.
- [5]. Bonde J. The risk of male subfecundity attributable to welding of metals: studies of semen quality, infertility, adverse pregnancy outcome, and childhood malignancy. *Int J Androl* 1993;16(Suppl 1):1-29.
- [6]. BondeJP, ErnstE, JensenTK, et al. The relation between semen quality and fertility. A population based study of 430 first pregnancy planners. *Lancet* 1998; vol. 352 (pg. 1172-1177)
- [7]. BondeJP, ErnstE. Sex hormones and semen quality in welders exposed to hexavalent chromium. *Hum Exp Toxicol* 1999; vol. 11 (pg. 259-263)
- [8]. BondeJP. Semen quality in welders exposed to radiant heat. *Br J Ind Me* 1993; vol. 50 (pg. 1055-1060)
- [9]. BostofteE, SerupJ, RebbeH. Relation between sperm count and semen volume, and pregnancies obtained during a twenty-year follow-up period. *Int J Andro* 1982; vol. 5 (pg. 267-275)
- [10]. Chashschin VP, Artunina GP, Norseth T. Congenital defects, abortion and other health effects in nickel refinery workers. *Sci Total Environ* 1994; 148 : 287-91.
- [11]. Clarkson, T. W., Nordberg, G., and Sager, P.R. (eds.), *Reproductive and Developmental Toxicity of Metals* (New York: Plenum Press, 1983).
- [12]. Cornelia. Metal passivity as mechanism of metal carcinogenesis: Chromium, nickel, iron, copper, cobalt, platinum, molybdenum. *Toxicological & Environmental Chemistry* 2007; Volume 89, - Issue 1.
- [13]. Costa, M. Molecular mechanisms of nickel carcinogenesis. *Annu. Rev. Pharmacol. Toxicol* 1991; 31: 321-337.
- [14]. D. Caserta, A. Graziano, G. Lo Monte, G. Bordi, M. Moscarini, Heavy metals and placental fetal-maternal barrier: a mini-review on the major concerns. *Eur Rev Med Pharmacol Sci* 2013 ; Aug;17;(16):2198-206.
- [15]. Danadevi.K, RoyaRozati, ReddyPP, Paramjit Grover in *Reproductive toxicology Elmsford NY. Semen quality of Indian welders occupationally exposed to nickel and chromium. reproductive toxicology* 2003; 17, 4, 451-456
- [16]. Das, K. K. and Dasgupta, S. Effect of nickel on testicular nucleic acid concentrations of rats on protein restriction. *Biol. Trace Elem Res.*, 73(2): 175-180.
- [17]. Domingo J. Metal-induced developmental toxicity in mammals: a review. *J Toxicol Environ Health* 1994;42:123-41.
- [18]. Domingo JL. Vanadium: a review of the reproductive and developmental toxicity. *Reprod Toxicol* 1996;10:175-82.
- [19]. D. Prasher, Heavy metals and noise exposure: health effects, *Noise Health* 11 (2009); 141-144.
- [20]. A Roy Chowdhury, N J Chinoy, AK Gautam, RV Roa, D J Parikh, G M Shah. Effect of lead on human sperm. *Adv contra Deliv SYAT*, 1986; 11,208-210.
- [21]. Elbetieha A, Al-Hamood MH. Long-term exposure of male and female mice to trivalent and hexavalent chromium compounds: effect on fertility. *Toxicol* 1997; 116:39-47.
- [22]. ErnstE. Testicular toxicity following short-term exposure to tri- and hexavalent chromium: an experimental study in the rat. *Toxicol Lett*, 1990; vol. 51 (pg. 269-275).
- [23]. Figa-Talamancal, TrainaME, UrbaniE. Occupational exposures to metals, solvents and pesticides: recent evidence on male reproductive effects markers, *Occup Med (Lond)* 2001; vol. 51 (pg. 174-188).
- [24]. Gerhard, S. Waibel, V. Daniel and B. Runnebaum. Impact of heavy metals on hormonal and immunologic factors in women with repeated miscarriages. *Human reproduction and Embryology* 1998; vol.4, No.3 pp.301-309.
- [25]. Hemminki, K., Niemi, M, L., and Kiskinen, K., 146 147. "Spontaneous Abortions Among Women Employed in Metal Industry in Finland, *Int. Arch. Occup. Environ. Health* 1980; 47:53-60.
