RESEARCH PAPER:

Occupational asthma in labourers employed at cement industries in Tadiparti Mandal of Anantapur district Andhra Pradesh, India

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SUMMARY

Investigation has been made on the occupational asthma in labourers of cement industries in Tadipatri Mandal of Anantapur district, Andhra Pradesh, India. Clinical data were obtained by conducting survey among 9258 long term exposed (8 to 11 years) labourers. The major respiratory symptoms prevalent were wheezing (17.75%), asthma (16.30%), dysponea (14.07%), and cough (productive and non productive cough) (12.63%). Asthma and dysponea were identified as major symptoms in labourers working at cranes and packing. Labourers working in kiln, raw mill and maintenance were reported with fewer symptoms than the labourers in cranes and packing. The prevalence of developing asthma (69%) was more in labourers at cranes and packing than labourers working in above said work satiations. Current smokers of cement industry were at higher risk of developing chronic bronchitis and wheeze. Chronic cough was common symptom in all the labourers and especially in laborers working at cranes and packing were at higher risk for developing productive cough and frequent attack of dysponea were more and incidence of respiratory symptoms was also higher in them after adjusting for age and smoking habit. Comparative study of blood samples between the exposed and control reveled significant variation with reference to differential leukocyte count, in particular eosinophils count, in loaders and packers, a sharp rise of eosinophils was noticed. Eosinophils in hyper responsive subjects (asthmatics) significantly increased the risk to develop on or more respiratory symptoms.

Key words : Occupational asthama, Wheezing, Dysoponea, Eosinophilis, Respiratory symptoms

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Production process in the factory involves three main work stations cranes, crusher and packing, kiln and raw mill, and maintenance of machinery. Exposure to cement dust is likely to vary in the different stages of production process. Therefore in order to understand the variation in dust exposure and the risk of developing of respiratory disorders in work place, three main work stations were selected form which the magnitude of variability in dust exposure was assessed within labourers and between labourers.

Several prevalence studies have suggested an association between occupational exposure and respiratory symptoms and asthma, but there has been a lack of incidence studies to verify this. This study examined the incidence of respiratory symptoms, asthma and to explore the respiratory morbidity in terms of symptoms in chronic exposed labourers working in cement industry for more than 11 years.

MATERIALS AND METHODS

All out patients N=9258 (attending Government Medical College Hospital in Anantapur district, Andhra Pradesh) were considered for the study during the period May 2003 to April 2008. The total strength of the labourers were categorized in to three groups according to the working areas (Table 2) which include cranes and packing, kiln and raw mill, and maintenance and administration. Labourers having respiratory problems like chest pain, dysponea, problems with nose and throat, cold, breathing problem, asthma, productive and non productive cough, and wheezing were included for the study. Subjects were considered symptomatic if they reported one or more of the following chronic respiratory symptoms cough or phlegm production on most days or nights as long as 3 consecutive months referred to as chronic cough/ chronic phlegm. A period of at least 3 week during the previous 2 years with increased cough and phlegm were considered as bronchitis, shortness of breathing when walking referred as dysponea, whistling sound in chest on most days or nights as persistent wheeze or attacks of shortness of

breath in the previous 2 years as asthma.

Most of the subjects (87%) were with initial chest X-ray. Information on respiratory symptoms, smoking status, age and sex was collected by Dutch version of British Medical Research Council standardized, pre-tested structure close ended questionnaire. Information was also colleted regarding socio-economic status and working conditions. Other details like use of abuse substance and smoking history were carefully recorded. Later clinical data were analyzed in terms of disordered functions and potential causatives. With regard to socio-economic status Kuppuswamy's Classification (Park JE, Park K. Park's 7th edition, 1979) was employed. During the investigation the response rate of labourers was nearly 92% at base line and follow up.

Blood samples were taken and eosinophils were counted in a 1:10 dilution using an improved Neaubauer chamber (Superior Germany) expressed in % mm^{-3}. Eosinophils were defined as 4-6% mm^{-3} in control subjects.

