CHAPTER 2

REVIEW OF LITERATURE

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2.1 History of byssinosis:

For over two hundred years, textile workers have been known to suffer from a chronic respiratory disease by inhalation of cotton dust. Occupational illness due to exposure to textile dusts was described by Ramassini* in 1705, as those who hackle in the flax and hemp to prepare it for being spun and wove, afford frequent instances of the unwholesomeness of their trade, for there flies out of this matter a foul mischievous powder, that entering the lungs by the mouth and throat, cause continual cough and gradually makes way for asthma. So at the long run if they find their affliction growing upon them, they must look out for another trade for 'tis a sordid profit that's accompanied with the destruction of health'.

Health impairment among cotton mill workers of Lancashire, England was described in 1818. Kay, describing it as 'spinners pthisis' in 1831 pointed out its relationship to dust and described particularly high frequency of illness in card room workers and reported that 'methods of ventilation and of covering the machines have considerably diminished the evil'.

In an official report presented to parliament in 1860, Greenhow described the illness we know as byssinosis but credit for coining the term 'byssinosis' belong to Adrien proust. The word byssinosis is derived from the

*Quoted by Harris et al (1972).
### Table 1
Distribution of byssinosis over the world

<table>
<thead>
<tr>
<th>Country</th>
<th>Raw material</th>
<th>Industry</th>
<th>Incidences</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>England</td>
<td>Cotton</td>
<td>Carding &amp; Blowing</td>
<td>60%</td>
<td>Schilling et al, 1955</td>
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<tr>
<td></td>
<td></td>
<td>Waste</td>
<td>30%</td>
<td>Dingwall, Fordyce et al, 1966</td>
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<td></td>
<td></td>
<td>Winding</td>
<td>17%</td>
<td>Makky et al, 1967</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ring - Spinning</td>
<td>1.5%</td>
<td>Lammers et al, 1964</td>
</tr>
<tr>
<td>Scotland</td>
<td>Flax</td>
<td>All workers</td>
<td>30%</td>
<td>Mair et al, 1960</td>
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<tr>
<td></td>
<td>Jute</td>
<td></td>
<td>Nil</td>
<td></td>
</tr>
<tr>
<td>North Ireland</td>
<td>Flax</td>
<td>Preparers</td>
<td>43%</td>
<td>Elwood et al, 1965</td>
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<tr>
<td></td>
<td></td>
<td>Other workers</td>
<td>35%</td>
<td></td>
</tr>
<tr>
<td>Egypt</td>
<td>Cotton</td>
<td>Pressing</td>
<td>53%</td>
<td>Batawi, 1962</td>
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<tr>
<td></td>
<td></td>
<td>Ginning</td>
<td>36%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Carding</td>
<td>27%</td>
<td></td>
</tr>
<tr>
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<td>Flax</td>
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<td>Batawi et al, 1964</td>
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<td>Card Room</td>
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<td>Vigliani, 1962</td>
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<td>France</td>
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<td>Merchant and Weiner, 1962</td>
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<tr>
<td></td>
<td>Flax</td>
<td>Card Room</td>
<td>67%</td>
<td>Bouhuys et al, 1961</td>
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<td>Netherlands</td>
<td>Cotton</td>
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<td>Lammers et al, 1964</td>
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<td>Tupens, 1961</td>
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<td>Raw material</td>
<td>Industry</td>
<td>Incidence</td>
<td>References</td>
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<td>---------------------</td>
</tr>
<tr>
<td>Yugoslavia</td>
<td>Soft-Hemp</td>
<td>All</td>
<td>39%</td>
<td>Zuskin et al, 1966</td>
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<td>Spain</td>
<td>Hemp</td>
<td>All</td>
<td>77%</td>
<td>Bouhuys et al, 1967</td>
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<td>West Germany</td>
<td>Cotton</td>
<td>Cleaning</td>
<td>11.4%</td>
<td>Antweiler et al, 1967</td>
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*Recent Advances in Clinical Pathology, edited by S.C. Dyke (1968).*
Greek word 'byssus'. For years the word 'byssus' meant a fine, soft, white fibre and probably originally referred to flax.

In 1871 Hirt in discussing the disease caused by inhalation of cotton dust, disliked Vancoetsen's term 'pneumonie cottonneuse', and used 'pneumoconiosis lyssinotica' and 'lyssinosis pulmonum' (Massoud, 1964). But Proust in 1877 realizing that Hirt had misused the word 'Lyssa' meaning rabies for byssus, called attention to the mistake and was first to use the term 'Byssinosis' (Harris et al, 1972).

The word byssinosis became well known after its use by Sir Thomas Oliver in 1902, and 1908 in his book on occupational diseases. Although it was first used to describe a disease caused by the inhalation of cotton dust, byssinosis also occur among flax and hemp workers and is used in this context (Massoud, 1964).

