Prevalence of Occupational Skin Diseases and its Predisposing Factors in Leather Tanning Workers of Southern India

PANJAKUMAR KARUNAMOORTHY1*, EMBIRANAHALLI MANI RAJESH2, BEERAPPA RAVICHANDRAN1, DHANANJAYAN VENUGOPAL1, MALA AMBIKAPATHY1 and SHRIDHAR JAGANNATH KONDHALKAR1

1Industrial Hygiene and Toxicology, ICMR-Regional Occupational Health Centre (Southern), Bangalore, India.
2Department of Microbiology, PSG College of Arts and Science, Coimbatore, India.

Abstract
Skin diseases are a major occupational health issue in tannery workers because of work related exposure to various toxic chemicals used in tanning process. In the present study, prevalence of various skin diseases and predisposing factors in tannery workers were investigated. A cross sectional study including 114 tannery workers (male-89; female-25) employed at different tanneries of Southern India was carried out. Face to face interview with pre-designed questionnaire and health examination was conducted. Skin samples obtained from the participants were subjected to microscopic examination and microbial culture for diagnosis of skin diseases. The prevalence of occupational skin disorders were 39% among the study participants. Contact dermatitis (16%), skin infections (16%), eczematous lesions (7%) and nail discoloration (1.75%) were identified. Skin infections of fungal origin were identified among 11.4% of subjects. The skin infections of fungi; tinea corporis, tineatinea cruris, tineatinea unguium, tineatinea versicolor, tineatinea pedis and Pityriosis versicolor were identified. Bacterial skin infections identified were associated with contact dermatitis. Lack of PPE usage was reported among 30% of workers. Hazardous working environment, chemical exposure, humidity and lack of PPE usage were significantly associated with increased skin disease incidence (p<0.05), indicating the major predisposing factors for Occupation skin diseases. The findings of the study emphasize that, workers in the pre-tanning section and tanning sections are more vulnerable to occupational skin diseases. Compliance to use of PPEs, engineering controls to reduce exposure, education, frequent health surveillance and early identification & treatment could mitigate the occupational skin diseases among tannery workers.
Introduction
The leather tanning industry holds a prominent place in the Indian economy, providing job to 4.42 million people, mostly of lower socio-economic status. Women workers occupy 30% in this sector, among the states Tamil Nadu, the southern part of India holds the major leather production centers. The state of Tamil Nadu is accountable for 60-70% of leather production in India. Tannery industries are the most toxic in the world owing to intensive chemical usage. The tanning industries involved manual operations, viz; hide handling, soaking, unhairing, trimming, tanning, dyeing and other finishing process. Thus tannery workers exposed to deleterious agents such as acids (Formic acid, sulphuric acid) chromium sulphate, ammonium salts, sodium salts and dyes etc. These chemicals are demonstrated as potential irritant and sensitizing agent among worker exposed for long duration. Chromium salts has potential ability to bind with skin proteins of tannery workers to produce complex antigens which lead to hypersensitivity reactions. Prevalence of occupational dermatitis has been reported among tannery workers in Asian countries.

Occupational skin diseases (OSD) are emerging concern and frequently encountered notifiable work related health issue. The worsening of pre-existing skin disorders by work related exposures are considered as OSDs which account for 34% of work related diseases. OSD contributes to the compromised productivity, loss of work days, switch over to other jobs, affects life style, disablement and increased health expenditure among working population. The most important agents responsible for the OSD are chemical, biological, physical and...
mechanical factors. Occupational skin diseases are classified into contact dermatitis, allergic contact dermatitis, contact urticaria, skin cancers, skin infections, skin injuries, pigmented disorders and miscellaneous types. Employment in tanneries is probably associated with occupational dermatitis. The prevalence of contact dermatitis, urticaria and skin infection, hand eczema, atopic eczema, and bacterial infection were 8%, 7%, 5%, 3%, and 0.5% respectively in the workers of Khartoum tanning industry. The chemicals used to treat the animal hides have the indistinguishable affect on human skin that disturbs immunological barrier of skin anatomy, consequently it rendered to opportunistic skin infections to the sensitized population. Moist area of the body such as in between the toes, genital area, and underneath the breasts and skin folds are more susceptible to fungal infections.