Statical analysis:

Analysis included all data collected during the survey from 2003 to 2008. Information of two successive surveys was compared to study the development of respiratory symptoms. The paired observations had a minimum interval of 2 years. The incidence of respiratory symptoms was calculated as their percentage of subjects with least symptoms at first of survey who had developed the symptoms at nearest follow-up conducted during the year 2007-08. Blood samples were statistically analyzed by employing Student's t- test. Comparison was made between t-calculated value and table value to find significant change in blood cells.

RESULTS AND DISCUSSION

At the first phase of survey, nearly 9258 labourers working at three work stations were enquired about their respiratory disorders, based on the clinical history, 1524 (16.46%) labourers were reported. Physician diagnosed on set of respiratory symptoms and at the end of the final survey 3729 (40.27%) labourers were identified as respiratory suffer as exhibiting various symptoms arisen as a result of chronic exposure to dust. In comparison of the first and final survey, there was an increase trend, nearly 23.81% for developing respiratory morbidity.

Among surveyed, 1647 labourers working at cranes and packing unit received the clinical diagnosis of asthma, according to their history, occurred during the first phase of survey in 280 (17%) were diagnosed on set of asthma and at the end of the final survey 407 (24.71%) labourers were reported. Physician diagnosed asthma and reported that their asthma was worse at work and also found with exacerbated respiratory symptoms or symptoms of asthma (Table 4). In comparison of the first and final surveys, there was an increase trend nearly 7.71% for developing asthma.

Table 1 : Percentage change of eosinophils count in exposed labourers working at surveyed work stations

Sr. No.	Work stations at which labourers were employed	Mean of control	Mean of exposed	Percentage
1.	Cranes	4.847826	6.108696	20.65
2.	Packing	4.759259	7.722222	38.37
3.	Raw mill	5.888889	8.476191	16.98
4.	Kiln	4.756757	8.72973	45.48
5	Maintenance of machinery	4.810811	9.324325	45.48
6.	Administration	4.945946	9.837838	48.41

Table 2 : Distribution of labourers in three work stations of cement industry

	Type of work station		
	Cranes and packing	Raw mill and cement kiln	Maintenance of machinery
Strength	2840	3670	2748
Percentage (%)	30.68	39.64	29.68
	Total strength: 9258		

Table 3 : Strength and percentage of labourers exibiting respiratory symptoms in three work stations

	Strength	Percentage (%)
Cranes and packing	1647	58
Raw mill and cement Kiln	1395	38
Maintenance of machinery	687	25

Most of the labourers were exposed to dust and fumes at an average of 8 hours per day for a period of 11 years. The major respiratory symptoms noticed were wheezing (17.56%), asthma (24.71%), dysponea (15.73%), and cough (productive and non productive cough) (12.87%). In all the labourers working at three work stations. Labourers employed at cranes and packing (58%) and kiln and raw materials (38%) suffered maximum due to repeated long term exposure (Table 3). The prevalence of developing asthma was more in labourers at cranes and packing 69% and kiln and raw material is 58%. Current smokers employed at kiln and

Table 4 : Description of respiratory symptoms exibited by the labourers working at cranes and packing unit after final survey

Sr. No.	Respiratory symptom	Strength	Percentage (%)
1.	Asthma	407	24.71
2.	Wheezing	289	17.56
3.	Dysponea	259	15.73
4.	Cough (Productive and non-productive)	212	12.87
5.	Breathing problems	171	10.38
6.	Problem with nose and throat	147	8.93
7.	Chest pain	119	7.23
8.	Cold	43	2.61
			Total strength:1647
			Total percentage: 58

raw materials were at higher risk of developing chronic bronchitis and wheeze but not asthma.

Chronic cough was the common symptom in all labourers employed at three work stations. Labourers working at cranes and packing, kiln and raw mill were at higher risk for developing productive cough and attacks of dysponea. (Table 4, 5). The incidence of respiratory symptoms was higher in labourers at cranes and packers, kiln and raw mill than maintenance of machinery, after adjusting for age and smoking habit (Table 6).