Byssinosis has been shown to be prevalent in cotton textile workers in all over the world. Byssinosis has a world wide distribution in cotton, flax and hemp workers and has been observed in many countries (Table 1). Reported prevalence of byssinosis varies from a few percent to practically all workers. Schilling, Hughes, Dingwall and Gilson in 1955 and Molynex and Tombreson in 1970 have stated that workers in British Cotton Mills concentrated in Lancashire have shown a consistently high prevalence of byssinosis.
Byssinosis was made a compensable disease in England in 1941, but until recently there were only sporadic reports of byssinosis, in the United States (Merchant, Lumsden, Killburn, Germino, Hamilton, Lynn, Byrd, and Baucom, 1973).

2.2 Etiology of Byssinosis:

As far back as in 1892 Arlidge* blamed the byssinosis on the inherent chemical nature of the vegetable fibres, Collis in 1909 believed that it was caused by the emery dust produced by grinding of Carding teeth. In 1926 Middleton suggested fungi, acting alone or with other constituents were responsible. Thiry in 1941 attributed it to moulds of bacteria.

The high bacterial content of cotton waste and card room dust led Furness and Maitland (1952) to associate the etiology of the byssinosis with infection.

Allergy has been considered to play an important role in the genesis of byssinosis by various workers (Branwell and Ellis in 1932, Fraumzits, 1936, Haworth and Macdonald, 1937, Gernes, Voisin, Jacob, Corsin and Doumen in 1962).

Tuffnell's experiments in which he exposed cotton workers to various types of dust, indicate that there is some active substance in the pericap and bracts of cotton pad which plays a role in the causation of byssinosis (Tuffnel, 1960).

* Quoted by Harris et al (1972)
Bouhuyes Lindell and Laudin in 1960 found that some of the symptoms of byssinosis are caused by histamin liberator in cotton dust inhaled by card room workers.

Nicholis in 1962 also demonstrated contraction of isolated human bronchial muscle by extracts of pericap and bracts of the cotton pad.

Massound and Taylor in 1964 compared the distribution of antibody titres in blood group of normal people and in card room workers with or without symptoms of byssinosis. They found that the titres were higher in card room workers than in normal individuals. Also sufferers of byssinosis showed higher titres than those who were free from it. They concluded that byssinosis had its basis in allergy. In 1971 Taylor, Massoud and Lucas found higher titres in card room workers suffering from byssinosis than normal subjects in card room who do not suffer from the disease.

Schilling in 1955 found a higher incidence of byssinosis among workers who had put in ten years or more in cotton industries. Tuypens in 1961 from Belgium found that no workers with less than 5 years service in card room was affected by the dust. The incidence among 53 men with less than 21 years exposure was 8% while in 34 subjects with 21 years or more exposure the incidence was 26%.

Mehrotra in 1964 did not come across any case with less

* Quoted by Taylor and Massoud (1968).
than 9 years of exposure. These studies underline the importance of duration of exposure in the genesis of byssinosis.

Kedarnath, Gupta, Omar, Samuel and Surma in 1966 stated that byssinosis is due to antigen antibody reaction, the antigen being present in the cotton dust, with prolonged exposure antibodies are produced. It has positive relation with duration of exposure. Bouhuys and Vaude Woestijne in 1970 found that due to the pharmacological bronchoconstrictor effect of the hemp dust airway conductance was decreased in subjects without symptoms of respiratory disease, while in subjects with respiratory symptoms airway conductance did not decrease but FEV₁, MEFR and FVC were decreased.

Zuskin and Valic in 1973 found higher prevalence of byssinosis in hemp and flax workers compared to cotton workers. Bouhuys in 1971 found that cotton and hemp dust caused chest tightness and decrease in flow rates in the majority of textile workers and healthy subjects. These acute response probably reflects narrowing of small intrapulmonary airways by toxic histamin releasing agents in the dust. The symptoms and the flow rate decrease can be potentiated by propranolol and inhibited by atropine. The balance between vagal sympathetic impulses which impinge on airways smooth muscle appears to be important in determining the lung's response to textile dust inhalation.
Zuskin and Bouhuys in 1975 found that textile dust extract contains a histamin releasing agent which explains its airways constrictor effect. This agent is a highly water soluble, heatstable low molecular weight compound which has not yet been chemically identified.

Ghosh, Gokani, Thakker and Chatterjee (1977) had conducted a preliminary survey in a textile mill located in Ahmedabad to find out the etiology of byssinosis. They observed that most of the occupational diseases due to the vegetable dusts were caused by fungus. They noted higher incidence of byssinosis in blow room and card room workers. Maximum number of strains of B. Subtilis and other gram positive were isolated from the air samples of card room and blow room. The recovery of number of colonies of B. subtilis from these two departments indicated possible relationship between B. Subtilis and byssinosis.

2.3 Pathological changes in byssinosis:

Pneumoconiosis which is caused by organic dust particularly that of cotton, hemp and flax is known as byssinosis. Main pathological findings in byssinotics are broncho constriction and chronic bronchitis which leads to emphysema and fibrosis of the lung tissues. Byssinosis therefore is a slowly acquired delayed broncho constriction due to exposure to an unknown constituent of cotton, hemp and flax dust. The long period of exposure before development of symptoms would favour formation of hypersensitivity
but symptoms can be produced by inhalation of cotton
dust in those not previously exposed. Furthermore, the
rapid tolerance displayed after Monday fever is not a
feature to be expected in hypersensitivity.

