

ORIGINAL ARTICLE

PREVALENCE OF RESPIRATORY SYMPTOMS AMONG EMPLOYEES AND RESIDENTS IN THE VICINITY OF A FERTILIZER FACTORY

Shaheen MZ, Sardar K, Ayyaz S, Murtaza HG, Nadeem M, Iftikhar U.

ABSTRACT

INTRODUCTION:

Approximately 10% of all adult onset asthma cases are related to occupation. It is estimated that 5% of subjects exposed to high molecular weight agents and up to 10% of subjects exposed to low molecular weight agents develop asthma. In addition, repeated exposure is found to be associated with the development of persistent asthma.

A fertilizer factory is a major chemical unit known to emit various gases which have the potential to cause occupational asthma. While preventive measures are not so optimum in most of the units in Pakistan, it was suggested that exposed workforce of a fertilizer factory could have higher asthma prevalence.

AIM:

To find out whether there is a higher prevalence of respiratory symptoms in the working and/or nearby residential population exposed to various gases and chemicals of the fertilizer factory which is located at the northern edge of Multan city.

STUDY DESIGN:

This is a cross sectional questionnaire based survey carried out in the employees and residents of the fertilizer factory located at the northern edge of Multan city. Questionnaire contained various asthma symptoms and was derived from ISAAC study questionnaire.

RESULTS:

Questionnaire on respiratory symptoms was circulated among 550 persons working and/or living in the factory. Four hundred and eighty nine (88.9%) people returned the questionnaire. Sixty six percent were males. Mean age was 38.02 ± 12.33 years. Mean duration of job/residence in the fertilizer company was 17.25 ± 10.97 years. The most prevalent symptom was allergic rhinitis/sneezing, in 54.80% (268/489) followed by breathlessness experienced by 51.73% (253/489). Other common symptoms included frequent dry cough in 33.53%, wheezing 17.79% and nocturnal shortness of breath/cough in 16.35% of the study population. Around 38.24% (187/489) cases were already known to have allergy/asthma, while 37.01% (181/489) cases had a doctor's advice or prescription for allergy/asthma. All these symptoms had significantly higher prevalence among those workers who lived within the residential compound of the factory as compared to those living outside the factory. In former, the most prevalent symptom was shortness of breath experienced by 162/261 (62.06%) persons as compared to 91/228 (39.91%) in those living outside the factory.

CONCLUSION:

This study has provided evidence of significantly higher prevalence of asthma/rhinitis related symptoms among workers as well as non workers living in the residential compound of the fertilizer factory. It indicates that measures should be taken to identify the causative agents, reduce the exposure and to relocate people who have developed asthma. Stringent health safety measures should be adopted at the work site and appropriate measures taken to control the emission and environmental pollutants emitted by the fertilizer plants.

Department of Pulmonology, Nishtar Medical College, Multan, Pakistan.

INTRODUCTION:

Several cross-sectional studies of populations at high risk of developing OA demonstrate that approximately 5 percent of subjects exposed to high-molecular-weight (proteinaceous) substances and 5 to 10 percent of subjects exposed to low-molecular-weight (chemical) agents develop OA (1,2). The prevalence of worsening asthma symptoms at work was approximately 10 percent in a meta-analysis of 43 risk estimates from 19 different industrialized countries. It suggested that 10 percent of all adult-onset asthma cases are presumed to be occupationally related (3).

Industries are linked with storage, physical contact and exposure to potentially toxic products and by-products of chemical reactions. They also excrete toxic wastes and emit various noxious gases at high concentrations. If these chemicals and their wastes are not treated in a proper way, they can become a serious health concern to the employees as well as to the people living in the vicinity. The workplace environment and composition of air within the working environment varies according to the nature of the industry, and a worker's respiratory health depends on the nature of such environment. Repeated exposures to irritant gases and chemicals increase the risk of wheezing and persistent asthma (4, 5).

Identifying environmental and specific occupational causes of asthma can significantly alter the clinical outcome. Evaluating a patient's workplace or industry may reveal the causative agents and other affected workers. It may also provide motivation to eliminate hazardous substances from the workplace or devise ways to minimize their exposure and promote primary prevention of occupational asthma for the work force.