Fungal skin infections are usually caused by dermatophytes, non-dermatophytic moulds and commensal yeasts. Particularly the fungal skin lesions may widespread if left untreated, therefore to treat the fungal skin infections effectively, appropriate laboratory diagnosis is essential for the differentiation of dermatophytosis from other non-mycotic dermatitis. The inappropriate treatment for tinea infections may progress to chronic, recurrent and multisite infection. Occupational illness is less likely to be reported in developing countries due to inadequate surveillance programmes. There are only limited studies on prevalence of infectious skin diseases among the tannery workers, especially of fungal dermatitis. Therefore, the present study designed to investigate the prevalence of occupational dermatitis, associated skin infections and the risk factors responsible for Occupational skin diseases among the tannery workers.

Materials and Methods

Study Design and Questionnaire

A cross sectional study was conducted to assess the prevalence of occupational skin diseases among tannery workers. The study was conducted at Southern region of India, included 114 tannery workers (male, n=86; female n=25) with similar socioeconomic strata. Those workers worked in different leather tanning sections, namely pre-
Microbial Culture
Isolation of fungi and bacteria was carried out according to Standard Operating Procedure mentioned in Textbook of Diagnostic Microbiology. Samples were cultured by inoculating the scraping pieces over the agar plates. For fungal isolation, the samples were inoculated into Sabouraud's dextrose agar (SDA) containing cycloheximide and chloramphenicol. Culture plates were examined for fungal growth. The fungal genus was identified by macroscopic character of culture, microscopic examination of isolates and biochemical characters for macroscopic character colony texture, rate of growth and pigmentation production of the front and the reverse side of the culture plates were observed. Microscopic identification of mould isolates was carried out using lactophenol cotton blue (LPCB). Bacterial culture was performed using Blood agar (BA) (contained 5% sheep blood) and MacConkey. Smear study, cultural characteristics and biochemical assays were performed to identify the infectious agent from the culture growth.

Statistical Analysis
The results were statistically analyzed using SPSS version 26. Descriptive statistics was performed. Chi-square test was used to find the significant association between skin diseases prevalence and other variables. The p-values p<0.05 was regarded as statistically significant.

Results
Demographic Characteristics and personal habits
Demographic characteristics of the workers are presented in Table 1. The mean age of workers was 43.8±10.4 years, ranges from 16 to 68 years. Of the study subjects 26% of them were illiterate, about 45.6% of workers had only primary education, higher secondary education completed by 26.3% workers and only 1.8% of them were graduated. Almost majority of the workers had lower monthly income varying from Rs.5000 to 8000/- and most of them were temporary employees (95.6%) for several years. Of the study subjects tobacco chewing habits observed among 9.6% subjects, smoking habits reported by 24.6% subjects and alcohol consumption were reported by 36.8% subjects.

Table 1: Demographic and occupational details of Tannery workers

| Variables               | Tannery workers (n=114) |
|-------------------------|-------------------------|
| Age (Years)             | Mean ± SD               |
|                         | 43.8±10.4               |
|                         | Range                   |
|                         | 18-68                   |
| Gender                  | Male                    |
|                         | 89 (78)                 |
|                         | Female                  |
|                         | 25 (21.9)               |
| Marital status          | Married                 |
|                         | 103 (90.3)              |
|                         | Unmarried               |
|                         | 11 (9.6)                |
| Education               | Illiterate              |
|                         | 30 (26.3)               |
|                         | Primary                 |
|                         | 52 (45.6)               |
|                         | Higher Secondary        |
|                         | 30 (26.3)               |
|                         | Graduate                |
|                         | 2 (1.8)                 |
| Monthly income          | <5000                   |
|                         | 6 (5.2)                 |
|                         | 5000-8000               |
|                         | 91 (79.8)               |
|                         | >8000                   |
|                         | 17 (14.9)               |
| Job description         | Temporary               |
|                         | 109 (95.6)              |
|                         | Permanent               |
|                         | 5 (4.3)                 |
| Tobacco Chewing         | Chewing                |
|                         | 11 (9.6)                |
|                         | Non-chewing             |
|                         | 103 (90.3)              |
| Smoking                 | Smoker                  |
|                         | 28 (24.6)               |
|                         | Non-smoker              |
|                         | 86 (75.4)               |
| Alcohol consumption     | Alcoholic               |
|                         | 42 (36.8)               |
|                         | Non-alcoholic           |
|                         | 72 (63.1)               |