The natural history of byssinosis can be described
in three stages: During the first stage the worker who
has been employed for a number of years in the dusty rooms
of the cotton mill develops tightness of the chest on
Monday or on the day of return after each holiday. The
condition is sometimes referred to as 'Monday sickness'.
The symptoms appear within a few hours of commencement of
work and disappear when the worker leaves the dusty rooms.
In second stage worker suffers with tightness of the chest
as well as with dyspnoea. This is due to the broncho con­
striction. In the third stage tightness of the chest and
dyspnoea persist throughout the week. Breathing trouble
develops and the symptoms are those of chronic bronchitis
and emphysema.

Chronic obstructive bronchitis (not necessary due
to cigarette smoking) progress hand in hand with the
broncho constriction and may give rise to severe disability.
The bronchial mucus glands are hypertrophied. This hyper­
trophy can be measured in sections of the bronchial wall.
The thickness of the gland layer is related to the thickness
of the bronchial wall (Reid Index). The gland/wall ratio
in normal is 0.26, while that in chronic bronchitis it is
The mucus secreting goblet cells proliferate in the surface epithelium most dramatically in the bronchioles where normally only an occasional goblet cell is seen, while in chronic bronchitis almost every cell may be transformed to one distended with mucus. The mucus is histochemically altered so that there is a higher concentration of fucose and sialic acid (Dyke, 1968).

Ulceration, granulation of tissue and fibrosis may cause irregularity, narrowing or dilatation of the smaller airways. Distally the acinus may be collapsed or scarred on the other hand the air spaces may be enlarged by a process of destruction or distension. The increase in size of the air spaces distal to the terminal bronchiole is termed emphysema. Organic narrowing and mucus impaction cause airway obstruction. This obstruction may be further potentiated by the destruction and distension of the alveolar wall.

If overall alveolar ventilation is inadequate then there is an increase in the arterial $P_cO_2$. X-rays show no characteristic changes except a few prominent vascular markings. In the advanced stage of the disease evidence of emphysema may be present with diffuse pulmonary fibrosis.
2.4 Literature on Byssinosis:

a) From abroad:

In 1961 McKerrow and Schilling found evidence of respiratory disease and impaired ventilation in card room workers in two U.S. textile mills. In 1962 Schilling reported that only fourteen cases of byssinosis had been recorded from the United States over a fifteen years period. Heaphy and Kilburn (U.S.A.) in 1965 described eighteen hospitalized patients with pulmonary disease who had typical 'Monday Asthma' and cotton dust exposure indicating byssinosis. In 1967 Bouhuys, Heaphy, Schilling and Welborn reported twenty two non hospitalized cotton workers with chronic respiratory disease, fourteen of whom were diagnosed as byssinotic. Increased interest in byssinosis was reflected in further reports from U.S.A.

In 1969, Bouhuys, Wolfson, Horner, Brain and Zuskin in one survey found 29% of 214 workers in a prison cotton mill were suffering from byssinosis.

Zuskin, Wolfson, and Harpel in 1969 found 25% of 59 and 12% of 99 spinners of two south Carolina cotton mills to have byssinosis. In 1969, Khogali found 20% of ginnery workers and 48.6% of furfure workers suffering from byssinosis in Sudan. Schmag and Gullet (1970) found byssinosis in 12% of 509 cotton mill in a North Carolina State Board of Health Survey. In 1970, Merchant
surveyed 404 workers, prevalence of byssinosis was 41%, in carding, 22%, in spinning and 21% in winding and twisting areas. These prevalence rates are similar to those of other foreign studies and indicate the magnitude of health impairment related to cotton dust.

Merchant, Kilburn, Ofallon, Hamilton and Lumsden in 1972 found 20% byssinosis in preparation area, 2% in yarn processing area and total prevalence of 6% in all population with a grade one or two byssinosis in North Carolina Textile Plant.

In 1973, Imbus and Suh studied 10,133 textile workers and found 4.6% prevalence of byssinosis in U.S.A. Similarly in 1973, Fox, Tombleson, Watt and Wilkie studied respiratory symptoms in cotton operatives in England and found prevalence of byssinosis as 26% in card room, 14% in winding and 4% in ring spinning departments.

Martin and Haggins (1976) studied byssinosis and other respiratory ailments in 14 plants of a large cotton textile manufacturing corporations of U.S.A. and found 3% prevalence of byssinosis, out of this 0.8% indicated both symptoms of byssinosis and objective sign by a 10% or greater drop in FEV1% during the first working day.

Barnes and Simpson in 1976 studied 493 workers from 8 cotton mills in New South Wales, they included assessment of lung function, estimation of total and respirable dust
levels as well as analysis of dust for protease enzyme. By these methods they detected 12 out of 493 (2.43%) workers suffering from byssinosis.