- [26]. Hemminki, K., Niemi, M.L., Kyyronen, P., et al., "Spontaneous Abortion As Risk Indicator in Metal Exposure," *Reproductive and Developmental Toxicity of Metals*, T.W. Clarkson, F.N. Gunnar, and P.R. Sager (eds.) (New York: Plenum Press, 1983); pp. 369-380.
- [27]. Hjollund NH, Bonde JP, Jensen TK, Henriksen TB, Andersson AM, Kolstad HA, Ernst E, Giwercman A, Skakkebaek NE, Olsen J. Male-mediated spontaneous abortion among spouses of stainless steel welders. *Scand J Work Environ Health* 2000; Jun;26(3):187-92.
- [28]. HjollundNH, BondeJP, HansenKS. Male-mediated risk of spontaneous abortion with reference to stainless steel welding, *Scand J Work Environ Health* 1995; vol. 21 (pg. 272-276).
- [29]. HjollundNH, BondeJP, JensenTK, et al. Male-mediated spontaneous abortion among spouses of stainless steel welders, *Scand J Work Environ Health* 2000; vol. 26 (pg. 18-192)
- [30]. Hobbesland A, Kjuus H, Thelle DS. Mortality from cardiovascular diseases and sudden death in ferroalloy plants. *Scand J Work Environ Health* 1997; 23,334-41.
- [31]. Hong Lif, Qiongyu Chenf, Shien Lif, Wu Yaof, Linghong Lif, Xianglin Shu:*, Liying Wangs, Vince Castranovas, Val Vallyathan, Erik Ernst§ And Chen Chenf. Effect of Cr(VI) Exposure on Sperm Quality: Human and Animal Studies. *Ann. occup. Hyg* 2001; Vol. 45, No. 7, pp. 505-511.
- [32]. Huang YL, Tseng WC, Lin TH. (2001) In vitro effects of metal ions (Fe²⁺, Mn²⁺, Pb²⁺) on sperm motility and lipid peroxidation in human semen. *J Toxicol Environ Health* 2001; 62, 259-67
- [33]. I. Gerhard, S. Waibel, V. Daniel, B. Runnebaum, Impact of heavy metals on hormonal and immunological factors in women with repeated miscarriages, *Hum. Reprod. Update.* 4 1998; 301-309.

- [34]. J.P. Bonde, J.M. Christensen, Chromium in biological samples from low-level exposed stainless steel and mild steel welders, *Arch. Environ. Health* 46 1991; 225–229.
- [35]. J.P. Bonde, The risk of male subfecundity attributable to welding of metals: studies of semen quality, infertility, fertility, adverse pregnancy outcome and childhood malignancy, *Int. J. Androl.* 1993; 1–29.
- [36]. Jelnes JE, Knudsen L. Stainless steel welding and semen quality. *Reproduction Toxicol* 1988; vol. 2 (pg. 209-212).
- [37]. Jensen, T.K., Bonde, J.P. & Joffe, M., 'The influence of occupational exposure on male reproductive function'. *Occup Med (London)* 2006; Vol. 56, pp. 544-553.
- [38]. Kakela RA, Kakela A, Hyvarinen H. Effects of nickel chloride on reproduction of the rat and possible antagonistic role of selenium. *Comp Biochem Physiol Pharmacol Toxicol Endocrinol* 1999; 123 : 27-37.
- [39]. Kumar S, Sathwara NG, Gautam AK, et al. Semen quality of industrial workers occupationally exposed to chromium. *J Occup Health* 2005; 47:424–30.
- [40]. Llobet JM, Colomina MT, Sirvent JJ, Domingo JL, Corbella J. Reproductive toxicology of aluminium in male mice. *Fundam Appl Toxicol* 1995; 25:45–51.
- [41]. M. Michael Aruldas, S. Subramanian, P. Sekar, G. Vengatesh, Gowri Chandrahasan, P. Govindarajulu, M.A. Akbarsha; Chronic chromium exposure-induced changes in testicular histoarchitecture are associated with oxidative stress: study in a non-human primate (*Macaca radiata* Geoffroy), *Human Reproduction* 2004; Volume 20, Issue 10, 1 October Pages 2801–2813.
- [42]. Monica Nordberg, Gunnar F. Nordberg, Bruce A. Fowler, Lars Friberg. Academic Press, 28-Apr-2011; Science - 1024 pages.