* Parenthesis indicates percentage (%)
**Occupational Details**
The occupational details of the workers represented in the table 2. According to the working departments of workers, they were proportioned into three groups, about 47.3% of subjects worked in preparatory or pre-tanning process (involved in sorting, curing, storage of hides, soaking, un-hairing, liming, deliming, bating, pickling and beam house process), 30% of them worked in tanning department (involved in tanning, sammying, and shaving process) and 22% of them involved in post-tanning department (fat liquoring, drying, dyeing and finishing process). The mean work experience of workers was 15.46±10.4 years, ranges from 1 to 36 years. The working hours of the subjects were ranges from 42 to 56 hours/week.

| Variables                        | Pre tanning (n=54) | Tanning (n=34) | Post tanning (n=26) | Total subjects (n=114) |
|----------------------------------|--------------------|----------------|---------------------|------------------------|
| Worker working section           |                    |                |                     |                        |
| Working hours/week               |                    |                |                     |                        |
| a) 42-48 hours                   | 16 (29.6)          | 29 (85.2)      | 0                   | 51 (44.7)              |
| b) ≥48 hours                     | 38 (70.3)          | 5 (14.7)       | 26 (100)            | 63 (55.2)              |
| Work experience                  |                    |                |                     |                        |
| a) 1-15 Years                    | 32 (59.2)          | 19 (35.1)      | 16 (61.5)           | 67 (58.7)              |
| b) 15-30 years                   | 19 (35.1)          | 12 (22.2)      | 9 (34.6)            | 40 (35)                |
| c) > 30 years                    | 3 (5.5)            | 3 (8.8)        | 1 (3.8)             | 7 (6.1)                |
| PPE usage                        |                    |                |                     |                        |
| a) PPE users                     | 43 (83.3)          | 25 (73.5)      | 21 (80)             | 79 (68.5)              |
| b) Non users                     | 11 (16.6)          | 9 (26.4)       | 15 (57.6)           | 35 (31.5)              |
| c) Gloves users                  | 43 (83.3)          | 25 (73.5)      | 3 (11.5)            | 71 (62.2)              |
| d) Apron users                   | 38 (70.3)          | 25 (73.5)      | 2 (7.6)             | 63 (55.2)              |
| e) Safety boots users            | 43 (83.3)          | 25 (73.5)      | 1 (3.8)             | 69 (60.5)              |
| d) Goggles users                 | 0                  | 0              | 0                   | 0                      |
| e) Mask users                    | 2 (3.7)            | 3 (8.8)        | 0                   | 5 (4.3)                |
| Reason for not wearing PPE       |                    |                |                     |                        |
| a) Not provided                  | 5 (9.2)            | 3 (8.8)        | 7 (26.9)            | 19 (16.6)              |
| b) Discomfort while use          | 2 (3.7)            | 2 (5.8)        | 2 (7.6)             | 11 (9.6)               |
| c) Allergic to PPE              | 1 (1.8)            | 1 (2.9)        | 0                   | 4 (3.5)                |
| d) Not able to afford PPE       | 3 (5.5)            | 3 (8.8)        | 6 (23)              | 19 (16.6)              |
| Handling of chemicals            |                    |                |                     |                        |
| a) Yes                           | 13 (24)            | 10 (29.4)      | 3 (11.5)            | 26 (22.8)              |
| b) No                            | 41 (75.9)          | 24 (70.5)      | 23 (88.4)           | 88 (77.1)              |
| Type of exposure                 |                    |                |                     |                        |
| a) Chemicals                     | 19 (35.1)          | 12 (35.2)      | 2 (7.6)             | 33 (28.9)              |
| b) Dust                          | 17 (31.4)          | 3 (8.8)        | 21 (80)             | 38 (33.3)              |
| c) Humidity                      | 24 (44.4)          | 27 (79.4)      | 4 (15.3)            | 55 (48.2)              |
| Wearing same clothes repetitively at work | 4 (7.4)     | 0              | 4 (15.3)            | 8 (7)                  |

*Parenthesis indicates percentage (%)

Use of Personal Protective Equipments (PPE’s) were reported among 60.5% of subjects and 29.8% of workers did not use any kind of PPE’s, further non-glove users 27.8% and non-apron users 54% were noted. Usage of face mask at work was noted only among 4.3% subjects. The study subjects stated that
discomfort while wear, allergic to PPEs, not offered PPEs by industry, and not able to afford PPEs by self, were the reasons for lack of PPEs use at work. As alternate for PPEs, workers were reported to be covering the body by self-designed impermeable protectivematerials such as polythene cover and rubber sheets.