There was found an association between occupational exposure to air pollutants and respiratory health and similar risk estimates (Mapp and Boschetto *et al.*, 2003). Previous, mostly cross-sectional studies of the relationships between socio-economic status and asthma, and other air way disorders, have obtained

Table 5 : Description of respiratory symptoms exibited by the labourers working at raw mill and cement kiln unit after final survey

Sr. No.	Respiratory symptom	Strength	Percentage (%)
1.	Breathing problems	312	22.36
2.	Wheezing	258	18.49
3.	Dysponea	217	15.56
4.	Cough (Productive and Non-productive)	177	12.69
5.	Asthma	144	10.32
6.	Cold	120	8.60
7.	Chest pain	97	6.95
8.	Problem with nose and throat	70	5.02
			Total strength:1395
			Total percentage: 38

Table 6 : Description of respiratory symptoms exibited by the labourers engaged at maintenance of mechinary after final survey

Sr. No.	Respiratory symptom	Strength	Percentage (%)
1.	Breathing problems	144	20.96
2.	Wheezing	115	16.74
3.	Problem with nose and throat	101	14.70
4.	Cough (Productive and Non-productive)	82	11.94
5.	Chest pain	71	10.33
6.	Cold	68	10.00
7.	Asthma	57	8.30
8.	Dysponea	49	7.13
			Total percentage: 25

divergent results, possibly due to differences in the study design, definitions of socio-economic status used, the age distribution of studied samples, occupational and other kinds of exposure and geographical aspects. Generally, Nordic studies have found high prevalence of respiratory symptoms or asthma (Bakke *et al.*, 1991; Bakke *et al.*, 1995) to be generally associated with higher degree of exposure especially in labourers employed at cranes and packing. Present results are quite consistent with those of two previous Cohort studies; one of Nordic adults (Eagan *et al.*, 2004) and the other US adolescents (Beckette *et al.*, 2001)

Particulate air pollution has direct implication on respiratory health. Elevated levels of particulate pollution had been associated with increased respiratory morbidity as measured by hospitalization for respiratory diseases (Sunyer *et al.*, 1991), and increased symptoms of pulmonary diseases (Schwartz *et al.*, 1991). Higher concentration of dust will be at cranes (38.6mg/$m^{3)}$, packing 21.3/$m^{3)}$, and crusher(13.5mg/ m^3) and lesser in cement mill (3.26mg/m^3), kiln (2.9 mg/m^3), raw mill (1.8 mg/m^3), maintenance (1.2 mg/m^3), and administration (0.3 mg/m^3). Long term exposure to particulate pollution and gaseous fumes had been associated with increased risk of developing respiratory morbidity (Archer, 1990).

The major respiratory symptoms noticed were wheezing (17.56%), asthma (24.71%), dysponea (15.73 %), and cough (productive and non productive cough) (12.87 %) (Table 4), suggesting an increased risk of developing respiratory symptoms and asthma in the surveyed population when exposed to dust or fumes.

Another subsequent source of particulate matter pollution in the study area includes quarrying and mining, which are inherently dusty and high in quartz and mineral

dust. Both mineral dust and quartz exposures were associated with higher risk of cough symptoms while only of mineral dust with a higher risk of dysponea and asthma. The prevalence for developing asthma is more in labourers employed at cranes and packing (38.6 mg/m^3 approximate dust concentration) and kiln and raw mill (3.26 mg/m^3 approximate dust concentration) as they are much more exposed to dust or fumes prevailing in the work stations of the industry than labourers at maintenance of machinery. Majority of the labourers were smokers (97.14%). We found that cigarette smoking clearly is associated with asthma, and asthma like symptoms. It is evident from present research, occupational exposure to cement dust and smoking habit may enhance the risk for developing asthma up to 47%. Current smokers employed at kiln and raw mill were also at higher risk for developing chronic bronchitis and wheeze but not of asthma. The smoking behaviour was assessed by self-report during a confidential interview each year of the study. Although some labourers probably did not provide accurate information, the information was collected prospectively and any error in classification was likely to be independent of subsequent asthma status. Therefore, the use of self reported smoking histories may have resulted in non differential misclassification of smoking status that would produce an underestimate of the association of smoking with new-on set of asthma.