- [43]. Mortensen JT. Risk for reduced sperm quality among metal workers, with special reference to welder. *Scand J Work Environ Health* 1988; vol. 14 (pg. 27-30)
- [44]. N.H.I. Hjollund, J.P.E. Bonde, T.K. Jensen, T.B. Henriksen, A.M. Andersson, H.A. Kolstad, E. Ernst, A. Giwercman, N.E. Skakkebaek, J. Olsen, Male-mediated spontaneous abortion among spouses of stainless steel welders. *Scand. J. Work Environ. Health* 2000; 187–192.
- [45]. Nawrot, P. S., Cook, R. O., and Harem, C. W., "Embryotoxicity of Broadband High Frequency Noise in the CD-1 Mouse" *J. Toxicol. Environ. Health* 1981;8:151-157.
- [46]. O.O. Ajayi, M.A. Charles-Davis, O.G. Arinola, Progesterone, selected heavy metals and micronutrients in pregnant Nigeria women with history of recurrent spontaneous abortion, *Afr. Health Sci* 12 2012; 153–159.
- [47]. Pallav Sengupta 2012. Environmental and Occupational Exposure of Metals and their role in Male Reproductive Functions. *Drug and Chemical Toxicology* September 2012; DOI: 10.3109/01480545.2012.710631
- [48]. Pallav Sengupta. Environmental and occupational exposure of metals and their role in male reproductive functions. *Drug and Chemical Toxicology* 2013; 36(3): 353–368
- [49]. Pandey R, Kumar R, Singh SP, Saxena DK, Srivastava SP. Male reproductive effect of nickel sulphate in mice. *Biometals* 1999; 12:339–46.
- [50]. Reijo Käkälä, Anne Käkälä, Heikki Hyvärinen. Effects of nickel chloride on reproduction of the rat and possible antagonistic role of selenium. *Comp Biochem Physiol C Pharmacol Toxicol Endocrinol* 1999 ; May;123(1):27-37.
- [51]. Rzymyski P1, Tomczyk K2, Rzymyski P2, Poniedziałek B1, Opala T2, Wilczak M3. Impact of heavy metals on the female reproductive system. *Ann Agric Environ Med* 2015; 22(2):259-64. doi: 10.5604/12321966.1152077.
- [52]. S. Kumar, Occupational, environmental and lifestyle factors associated with spontaneous abortion, *Reprod Sci.* 2011; 18,;915–930.
- [53]. Safia Beshir*, Khadiga Salah Ibrahim, Weam Shaheen, Eman M. Shahy. Hormonal Perturbations in Occupationally Exposed Nickel Workers. *Journal of Medical Sciences* 2016; <http://dx.doi.org/10.3889/oamjm.046> eISSN: 1857-9655.
- [54]. Sheiner EK, Sheiner E, Hammel RD, Potashnik G, Carel R. Effect of occupational exposures on male fertility: literature review. *Ind Health* 2003; vol. 41 (pg. 55-62)
- [55]. Sram RJ, Binkova B. (2000) Molecular epidemiology studies on occupational and environmental exposure to mutagens and carcinogens. *Environ Health Perspect* 1997–1999; 108(1),57-70.
- [56]. Sunderman, F.W. Jr., Shen, S.K., Mitchell, J.M., Allpass, P.R. and Damjanov, I. 1978. Embryotoxicity and fetal toxicity of nickel in rats. *Toxicol Appl. Pharmacol* 1978; 43(2): 381–390.
- [57]. Tas S, Lauwerys R, Lison D. Occupational hazards for the male reproductive system. *Crit Rev Toxicol* 1996; vol. 26 (pg. 261-307).
- [58]. Thonneau P, Bujan L, Multigner L, Mieusset R. Occupational heat exposure and male fertility: a review. *Hum Reprod* 1998; vol. 13 (pg. 2122-2125)
- [59]. Tina Kold Jensen, Jens Peter Bonde, Michael Joffe; The influence of occupational exposure on male reproductive function. *Occupational Medicine* December 2006; Volume 56, Issue 8, 1 Pages 544–553
- [60]. V. Sree Devi, M. Hema Prasad, V Durga Rao, G. Sandhya Devi and P. P. Reddy. Reproductive Outcome in the Wives of Traffic Policemen Exposed to Automobile Exhaust. *J. Hum. Ecol* 2006; 20(2): 77-82 (2006).