There are a lot of industries in and around Multan which includes a major fertilizer factory situated at the northern edge of the city. Most of these industries are poorly regulated in terms of waste emissions and environmental pollution. This fertilizer factory is a major chemical unit where almost 2500 employees work at various plant sites or offices and many of them live in the residential compound with their families. The facility consists of three important plants namely; urea, calcium ammonium nitrate (CAN) and Nitro-phosphate (NP). In the urea plant carbon dioxide and ammonia are used to produce around 300 metric tons of urea per day and this plant emits fine urea dust in the range of 90-240 mg/m³ from urea pilling tower. CAN plant combines Calcium Nitrate, Nitric Acid and Ammonia in the reactors to produce 1500 metric ton of Calcium Ammonium Nitrate per day. During this process, it emits around 300-800mg/m³ of fine dust from CAN prilling tower. Nitro-phosphate plant has 1015 metric ton production per day by combining rock phosphorus and ammonia with nitric acid and ammonium nitrate while emitting NO, NH₃ and 30-40 mg/m³ of fine NP dust.

It is likely that people working within the manufacturing area, in the adjacent offices or the families living in the adjacent residential compounds are exposed to chemicals and gases. Such exposure may or may not be responsible for causing various respiratory symptoms or even asthma. There is no scientific data available regarding what percentage of exposed population suffers from respiratory symptoms. This makes the basis of our study which was designed to find out whether there is a higher prevalence of respiratory symptoms in such population or not. We also wanted to see whether there is difference in prevalence of such symptoms among people working on plant sites, in the offices and in the family members living in the residential compounds in the vicinity of the factory. According to AIRIP study, prevalence of asthma related symptoms in general population in Multan city is 7 percent (6). We have compared this data with our study.

AIM OF THE STUDY:

To find out whether there is a higher prevalence of respiratory symptoms in a population working and/or living in the vicinity of the fertilizer company compared to the general population. We also wanted to see whether there is difference in prevalence of such symptoms among people working on plant sites, in the offices and in the family members living in the residential compound in the vicinity of the factory.

MATERIALS AND METHODS:**STUDY DESIGN:**

A cross-sectional survey was carried out in residents and employees of the Fertilizer Company located on Khanewal Road Multan at the edge of Multan city.

QUESTIONNAIRE:

All individuals of age 10 yrs were invited to take part in the study. A questionnaire on respiratory symptoms was circulated among 550 persons working in the factory. 489 (88.9%) people returned the questionnaire while 61 (11.09%) people did not report back.

Symptoms in the questionnaire were taken from ISAAC study questionnaire (7). They were translated into Urdu to overcome the language barrier and then translated back into English to compare the primary nature of the question (Table 1). There were also questions on tobacco smoking and the department of their job. Current smokers were defined as those who were smoking within a month from the study, nonsmokers who never smoked and the remainders were ex-smokers.

STATISTICAL ANALYSIS:

All the results were analyzed by using unpaired two tailed chi-square test using SPSS v.16 package.

Table 1: QUESTIONNAIRE

Question Labeling	Description
Known asthma or allergy problem	"Do you already have asthma or allergy"
H/O Asthma medication usage	"Have you ever been prescribed asthma/allergy medication (including inhalers, aerosols or tablets)?"
Dry cough	"Do you frequently experience dry cough?"
Difficulty breathing	"Have u ever experienced difficulty in breathing"
Wheeze	"Have you ever experienced wheezing or whistling in your chest?"
Nocturnal shortness of breath or cough	"Have you been woken by an attack of shortness of breath or of coughing?"
Allergic rhinitis	"Do you frequently experience sneezing, rhinitis or rhinorrhea?"
Functional limitation due to asthma related symptoms	"Does shortness of breath/cough/rhinitis affect your daily activities and how much they affect your life"

RESULTS:

A questionnaire on respiratory symptoms was circulated among 550 persons working in the factory. 489 (88.9%) people returned the questionnaire while 61 (11.09%) people did not report back. Mean age of the population under study was 38.02 ± 12.33 . The range of age in our study was from 10 to 80 years. Mean duration of job/residence in the fertilizer company was 17.25 ± 10.97 years. Frequencies of various questions in our study population ($n = 489$) in total are shown in table 2.