**Exposure Assessment**

Direct handling of chemicals and exposure to chemicals was reported among 33% subjects, exposure to dust 36% and experience of high humidity at workplace was reported among 48% (Table 2). The major chemicals reported to be directly handled by the workers were ammonium sulphide, ammonium chloride, sodium chloride, sodium sulphide, sodium metabisulphide, formic acid, sulphuric acid, and chrome sulphate tanning and in pre-tanning sections (table 5). These chemicals are classified as potential irritant and sensitizing agent to skin and eyes is given in the table 3. These indicate that the workers in pre-tanning and tanning departments are exposed to those chemicals constantly at work.

| Dept                  | Chemicals used          | Application                                                                 | Health effects                                                                 |
|-----------------------|-------------------------|------------------------------------------------------------------------------|--------------------------------------------------------------------------------|
| Pre-tanning sections  | Sodium sulphide         | To destroy the hair on hides                                                | May cause sensitization. Can severely irritate and burn the skin and eyes       |
|                       | Sodium hydrosulphide    | Destroys the hair on hides or skins                                          | Contact can severely irritate and burn the skin and eyes                        |
|                       | Sodium hydroxide        | Used in liming process to remove protiens                                    | Skin irritant: Contact can cause pain, redness, burns, and blistering          |
|                       | Ammonium sulphate       | Used to remove alkaline chemicals form skin                                 | Prolonged skin contact may cause skin irritation and/or                         |
|                       | Ammonium chloride       | Used in deliming process to clean skin and eyes                              | Contact can severely irritate the skin and eyes                                  |
|                       | Sodium metabisulphite   | Act as whitening agent in deliming process                                  | Cause skin and eye irritation                                                  |
|                       | Formic acid             | Penetrate into hide and acidify to prepare for tanning process inflammation  | Contact can cause pain, burns and ulcers. Eye contact causes pain, watering eyes, and inflammation |
|                       | Sulphuric acid          | To reduce the pH level and acidify the hide                                 | Contact can cause pain, redness, burns, and blistering.                        |
|                       | Sodium formate          | Facilitate chromium compound perforation into hide                           | Contact can cause skin and eye irritation                                        |
| Tanning section       | Chromium sulphate       | Penetrates into the collagen matrix during tanning and that stabilize the skin structure | May cause skin allergy, if allergy develops, can cause itching and skin rash.   |
|                       | Aldehydes               | Aldehydes are tanning agents used to make wet white                         | Irritation of the eyes and skin                                                |
| Post-tanning section  | Dyes                    | Dyes are used to give the leather a desired color                           | Contact with skin may cause irritation including redness,                       |
|                       | Epoxy resins            | Facilitate high chemical resistance and low water absorption.               | Contact cause skin irritation                                                  |

Sources: https://sites.google.com/site/isttschool/useful-information/chemicals-used-in-leather-processing24; http://www.cdc.gov/niosh/programs.html25
Fig. 2: Illustration of occupational dermatitis in tannery workers (e-f)

- a) Contact dermatitis
- b) Allergic dermatitis with infection
- c) Nail discoloration
- d) Seborrheic Psoriasis
- e) Seborrheic Eczema
- f) Contact allergic dermatitis
Skin Disease Pattern
The medical examination among workers explored about 45.6% (n=54) of the study subjects were suffering from skin disorders (Table 4). Skin disorders, viz; Contact dermatitis, allergic dermatitis, seborrheic eczema, seborrheic psoriasis and skin infections were identified among the subjects (Figures 2 & 3). The diagnostic pattern to confirm the work related skin diseases (39%; n=44) among tannery workers is given in figure 4.