Chinn, Cinkotai, Lockwood and Logan in 1976 had surveyed 60 workers in five willowing mills. The process of willowing is the most dusty in the cotton industry. The air borne dust was investigated in the five willowing mills still in operation and the prevalence of byssinotic symptoms and the pulmonary function were studied in the 60 operatives. Despite the extraordinary high concentration of dust and enzymes, only 3 operatives appeared to have byssinotic symptoms (all grade 7/2) and none was a certifiable case. However, over half of the workers had symptoms of chronic bronchitis and this was possibly related to the abundance of protease in the mill air.

b) From India:

In India a survey of 508 operatives of the mixing, blow and card rooms in three mills (Tata, Swadeshi and Advance) was undertaken in 1953. Nearly 13% had byssinosis (Annual Report, 1953). In 1958 the incidence of byssinosis among textile workers of mixing, blow room and card room and frame department of Tata and Swadeshi was found to be 7.3% out of 786 workers (Annual report local cited). In 1963 Gupta and Kulkarni surveyed textile mills in Ahmedabad and examined 253 workers of card and blow rooms and found 6.3% incidences of byssinosis. One case from Kanpur has been
<table>
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<th></th>
<th>I C M R Studies</th>
<th>Other Studies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Madurai</td>
<td>Ahmedabad</td>
</tr>
<tr>
<td>No. of mills</td>
<td>01</td>
<td>13</td>
</tr>
<tr>
<td>studied</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of workers</td>
<td>900</td>
<td>253</td>
</tr>
<tr>
<td>examined</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of cases</td>
<td>01</td>
<td>16</td>
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<tr>
<td>of byssinosis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percentage of</td>
<td>0.01</td>
<td>6.3</td>
</tr>
<tr>
<td>cases of byssinosis</td>
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</tbody>
</table>

*"Pneumoconiosis" by S.K. Chartterjee
Ind.J.Tuberculosis, XXV, No.1, Page 33-37, 1977."
reported by Narang and Sharma in 1961. Damodaran, Gupta and Vishwanathan in 1962 have reported five cases of byssinosis among cotton workers. Vishwanathan, Damodaran, Subramaniam, Chakravorti, Siddhu Gupta, Chandraseker and Sen in 1967 have reported that 8.4% of workers were suffering from the disease in Delhi textile mills. Gupta in 1969 had reported that the prevalence of byssinosis in India, ranges from 3.2 to 8.4% and in card room it varies from 7.3% to 20%. In 1970 Thiruvengadam, Kamat, Arunachalan, Pauldas, Kalyan Sundram and Chetty studied 1571 cases in textile mills of Madras and reported 4.2% incidences of byssinosis (Table II, showing incidences of byssinosis in India).

Pandit, Sabnis, Pamapattiwar and Kothari in 1972 had selected three types of mills in Bombay according to the concentration of dust: (a) fine mill, (b) coarse mill and (c) ginning process. Byssinosis was ascertained by the method of questionnaire and showed incidence rate of disease 10.2%, 19.6% and 39.9% for a, b and c mills respectively.

Salpekar, Kamat, Velamurgan and Panadikar in 1974 reported the incidence of byssinosis among textile workers of three mills in relation to their working departments as follows:


Mill Department-wise incidence of byssinosis

<table>
<thead>
<tr>
<th>Mill</th>
<th>Carding</th>
<th>Spinning</th>
<th>Winding</th>
<th>Controls</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>No.</td>
<td>%</td>
<td>No.</td>
<td>%</td>
</tr>
<tr>
<td>X</td>
<td>25</td>
<td>16</td>
<td>32</td>
<td>19</td>
</tr>
<tr>
<td>Y</td>
<td>15</td>
<td>13</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Z</td>
<td>2</td>
<td>5</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

Where X mill = Old, Y mill = Semi modern and Z mill = modern.

The incidence of byssinosis was more in the old mill.


They found overall incidence of byssinosis in exposed group was 12% and in control group it was 2%. Millwise incidences in exposed groups were 16%, 8% and 3% in mill A, B and C respectively.

Padma and Rao in 1976 have quoted the statement of Mr. Singh (Deputy Commerce Minister) on May 7th, 1976 in Lok Sabha that a study by E.S.I.C. showed one out of every four textile workers in India suffering from bronchitis. In Ahmedabad, the Manchester of India, more than 40% of mill hands suffer from crippling lung diseases. Among the chest diseases commonly afflicting mill workers are pulmonary tuberculosis and variations of bronchitis. One of these
which is peculiar to only mill hands exposed to cotton dust and flax is called as byssinosis.

Ahluwalia in 1977 had examined 1064 cotton textile workers working in a largest mill manufacturing coarse and medium counts of yarn and cloth. He found 5.6% (60 out of 1064) having byssinosis which was low when compared with rates from other countries.

2.5 Study of lung function in byssinosis:

A. Foreign Studies:

McKerrow McDermott, Gilson and Schilling in 1958 reported that symptoms of byssinosis are frequently associated with reduced pulmonary function, objective measurements of such changes have become an integral part of the evaluation of degree of involvement in the workers. Subjects with byssinosis usually show a decrease in expiratory flow rates and in vital capacity on Monday after 3 to 4 hours exposure to dust after a day's 'rest' on Sunday. Different parameters of pulmonary function were studied by various workers.