There were 165 (33.7%) cases which never experienced any asthma related symptom. Majority of these persons 116/165 (70.3%) were found to have a residence outside the boundaries of the factory.

The comparison of frequencies of these questions among residents living in the vicinity and those living outside the boundaries of the fertilizer factory showed that all the symptoms had significantly higher prevalence in those who lived within the residential compound of the factory as compared to those living outside the factory (table 3). The most prevalent symptom experienced was shortness of breath which was experienced by as many as 162/261 (62.06%) persons living in the vicinity of the factory whereas it was reported by only 91/228 (39.91%) of those living outside the factory.

Table 2: PREVALENCE OF VARIOUS RESPIRATORY SYMPTOMS REPORTED BY THE STUDY POPULATION

Symptoms	No. of persons with positive symptom	Percentage of persons with positive symptom
Q.1 known asthma/allergy problem	187/489	38.24%
Q.2 asthma medication usage	181/489	37.01%
Q.3 dry cough	164/489	33.53%
Q.4 difficulty breathing	253/489	51.73%
Q.5 wheeze	87/489	17.79%
Q.6 nocturnal cough /SOB	80/489	16.35%
Q.7 allergic rhinitis	268/489	54.80%
Q.8 functional limitation due to asthma symptoms	125/489	25.50%

Table 3: COMPARISON OF FREQUENCIES OF VARIOUS SYMPTOMS BETWEEN THOSE LIVING IN THE VICINITY OF THE FACTORY AND THOSE LIVING OUTSIDE THE FACTORY AREA

Symptoms	Residence in the vicinity	Residence outside the factory area	p-value
Q.1 known asthma/ allergy problem	124/261 (47.50%)	63/228 (27.63%)	<0.0001
Q.2 asthma medication usage	130/261 (49.8%)	51/228 (22.36%)	<0.0001
Q.3 dry cough	112/261 (42.91%)	52/228 (22.80%)	<0.0001
Q.4 difficulty breathing	162/261 (62.06%)	91/228 (39.91%)	<0.0001
Q.5 wheeze	56/261 (21.45%)	31/228 (13.5%)	<0.025
Q.6 nocturnal cough/ SOB	58/261 (22.22%)	22/228 (9.6%)	<0.0001
Q.7 allergic rhinitis	189/261 (72.4%)	79/228 (34.64%)	<0.0001
Q.8 physical limitation due to symptoms	92/261 (35.24%)	33/131 (25.91%)	<0.0001

When the frequency of these questions was compared between plant site and non-plant site (office) workers it was found that the most prevalent symptom reported was dyspnea, experienced by 31/168 persons (18.45%) and 57/146 (39.04%) among plant workers and non plant workers respectively. All the questions had a higher reported frequency among non plant workers.

Table 4: FREQUENCIES OF VARIOUS SYMPTOMS IN PLANT AND NON PLANT SITE WORKERS

Question	Plant site workers	Office job	p-value
Q.1 known asthma/ allergy problem	15/168 (8.9%)	54/146 (36.98%)	<0.0001
Q.2 asthma medication usage	20/168 (11.9%)	52/146 (35.61%)	<0.0001
Q.3 dry cough	18/168 (10.7%)	49/146 (33.56%)	<0.0001
Q.4 difficulty breathing	31/168 (18.45%)	57/146 (39.04%)	<0.0001
Q.5 wheeze	13/168 (7.73%)	35/146 (23.97%)	<0.0001
Q.6 nocturnal cough/ SOB	14/168 (8.34%)	37/146 (25.34%)	<0.0001
Q.7 allergic rhinitis	35/168 (20.83%)	71/146 (48.63%)	<0.0001
Q.8 physical limitation due to symptoms	49/168 (29.17%)	77/146 (52.73%)	<0.0001

Prevalence of reported respiratory symptoms was also compared among workers at five different plants of the factory (table 5). The only statistically significant finding was of asthma medication usage in Nitric acid plant workers. Other, non-significant findings, included dry cough and wheeze commonest in NP plant workers, breathlessness in Urea plant workers, allergic rhinitis and activity limitation (due to symptoms) in Nitric oxide workers; nocturnal cough and/or breathlessness was interestingly found only in one worker of CAN plant.