We did not investigate the mechanisms that mediate the associations of regular smoking with new-onset asthma**;** however, the association of new-onset asthma with smoking has strong biological plausibility. Cigarette smoke is a complex mixture that produces a spectrum of pathophysiologic effects in the lung that may mediate the relationship of smoking and new-onset asthma (Tager 1998). Active smoking has complex acute and chronic effects on pulmonary immune function and proinflammatory responses (Van der *et al.,* 2004, 2005). The effects of smoking may also be mediated by changes in airway function, as smoking causes increased bronchial hyperresponsiveness (BHR) without asthma (Chinn *et al.,* 2005). The combined effect of increased BHR and the proinflammatory milieu in smokers may set the stage for the onset of asthma**.** Smoking may act through nonallergic pathways and have larger effects in those with low lung function.

Viegi and coworkers (1991) reported that the effect of occupational exposure on several respiratory disorders including wheezing and asthma were higher among smokers than among nonsmokers. Role of smoking in the occurrences of asthma and chronic wheeze has been controversial because of problems of diagnostic bias. In our data, labourers working at cranes and packing unit were more likely to report a doctor's diagnosis of asthma than labourers working at maintenance of machinery and administration (1.2 mg/m^3 approximate dust concentration) and maintenance and later tended to have respiratory symptoms without specific doctor's diagnosis. Therefore, exposure is the most important determinant of occupational asthma (Viegi *et al.,* 1991). The higher degree of exposure, higher will be the prevalence of developing asthma in them (Chan-Yeung *et al.,* 1995).

In sensitized labourers, the main factor that influences the on set of symptoms was the degree of exposure (Venables *et al.,* 1990). However, there is a lack of information regarding the risk of sensitization at low concentration and existence of no-effect level (Nieuwenhuijsen, 2003). Some studies have shown that intensity of exposure is an important determinant of sensitization and asthma caused by respiratory antigens. A review of exposure-response relations for occupational inhaled allergens (Heederik *et al.,* 2001) suggests that there is enough data for assessment of exposure-response relations for several occupational agents (Baur *et al.,* 2003). Concentration of an occupational allergen that sensitizes is quite different from one that provokes symptoms in workers already sensitized (Baur, 2003). Finding of concentration of an occupational agent below which sensitization is uncommon is relevant for prevention. Thus, the minimum concentration that induces sensitization is at least one order, and probably two orders, of magnitude greater than the minimum concentration that elicits symptoms. So, the permissible exposure limit (Swanson, 2003) for eliminating sensitization is easier for industry to achieve than the permissible exposure limit for eliminating asthamatic symptoms**.**

The mechanism of asthma induced by irritants is unknown (Malo, 1998). Many reports indicate that unintentional high-level respiratory irritant exposures can induce the new onset of asthma (Tarlo, 2000). Occupational asthma occurs after inhalation of high levels of irritants, the main target for the initial injury could be the bronchial epithelium, which becomes denuded and loses its protective properties. Consequences of the damage in the bronchial epithelium are the loss of relaxing factors derived from epithelium, the exposure of nerve endings leading to neurogenic inflammation, and the release of inflammatory mediators and cytokines after the nonspecific activation of most cells (Gautrin, 1994). A further consequence of the disruption of the epithelium accompanied by the secretion of growth factors for epithelial cells, smooth muscle, and fibroblasts, together with matrix degradation, is a tissue-regenerative and

remodeling response (Gautrin, 1994). Pathologic changes consist of marked fibrosis of the bronchial wall and denudation of the mucosa with fibrinohemorrhagic exudates in the submucosa (Lemiere, 1997).