Contact dermatitis (15.7%), skin infections (16%), eczematous lesions (6.1%), and nail discoloration (1.7%) were identified as work related skin diseases. The frequency of skin morbidity was found to be high among the workers of pre-tanning and tanning departments. Pickling, liming, and tanning are the major activities that have been reported to be worsen the skin conditions among workers. Sickness absenteeism reported among 32% of workers due to skin disease burden.

The other health complications of musculoskeletal disorder (32%), joint pain (30%) and eye complaints (8%) were also recorded among workers while performing work.

Skin Infections
Fungal skin infections were identified among 11.4% subjects. The skin infections of; tinea corporis, tinea cruris, tinea unguium, tinea versicolor, tinea pedis and Pityriasis versicolor were identified. The fungal genera of dermatophytes; Trichophyton spp, Microsporum spp, Malassezia spp
and non-dermatophytic fungi; Candida spp, Fusarium spp, Curvularia spp and Aspergillus spp skin infections were identified. Bacterial skin infections were identified among 5.3% of study subjects. Skin infections of Staphylococcus aureus and Klebsiella pneumonia were identified. Bacterial skin infections identified were associated with contact dermatitis. Chronic and recurrent skin infections were identified among 9.6% (n=11) of study subjects.

### Table 4: Skin disease profile of the study subjects according to their working section

| Variables                      | Pre tanning (n=54) | Tanning (n=34) | Post tanning (n=26) | Total subjects (n=114) |
|-------------------------------|--------------------|----------------|---------------------|-----------------------|
| **Skin diseases prevalence**  |                    |                |                     |                       |
|                               | 34 (62.9)          | 14 (41.1)      | 4 (15.3)            | 52 (45.6)             |
| **Types of skin disorders**   |                    |                |                     |                       |
| a) Fungal dermatitis          | 8 (14.8)           | 4 (11.7)       | 1 (3.8)             | 13 (11.4)             |
| b) Bacterial skin infections  | 3 (5.5)            | 3 (8.8)        | 0                   | 6 (5.2)               |
| c) Contact dermatitis         | 11 (18.4)          | 5 (14.7)       | 2 (7.6)             | 18 (15.7)             |
| d) Eczematous lesions         | 7 (7.4)            | 1 (5.5)        | 0                   | 8 (6.1)               |
| e) Others                     | 5 (1.8)            | 1 (2.9)        | 1 (3.8)             | 7 (3.5)               |
| **History of skin disorder**  |                    |                |                     |                       |
| a) Recent skin disease        | 8 (14.8)           | 3 (8.8)        | 2 (7.6)             | 13 (11.4)             |
| b) Within the past 3 months   | 11 (20.3)          | 4 (11.7)       | 1 (3.8)             | 16 (14.0)             |
| c) Between 3-12 months        | 6 (11.1)           | 2 (5.8)        | 1 (3.8)             | 9 (7.8)               |
| d) More than 12 months        | 7 (12.9)           | 3 (8.8)        | 0                   | 10 (8.7)              |
| e) Only of past history       | 2 (3.7)            | 2 (5.8)        | 0                   | 4 (3.5)               |
| **Seasonal effects in Skin disorder** |              |                |                     |                       |
| a) No seasonal variation      | 4 (7.4)            | 4 (11.7)       | 0                   | 8 (7.0)               |
| b) Summer                     | 28 (51.8)          | 9 (26.4)       | 4 (15.3)            | 41 (36)               |
| c) Winter                     | 2 (3.7)            | 1(2.9)         | -                   | 3 (2.6)               |
| d) Rainy                      | -                  | -              | -                   | -                     |
| **Major activity worsen skin condition** |              |                |                     |                       |
| a) Liming and pickling        | 19 (35.1)          | 0              | 0                   | 19 (16.6)             |
| b) Tanning                    | 0                  | 14 (41.1)      | 0                   | 14 (12.2)             |
| c) Dye spray                  | 0                  | 0              | 2 (7.6)             | 2 (1.7)               |
| d) Other activities           | 15 (27.7)          | 0              | 2 (7.6)             | 17 (14.9)             |
| **Severity of skin disease**  |                    |                |                     |                       |
| a) Manageable                 | 8 (14.8)           | 2 (5.8)        | 1 (3.8)             | 8 (7)                 |
| b) Awful                      | 17 (31.4)          | 5 (14.7)       | 2 (7.6)             | 23 (20.1)             |
| c) Extremely awful            | 9 (16.6)           | 7 (20.5)       | 1 (3.8)             | 14 (12.2)             |
| Musculoskeletal disorder      | 27 (50)            | 6 (17.6)       | 3 (11.5)            | 36 (31.5)             |
| Joint pain                    | 22 (40.7)          | 7 (20.5)       | 5 (19.2)            | 34 (29.8)             |
| Eye irritation                | 5 (9.2)            | 3 (5.5)        | 1 (3.8)             | 9 (7.8)               |
| Sickness absenteeism          | 18 (33.3)          | 16 (47.0)      | 1 (3.8)             | 37 (32.4)             |