This very high prevalence points towards improperly planned environmental safety measures and uncontrolled working conditions. This also indicates poor control of environment protection agency which regulates working of such chemical plants. The workers and residents who are exposed to such hazardous chemicals need proper protection from these chemicals and stringent measures to minimize the effects of various toxic gases emitted from such a facility. They also need regular health check-ups including spirometry and prompt treatment for any symptoms suggestive of asthma.

Table 5: COMPARISON OF FREQUENCIES OF VARIOUS RESPIRATORY SYMPTOMS AMONG WORKERS IN DIFFERENT PLANTS OF THE FERTILIZER FACTORY

Question(n=169)	Ammonia	Urea	CAN	NP	Nitric Acid	p- value
Q.1 known asthma/ allergy problem	5/36 (13.8%)	2/21 (9.52%)	3/80 (3.75%)	3/16 (18.75%)	2/16 (12.5%)	<0.28
Q.2 asthma medication usage	4/36 (11.11%)	3/21 (14.29%)	2/80 (2.5%)	4/16 (25%)	7/16 (43.75%)	<0.0001
Q.3 dry cough	4/36 (11.11%)	3/21 (14.28%)	7/80 (8.75%)	3/16 (18.75%)	2/16 (12.5%)	<0.80
Q.4 difficulty breathing	7/36 (19.45%)	5/21 (23.80%)	14/80 (17.5%)	3/16 (18.75%)	2/16 (12.5%)	<0.93
Q.5 wheeze	3/36 (8.3%)	0/21	8/80 (10.0%)	3/16 (18.75%)	0/16	<0.20
Q.6 nocturnal cough / SOB	0/36	0/21	1/80 (1.25%)	0/16	0/16	<0.75
Q.7 allergic rhinitis	7/36 (19.45%)	4/21 (19.04%)	13/80 (16.25%)	5/16 (31.25%)	7/16 (43.75%)	<0.13
Q.8 physical limitation due to symptoms	9/36 (25%)	5/21 (23.8%)	20/80 (25%)	5/16 (31.25%)	9/16 (56.25%)	<0.29

DISCUSSION:

Chemical industries have been documented to produce more respiratory symptoms in their employees. In a study conducted in 35 workers of a phosphoric acid producing plant, high prevalence of chronic bronchitis (45.7%), obstructive spirometric impairment (37.1%), and decreased values of DLCO (31.4%) were detected (8).

Chemical fertilizer industries use natural gas to produce ammonia, which is then used directly as a fertilizer or used to produce urea and ammonium nitrate fertilizers. Nitrogen fertilizer factories discharge ammonia and nitric acid into the air. They also release carbon monoxide, a greenhouse gas with consistency of fine particulate matter that can clog capillaries in the lungs and cause respiratory infections. The gases that cause acid rain also form fine sulfate and nitrate particles that increase the risk of heart and lung disorders, including asthma and bronchitis. Personal exposures to ammonia and acute respiratory effects were determined in workers at a urea fertilizer factory in Bangladesh. (9) Urea plant workers had higher prevalence of acute respiratory symptoms than did workers in the ammonia plant. The symptoms with highest prevalence in the urea plant were chest tightness (33%) and cough (28%). Ammonium nitrate is an important fertilizer component, made by mixing ammonia and nitric acid. It is highly corrosive, strongly reactive, a powerful oxidizer and a poison (10). In phosphate fertilizer industries when the raw phosphate ore is processed into water-soluble phosphate (via the addition of sulfuric acid), the fluoride content of the ore is vaporized into the air, forming highly toxic gaseous compounds such as hydrogen fluoride and silicon tetra fluoride (11).

Frequency of respiratory symptoms had been studied in two urea fertilizer producing factories in Saudi Arabia. (12) The exposed subjects in factory A had significantly higher relative risks (RR) for all respiratory symptoms; the same was true for haemoptysis (RR: 4.1, 95% confidence interval: 1.63-10.28). Bronchial asthma, chronic bronchitis, and a combined diagnosis were significantly higher among those exposed to high cumulative ammonia levels. In the logistic regression analysis ammonia concentration was significantly related to cough, phlegm, shortness of breath with wheezing and bronchial asthma.