In 1961, McKerrow and Schilling from U.S.A. during their pilot enquiry into byssinosis in two cotton mills, reported that there is a decrease in forced expiratory volume in one second (FEV₁) and FEV 0.75 sec. The fall was more in workers having smoking habits than nonsmokers. In 1967 Boubuys et al found lower value of ventilatory capacities in hemp, cotton and flax workers than control.

* Quoted by Ray (1978)
subjects. In a further study on byssinosis, chronic bronchitis and ventilatory capacities in workers exposed to soft hemp dust valic, Zuskin, Walfard, Kersk, and Paukovic in 1968 have shown decrease in FVC and FEV 0.75 sec. in all group during the work shift. There was also marked reduction in FEV 0.75/FVC ratio. While studying pulmonary function in Bagasse workers' lung disease in 1968 Pierce, Nicholson, Miller and Johnson reported that total lung capacity, forced vital capacity and forced expiratory volume in one second reduced by inhalation of bagasse dust from sugar can pulp. Also Simpson and Barnes in 1968 reported that there was a significant fall in forced expiratory volume in one second with exposure to cotton dust while other workers in the same plant not exposed to dust were not affected. Bouhuys, Walfson, Horner, Brain and Zuskin in 1969 also studied byssinosis in textile workers and found decrease in FEV 1 and MEF 25. Bouhuys, Barbero, Schilling, Van-De-Woestijne in 1969 reported that there was a reduction in forced expiratory volume in one second in hemp workers. A study on rope workers exposed to hemp and flax dust made by Smith, Coles, Schilling and Walfard in 1969. They found decrease in forced expiratory volume in one second. Khogali in 1969 reported that there was mean fall of 100 ml. in FEV 1 during the work shift in cotton ginnery workers of Sudan.
In a study made by Bouhuys and Vaudewoestijne in 1970, it was found that acute exposure to hemp dust resulted in decrease in \( \text{FEV}_1 \), MEFR and VC. In 1971 Bouhuys studied airway responses caused by inhalation of textile dust and found a significant decrease in MEFR in the majority of textile workers.

El-Sadik, Moselhi, Hinady and Mostafa in 1972 studied lung function changes among different grades of byssinosis. They found \( \text{FEV}_1 \) and MEFR reduced more in byssinotics. Grade three byssinotics showed changes in predicted vital capacities, residual volume and total lung capacity.

Lapp, Hankison, Burgess, Brien in 1972 also studied changes in ventilatory function in coal miners after a work shift and revealed that there was significant decrease in ventilatory parameters like FVC, \( \text{FEV}_1 \) and \( \text{FEV}_1 \), 50% of VC and \( \text{FEV}_0.75/\text{VC} \) ratio. Merchant et al in 1972 have shown that pulmonary function was affected in the textile workers. Yalic and Zuskin studied the effect of different vegetable dust exposure in relation to lung function in 1972 and reported that there was a 19% reduction in \( \text{FEV}_1 \) in workers exposed to hemp dust, 11% reduction in \( \text{FEV}_1 \) in subjects exposed to flax dust, 8% reduction in \( \text{FEV}_1 \) in subjects exposed to cotton dust, 7% reduction in \( \text{FEV}_1 \) in workers exposed to sisal dust and 5% reduction in \( \text{FEV}_1 \) in subjects exposed to Jute dust.
Berry, McKerrow, Molyneux, Rossi and Tombleson in 1973 studied the acute and chronic changes in the ventilatory capacities of workers in Lancashire cotton mills of England and found that there was an annual decline of 54 ml/year in FEV\textsubscript{1} value in cotton workers while only 32 ml/year in man-made fibre mill workers.

Gayatt, Douglas, Zuskin and Bouhuys in 1973 studied airways obstruction in hemp workers with byssinosis and found vital capacity and FEV\textsubscript{1} were significantly less than predicted values. Hamilton, Germino, Merchant, Lumsden and Kilburn in 1973 studied byssinosis in a non-textile workers in a textile mills of U.S.A. and found acute profound decrease in FEV\textsubscript{1}, and arterial tension were noted within 15 minutes of entering mill and were correlated with the development of severe shortness of breath. Imbus and Suh in 1973 also studied FEV\textsubscript{1} and FVC in textile workers and found that FEV\textsubscript{1} and FVC were reduced significantly and found relationship between byssinosis and lower pulmonary function. Valic and Zuskin in 1973 also have shown that exposure to flax dust results in fall of FEV\textsubscript{1} and MEFR at 50% of VC.