Sex also plays an important role in the distribution of occupational lung diseases, because there are sex differences in specific jobs, and therefore, differences in exposure to agents causing these diseases (Occupational Safety and Health Administration 29 CFR 1910.1025, Revised March, 1983). In addition, one study reported that the risk of occupational asthma was higher for men (Wai *et al*., 2003) especially in cranes, crusher and packing sections of cement industry than women.

In hyper responsive subjects especially in asthmatics, there was rise in eosinophils accompanied by wheeze or dysponea whereas in labourers working at raw mill and kiln who continued to smoke during the follow up had higher percentage of eosinophils and also had higher risk to develop chronic cough, chronic phlegm, dysponea, wheezing and attacks of bronchitis and doctor diagnosed on set of asthma when compared with never smokers (Table 1). Dysponea and wheeze appear to occur especially in subjects with both asthma and eosinophilia. Our studies showed an increased risk to develop wheeze and dysponea only when eosinophilia and asthma are present. Exact mechanism how eosinophils inflammation triggers the development of asthma is not clear, however based on the findings of other investigators, it is evident that labourers with severe asthma with persistent eosin eosinophils at any age have increased levels of TGF-ß (specifically, TGF-ß2) in tissue and the 15-lipoxygenase enzyme and its product, 15-hydroxyeicosatetraenoic acid (Wenzel *et al.,* 1999, Balzar *et al.,* 2005, Chu *et al*., 2000, Chu *et al.,* 2002). Structural changes, such as a thicker sub epithelial basement membrane (SBM), also appear to be associated with persistence of eosinophilic inflammation without regard to age at onset (Miranda *et al.,* 2004, Wenzel *et al.,* 1999).

Although eosinophils have been associated with Th2 immune processes, whether Th2 inflammation drives lung eosinophilia in severe asthma is not clear. IL-4 or IL-13 appears to be elevated in both atopic and nonatopic forms of mild asthma (Humbert *et al.,* 1997). However, neither IL-4 nor IL-13 has been definitively shown to increase in relation to disease severity or eosinophilic disease. A recent analysis of bronchoalveolar lavage cells or tissue-derived IL-4 or IL-13 mRNA and protein demonstrated lower levels in labourers with severe (steroid-treated) asthma than in control subjects with milder asthma**,** independent of age at onset or eosinophils (Wenzel *et al.,* 2004). Indeed, although "allergic" disease is more common in early-onset severe asthma, this group is less likely to have persistent tissue eosinophilia than severe asthma with disease onset later in life (*i.e.,* where there is less evidence for atopy/allergy).

Chronic cough was the most common symptom in both sexes exposed to dust and among men there was a higher risk for developing productive cough and attacks of dysponea. Among labourers employed at cement industry there was higher risk for developing wheeze in those exposed to dust compared with unexposed. A dutch longitudinal community study (El-Zein *et al.,* 2003) observed a higher incidence of chronic non-specific lung diseases in those occupationally exposed.

In respiratory diseased labourers, dysponea was commonly associated condition in which respiratory drives are increased or respiratory system is excessively loaded. In affected labourers, it is characterized by perception of "air hunger" or increased effort of breathing. It was identified in labourers with airflow obstruction like bronchial asthma; chronic pulmonary diseases and dysponea was commonly associated. The impact of pulmonary hazards is also influenced by air pollution in general; age, smoking history, nutritional status, and other less well understood factors such as genetics and stress. Many work processes generate several contaminants at the same time. The health consequence of these hazards can simply be additive or, worse, they can be synergistic.

In conclusion, this study shows that labourers due to repeated, long-term occupational airborne exposure to irritants prevailing at cranes and packing unit of cement industry can increases the risk for developing respiratory symptoms and asthma. This effect is independent of sex, age and educational level. Smoking and occupational dust exposure act synergistically and can increase both severity of an occupational lung diseases and risk of developing respiratory symptoms.

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