*Parenthesis indicates percentage (%)

The severe skin symptoms of itching, burning sensation, rashes, peeling skin, dry skin, scaling skin and skin lesions were experienced by the subjects. The most affected body sites by the skin disorders are in the order of hand > legs > hip & thigh > groin > foot & toes > face > chest and neck (Figure 5). It was informed by these workers that during summer season the skin infection exacerbate (36%).
Predisposing Factors for Skin Diseases
Chi square test was performed to find the association between skin diseases incidence and the variables of worker's working section, chemical exposure, dust exposure, humidity, PPE usage, personal habits (tobacco chewing, smoking & alcohol intake), age, monthly income and with work experience (Table 5). The characteristics of working sections, chemical exposure, humidity and lack of PPEs usage were strongly associated with high incident of skin disorders among subjects (p<0.05).
Table 5: Predisposing factors of skin disorders among the tannery workers

| Variables                  | Skin disorder n=52 (%) | p-value |
|----------------------------|------------------------|---------|
| Working section            | Pre-Tanning 34 (65)    |         |
|                            | Tanning 14 (26.9)      | 0.010*  |
|                            | Post Tanning 4 (7.9)   |         |
| Age                        | ≤30 15 (28.8)          | 0.266   |
|                            | ≤40 21 (40.3)          |         |
|                            | >40 18 (34.6)          |         |
| Gender                     | Male 42 (80.7)         | 0.406   |
|                            | Female 10 (19.2)       |         |
| Monthly income             | ≤5000 2 (3.8)          | 0.835   |
|                            | 5000-8000 39 (75)      |         |
|                            | >8000 8 (15.3)         |         |
| Tobacco chewing habit      | Yes 6(11.5)            | 0.248   |
|                            | No 46 (88.4)           |         |
| Smoking habit              | Yes 11 (21.1)          | 0.515   |
|                            | No 41 (78.8)           |         |
| Alcohol consumption        | Yes 18 (34.6)          |         |
|                            | No 34 (65.3)           | 0.700   |
| PPE Usage                  | Yes 47 (90.3)          | 0.018*  |
|                            | No 5 (9.6)             |         |
| Taking bath after work     | Yes 48 (92.3)          | 0.496   |
|                            | No 4 (7.6)             |         |
| Hand wash                  | Yes 50 (96)            | 0.871   |
|                            | No 2 (4)               |         |
| Chemical contact           | Yes 28 (53.8)          | 0.001*  |
|                            | No 24 (46.1)           |         |
| Dust exposure              | Yes 23 (40.3)          | 0.143   |
|                            | No 29 (59.6)           |         |
| Humidity                   | Yes 39 (75)            | 0.001*  |
|                            | No 13 (25)             |         |
| Work experience            | 1-15 26 (55.4)         | 0.5774  |
|                            | 16-30 18 (34.6)        |         |
|                            | >30 8 (15.3)           |         |
| Sickness absenteeism       | Yes 33 (63.4)          | 0.010*  |
|                            | No 19 (36.5)           |         |