Noweir, Sadik, Dakhany and Osman in 1975 studied FEV\textsubscript{1} in workers processing flax in Egypt and found FEV\textsubscript{1} reduced by more than 10% at the end of the first morning work-period.
Zuskin, Valic, Butkovic and Bouhuys studied lung function in textile workers in 1975 including acute changes in ventilatory function during a workshift with exposure to hemp, flax and cotton dust on Monday after a rest on Sunday. Large acute reductions during dust exposure were recorded in MMFR at 50% of VC ranging from 38% to 22%. Acute reduction in FEV₁ were considerably smaller ranging from 17% to 9%. There was a statistically significant increase in RV and very small and insignificant change in total lung capacity. Although preshift, FEV₁ and FVC were decreased, diffusing capacity was within normal limits. Zuskin and Valic also studied the changes in the respiratory response to coarse cotton dust over a ten years period in 1975, and reported that the prevalence of byssinosis was increased in the ten year period in men and women in addition there was an increase in the prevalence of all other chronic respiratory diseases. There was a significant decrease in FEV₁ and FVC over the Monday shift. The mean annual decline of FEV₁ was 70 ml/year during the ten year period in men.

Martin and Haggins in 1976 studied pulmonary function in relation to byssinosis and other respiratory ailments in textile workers of U.S.A. They have reported that there was a 10% or greater drop in the forced expiratory volume in one second, during the working days.
Zuskin, Valic and Bouhuys studied the effect of wool dust on respiratory function in 1976. They found that workers exposed to wool dust for more than 10 years had a higher prevalence of chronic respiratory symptoms. Significant reduction, during the workshift were found in FEFR at 50% of VC and FEV₁.

B. Indian Studies:

Gupta et al in 1963 from Ahmedabad reported decrease in vital capacity value in persons suffering from byssinosis. In Bombay, a study of respiratory function in byssinosis was done by Raghvan, Nagendra and Thaker in 1964. They studied maximum breathing capacity, vital capacity, FEV₁, RV and RV/TLC ratio. They found decrease in MBC, VC and FEV₁% values and increase in RV and RV/TLC ratio in byssinotics in proportion to the severity of the disease. Wig, Guleria, Bhasin, Holmes Vasudev and Sing in 1964 also have shown that maximum breathing capacity, FEV₁; FEV₂ were decreased and RV, RV/TLC ratio were increased in textile workers.

In Kanpur, Kedarnath et al studied byssinosis amongst cotton operatives in 1966 and found decrease in pulmonary capacities. Similarly in 1966 Siddhu, Kedarnath, also studied byssinosis among cotton and jute workers in Kanpur and reported that pulmonary functions were more affected in cotton workers than jute workers.
In 1967 Vishwanathan et al studied byssinosis and pulmonary function in Delhi textile workers and found marked reduction in vital capacity. Reduction was more prominent in subject with byssinosis.

Sen (1968) showed that 66 out of 203 or 32.5% textile workers had FEV$_1$ below 80%VC. The mean FEV$_1$/FVC of the 203 workers was found to be 82.45 while mean of 49 control subject was 89.56 and this was highly significant. An appreciable reduction in the ventilatory capacity was found among workers in card room.

Thiruvengadam, et al in 1970 during the study of byssinosis in textile population of Madras reported that ventilatory capacities were affected due to the exposure to the cotton dust.

Mathur and Misra in 1972 from Lucknow studied the incidence of pulmonary disease among wool workers in Bikaner and found reduction in FEV$_1$, FEV$_2$, FEV$_3$ and TV values significantly in wool workers. They had higher prevalence of respiratory ailments depending upon the exposure to the wool dust.

Kamat, Salpekar, D'ra, Sing, Sadekar: Kamat and Kale: in 1976 also have reported that pulmonary function values decreased with increase in age and years of employment in textile workers.
Gaekwad, Oza, Niyogi and Wani (1977) have observed a definite decline in the peak flow-rate and vital capacity of the textile workers in comparison to the normal healthy Indians in Baroda.

2.6 Smoking and lung function tests:

Earliest investigation into the effect of smoking on lung function were made by Barp in 1925 and by Turley and Harrison in 1932. They found no difference in vital capacity and respiratory efficiency between smokers and non smokers. This is in contrast to the most of the findings of other workers. The reasons for this is that they have performed very limited tests which may not be able to evaluate the effect of smoking.

Olsen and Gilson in 1960 during the study of Anglo Danish population reported that pulmonary function reduced in cigarette smokers.

McKerrow and Schilling in 1961 reported that the decrease in $F_{EV_1}$ was 0.3 lit. per shift in smokers while in non smokers, it was only 0.15 lit per shift.

Simonsson in 1962 studied the effect of cigarette smoking on the forced expiratory flow rate and reported that there were significant decrease in $F_{EV_1}$ and $F_{EV_1}/F_{VC}$ ratio due to the increase airway resistance. Nicholas, Kennel, Goldsmith and Dawber in 1962 also reported decrease in ventilatory values in smokers compared to the predicted
values of the pulmonary function. Brinkman and Coates in 1963 have shown that PEV was decreased in proportion of cigarette smoking. Also there were a reduction in FVC and MBFR values.

Hensler and Giron in 1963 studied pulmonary function in smoker and non smoker military officers and found to have significantly lower average ventilatory capacities and increased residual volume in smokers as compared to non smokers. Zamel, Hosny and Prine in 1963 reported higher airway resistance in smokers than in a parallel group of non smokers.

Zwi, Goldman and Levin in 1964 have shown during their study that in smokers VC and TLC were less than non smokers and residual volume (RV) and RV/TLC ratio were higher than non smokers.