AIRIP study has shown prevalence of asthma related symptoms in urban population of Pakistan which is 7 percent (9). Data from Multan city has shown the prevalence of asthma related symptoms at 7.1 percent in general population. Comparing this with our study the prevalence of asthma / rhinitis related symptoms are much higher. This may indicate clustering of these problems among the workers / residents of this fertilizer factory as well as their exposure to higher concentrations of noxious substances used at the workplace or emitted into the atmosphere.

In the current study we also tried to find out the prevalence of asthma in a population which was exposed to higher concentrations of various noxious gases and toxic wastes, either directly as in the workers at various plant sites, or indirectly by the families of the employees of the fertilizer factory. A total of 268 persons (54.80%) of the study population reported allergic problem in the form of either allergic rhinitis or sneezing. Breathlessness was experienced by 51.73%. Thirty seven percent of the study population had a doctor's diagnosis and treatment for asthma which is again higher than the general population. When the effect of residence on the frequency of various respiratory symptoms was analyzed, it was found that all the reported symptoms had a significantly higher prevalence among those who were residing in the residential compound of the factory as compared to those who had their private residence somewhere outside the boundaries of the factory.

There were 165 (33.7%) cases who never experienced any asthma related symptoms and majority of these persons 116/165 (70.3%) were found to have a residence outside the boundaries of the factory. Symptom of rhinitis was experienced by 72.4% of those who were living within the vicinity of the factory while only 34.64% of outside residents experienced this symptom. Shortness of breath was the second most common symptom experienced by 62.06% of those living inside the factory. These figures point towards the possible association of prolonged exposure to higher concentration of various toxic gases inside the boundaries of the factory with the higher prevalence of asthma related symptoms in the population living in there. These toxic gases contain fine particulate matter which may settle down in the nearby environment of the factory and when inhaled by those who live in such areas produce respiratory problems. Confirmation of this explanation needs sampling and chemical analysis of the air in the surroundings of the factory which was beyond the scope of our study.

Comparison of the respiratory symptoms among the employees according to their nature of job was also done. It was anticipated that those who were working in different plants and were directly exposed to various chemicals by direct handling and close contact were more likely to develop respiratory problems as compared to those who were having a non-plant site job such as in an office. However, our results showed higher percentage of all respiratory symptoms in those who had a job nature not directly related with plant site. This might be due to the lower socio-economic class of the workers at the plant site, with different attitude towards milder asthma related symptoms. Alternatively, there might be a possible role of desensitization due to repeated exposures.

To find out which plant was most strongly associated with development of respiratory problems it came out that workers of nitric acid plant had the highest percentage of symptoms, 43.75% of the workers of nitric acid plant had allergic rhinitis and a similar percentage has sorted a doctor's advice for their respiratory problem. Nitro-phosphate plant was associated with high percentage of almost all of the symptoms asked in the questionnaire. Moreover, it is not clear exactly which substances are responsible for these problems because it was not possible to sample and analyze the concentration of various substances in the atmospheric air of the working environment and emitted gases. However, all the main agents used or excreted by such a fertilizer plant such as ammonia, nitric acid, phosphate compounds, sulfur dioxide and carbon monoxide have already been documented to be associated with short or long term respiratory problems (9,10,11,12).

There was a lot of limitation to our study such as spirometric measurements were not done and the concentrations of various gases in the atmosphere of the fertilizer factory were not sampled and analyzed to demonstrate their association with a higher percentage of asthma / rhinitis like symptoms in the study population. Our study was designed to establish whether a population exposed to various chemicals in the fertilizer factory had a higher prevalence of respiratory symptoms or not. This study has clearly shown a significantly higher prevalence of these symptoms in the exposed population. The data indicates that urgent measures should be taken to identify the causative agents, reduce the exposure and to relocate people who have developed occupational asthma. Stringent health safety measures should be adopted at the work site and appropriate measures taken to control the emission and environmental pollutants emitted by the fertilizer plants in order to limit respiratory health related problems caused by such chemicals.

Data from this survey shows a great need to protect population from such facility which is almost lying in the city and there is serious need to take measures to prevent emission of such gases into the environment. In principal such a large chemical unit should not be in such close proximity to residential area and although we studied only one such factory but similar suggestions should be applied to any industry close to the residential area and not being monitored properly.

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