In further study Zwi et al in 1964 examined twenty medical students and found that non smokers had higher values of ventilatory function than smokers. Residual volume was smaller in non smokers than smokers. RV/TLC ratio was 1.7% smaller in nonsmokers than smokers. They also reported that cigarette smoking affects pulmonary function in the direction of chronic obstructive lung diseases within the (15 years) fifteen years after commencing the habit and adversely affects the cardiovascular system.
Krumholz, Chevalier and Ross in 1965 have shown that pulmonary compliance was lower in smokers than non-smokers. Edelman, Mittman, Norris, Cowhen and Shock in 1966 also found consumption-related impairment of ventilatory function among cigarette smokers. In which they have shown FVC and FEV₁ decreased in smokers. This effect is reversible. They found higher ventilatory capacity and flow rates in non-smokers than smokers.

In studying the effect of smoking on pulmonary function and respiratory symptoms in a college-age group, Peter and Perris in 1967 reported decrease in FVC, FEV₁, and flow rate at 75%, 50%, 25% and 10% of VC. Smokers had significantly higher frequency of cough, phlegm, breathlessness, wheezing, and chest involvements with colds than a group of non-smokers.

Carey, Dawason and Merrett in 1967 have shown that ventilatory capacities and flow rates in smokers were lower than non-smokers. Fox et al. in 1973 surveying the respiratory symptoms in cotton operatives found that the prevalence of byssinosis increases with smoking habits. Peterson, Lovergem and Hardings in 1968 and Canter and Luchsinger in 1968 have shown decreased ventilatory capacities and flow rates in smokers. Bouhuys et al. in 1969 also showed that workers with less number of years of exposure to cotton dust but with heavy smoking habits were having higher prevalence of byssinosis. Chiang and Wang in 1970 have studied the acute effect of cigarette smoking and demonstrated that there was a sharp fall in flow rates.
Brinkman, Black and Cress (1972) have studied the effect of bronchitis and occupation on pulmonary ventilation over an eleven years period. They have shown an inverse relationship between the amount of cigarette smoking and decrease in $FEV_1$. Merchant et al from U.S.A. in 1972 have reported lower values of ventilatory capacities in smokers with greater risk of byssinosis when exposed to cotton dust, compared to non smokers. Woolcock, Colman and Blackburn in 1972 also found that smoking adversely affects lung function.

Superman and Riker in 1973 found reduction in flow rates and incidence of severe airway obstruction in cigarette smokers. Grimes and Hanes in their study of influence of cigarette smoking on the spirometric evaluation of employees of a large insurance company in 1973 reported that cigarette smoking in men was associated with lower values of FVC and $FEV_1$ and the level of cigarette smoking was related to the impairment of spirometric function. The data suggested reversibility of these impairment on cessation of cigarette smoking. Imbus and $\text{Suh}$ in 1973 during the study of byssinosis found that the cigarette smoking had increased the incidences of bronchitis and lower pulmonary function in textile workers of U.S.A. Krumholz and Hedrick in 1973 in further studies of pulmonary function, in normal smoking and non smoking middle aged white collar workers reported the closer correlation of flows with age in smokers than
in non smokers and suggested that smoking increases age related changes in pulmonary function.

Black, Hofford and Hyatt in 1974 reported that the effect of smoking on MEFR increases with age. Berry, Molyneux and Tombreon in 1974 found 40% higher prevalence of byssinosis in smokers than non smokers. They reported that smoking is one of the factor which had close relationship with the prevalence of byssinosis and bronchitis in Lancashire cotton mills of England. Seltzer, Siegelaub, Friedman and Collon in 1974 and Woolf in 1974 also reported lower values of pulmonary function in smokers compared to that in non smokers. Zuskin and Valic in 1974 found significant higher prevalence of respiratory symptoms in smokers than non smoker medical students.

In the Framingham study in 1975 Ashley, Kennel, Paul and Masson found that cigarette smoking affects pulmonary function adversely. In recent study regarding smoking, behaviours and its consequences in 1975, Athanson found that FEV₁/FVC ratio was reduced in smokers. There was a higher rate of morbidity among cigarette smokers. Prevalence of higher rate of respiratory diseases in smokers was found.

Zuskin, Valic and Bouhuys in 1976 have shown higher prevalence of respiratory ailments in wool workers having smoking habits than non smokers. They have also found
lower pulmonary function values in smokers than non smokers. Martin et al from U.S.A. in 1976 have reported that increased incidences of byssinosis was related to increased cigarette consumption.

Tockman, Menkes, Cohen, Benjamin, Ball and Tonsacia in 1976 have shown that ventilatory capacities and flow rates in non smokers were higher compared to smokers.

In India, Vishwanathan has shown in 1964 that prevalence of chronic bronchitis and emphysema syndrome were higher in smokers than non smokers. In 1968 Mohanty and Gupta demonstrated lower values of MBC and vital capacity in adivasi smokers than in non smokers. Islam, Datta, Misra and Chakravorty in 1970 have reported that long term smoking may affect lung compliance and so the vital capacity was reduced. Thiruvengadam et al in 1970 from Madras found that tobacco smoking potentiates the effect of cotton dust inhalation. Heavy smokers showed a greater fall in ventilatory capacities during the working day than light smokers. There was a significantly greater prevalence of byssinosis in smokers than non smokers. In 1971 Marwaha and Pande from Baroda have reported that smokers were having lower values of FVC, FEV₁, 0.75, FEV₀.75/FVC ratio and PFR than non smokers. Mathur et al in 1972 studied respiratory diseases in wool workers and found lower values of ventilatory function in smokers than non smokers. He also
reported higher prevalence of respiratory symptoms in smokers than in non smokers.


By analysing the prevalence of byssinosis and bronchitis in relation to smoking habits, they found that smoking had no effect on the prevalence of byssinosis or bronchitis. This is contradictory to the findings of other workers.

Gupta and Tandon in 1977 studied the acute effect of cigarette smoking and found sharp decrease in flow rates. Decreased in PEFR was highly significant.

Gaekwad et al in 1977 had examined 242 male textile workers aged between 25 to 50 years of the morning shift of a textile mill in Baroda. They found that effect of smoking on reduction of vital capacity was statistically significant. There was also reduction in peak flow rate of the workers but smoking did not prove any significant relation. There was a higher rate of respiratory illness among the smokers and it was proved statistically significant.

2.7 Dust concentration and lung function tests:

Pulmonary function and prevalence of byssinosis are varied with the concentration of the dust present in the atmosphere, size of the dust, duration of exposure and
the age of the workers. Higher prevalence of respiratory symptoms are associated with high concentration of dust with longer duration of exposure in aged workers.

Schilling in 1956, McKerrow et al in 1961 from U.S.A., Bouhuys et al from U.S.A. in 1967, Simpson et al in 1968, Bouhuys et al in 1969, Khogali in 1969, Smith et al in 1969, Molyneux and Tombleson in 1970 from U.K., Schrg and Gulleet in 1970, Merchant et al in 1972, Fox et al in 1973, Zuskin et al in 1973 have shown that respiratory symptoms and prevalence of byssinosis were increased with increased duration of exposure to the cotton, hemp and flax dust and pulmonary functions were also more affected in workers exposed to high dust concentration with 15-20 years of exposure to these dust.

Berry, Molyneux and Tombleson in 1974 reported that strippers and grinders had the highest prevalence of byssinosis and bronchitis due to the higher concentration of dust, than ring spinners, where the concentration of cotton dust is less compared to above one.

Barhad, Filat and Teculescu (1975) from Romania had found relationship between dust concentration and lung diseases. In 1975 Utidjian recommended 1 mg/m$^3$ as the ceiling limit of dust concentration at which the prevalence of byssinosis was lowest. It increases with increasing concentration of cotton dust.
Roach and Schilling in 1960 have found that the prevalence of byssinosis had high correlation with the concentration of dust particles of a size range $7 \mu - 2 \text{mm}$. They also stated that the fine dust may affect the smaller airways without causing symptoms, while the larger particles may produce the sensation of chest tightness by their presence in the upper airway. McKerrow, Roach, Gilson and Schilling (1962) concluded that fine fraction under $7 \mu$ of cotton dust produces changes in respiratory functions and may be alone responsible. Their findings suggest a direct action by the dust on the smaller air passages and imply that to be completely effective, dust suppression measures in cotton mills should remove fine dust.

Nowier et al in 1975 from Egypt have reported that prevalence of byssinosis and fall in $\text{FEV}_1$ were increased with increased duration of exposure to the flax dust. In 1975 Zuskin and Valic also have shown relationship between byssinosis and duration of exposure to the cotton dust.

Martin et al from U.S.A. (1976) and Khogali (1976) from Egypt found positive association between prevalence of byssinosis and level of cotton dust concentration. In 1976 Zuskin et al also found that prevalence of respiratory symptoms were higher in workers who were exposed to woollen dust for more than ten years than those with less number of years of exposure.
Gupta et al from Ahmedabad in 1963, Raghvan et al from Bombay in 1964, Siddhu et al from Kanpur in 1966, Vishwanathan et al from Delhi in 1967 and Chakravorty, Arunchalam, Pauldas, Sharma, Kamat and Thiruvengadam in 1971 from Madras and Mathur et al (1972) had shown that respiratory symptoms and prevalence of byssinosis were closely related to the concentration of dust and the duration of exposure in years.

Thiruvengadam et al in 1970 had shown the peak values of the age incidence for various grades of byssinosis. They are like this: grade-1/2: it is 21-30 years; for grade-I: it is 31-40 years; for grade-II and for III: it is 51-60 years. This showed that generally the severity of the disease significantly increased with age.

Pandit et al in 1972, Kamat et al (1976), Salpekar et al in 1974, Gaekwad et al in 1977 and Ahluwalia in 1977 have shown that higher incidences of byssinosis were found to be strongly associated with high dust concentration.

Kamat et al (1976) and Ahluwalia (1977) have shown that occurrence of byssinosis had strong relationship with the duration of exposure.