* p value < 0.05

Discussion

Occupational contact dermatitis (OCD) has a significant impact on quality of life, work activity impairment, sickness absenteeism and economic recession. Likewise, a high prevalence of dermatitis was reported among Kenyan tannery workers. Dermatophytosis, urticaria, Candidiasis, eczematous lesions and folliculitis were reported among Bangladeshi tannery workers. A study among tannery workers of Indonesia leather processing industries showed a prevalence of similar studies.
7.4% Occupational skin diseases. Dermatological symptoms of skin rashes, itching and papules were reported among Indian leather tannery workers. Similarly high prevalence of occupational dermatitis was reported among Bangladesh and Sudan tannery workers (67.4%). The present study reported high prevalence of occupational dermatitis (38%) among tannery workers than several other studies of Indonesia, Kenya, Argentina, Korea and two Indian studies. The differences in the working conditions and the sampling size may also affect the prevalence rate reported among the tanners. In present study chronic and recurrent skin disorder was found among 10% of workers. Prolonged period of exposure to allergens or irritants associated with recurrent occupational dermatitis. This study also found severe skin complications among the workers, which was similarly reported in other studies as occupational aggravate. The severity varies on individual physical characteristics including allergen sensitivity, immune capacity and exposure duration to the contaminants. Occupational factors may play a synergistic role with pre-existing predisposition to allergy.

In present study the major chemicals reported to be handled by workers in pre-tanning and tanning process are demonstrated as potential irritant and sensitizer. Chromium sulphate, N-diphenylguanidine, benzidine and sodium metabisulfite were demonstrated as sensitizing agent to the exposed workers. Chromium induced hyper-pigmentation of skin was reported by Al-Hossain et al. A study found chromate as frequent allergen to tannery workers that increased serum immunoglobulin E (IgE) level. Workers are exposed to the chemicals while loading, unloading, handling and discarding. The possible exposure routes are inhalation, ingestion and skin absorption. The exposure to chemical agents pose occupational hazard to the workers engaged in these environment, if failed to adopt appropriate personal protective equipments (PPEs).

Present study found 30% of the study subjects did not use any kind of PPE’s at work, it has been stated that workers who wore gloves were less likely to develop skin diseases compared to those who did not wear gloves. A significant association between lack of PPE use and increased incidents of skin disorder was demonstrated in present study (p<0.05). The finding was concordant with the findings of Hasan et al. In the study area the workers substituted the unavailability of PPEs with self-designed impermeable protective equipments such as plastic covers and rubber covers. These indicate inappropriate safety practice at workplace, which increase the chances of hazard exposure. The rubber gloves used as personal protective equipment can cause leukoderma as reported by Raidas et al. In developing countries like India the awareness level about health risk and PPE use at workplace are short due to inadequate training.

In the present fungal dermatitis was identified among 11.4% subjects. Few studies reported dermatophytosis among tannery on dermatological examination. Present study identified the causative fungal agents in the view of appropriate treatment. The improper treatment for tinea infections may progress to chronic, recurrent, recalcitrant and multisite infection. The fungal skin lesions may widespread and may impact on social, psychological, and occupational health effects, and the quality of life. Bacterial skin infections were associated with contact dermatitis in present study. The important predisposing factor for fungal skin infection was wet and humid working conditions. The work environment of pre-tanning and tanning sections were recorded with hot and high humid conditions.

Present study found that OSD was prevalent among the workers involved in pre-tanning and tanning process. These emphasize the workers in pre-tanning sections and tanning sections are prone to health issues due to work place exposure. Occupational skin diseases were high among beam house workers compared with other leather processing departments. During beam house activities the handling of wet hides with bare hand exposed to sulfuric acid, a strongly corrosive agent may cause permanent damage to skin. Workers with occupational skin diseases (OSD) were significantly correlated with hazardous risk factors of chemicals contact, inhalation of dust, smoke or vapor, fumes, low and high temperature and humidity.
Occupational skin diseases among work population are easily treatable and can be preventable, if appropriate preventive measures, workplace improvement and prior training on employment are effectively implemented.

Conclusion
Occupational skin disorders were found to be prevalent among tannery workers. They were followed and treated efficiently. This study also demonstrates the burden of skin disease among tannery workers and its impact on quality of their normal life. Identification of fungal skin infections crucial to prevent chronic and recurrent infections. The study finding emphasizes that pre-tanning section and tanning sections were more susceptible to occupational skin diseases. This working environment serves as a predisposing factor for skin disease morbidity. Obligate use of PPE, workplace improvement, education and frequent surveillance programmes, early identification and treatment could minimize the Occupational skin diseases burden in tannery workers.

Acknowledgements
We are thankful to the Director, ICMR-National Institute of Occupational Health, Ahmedabad for financial support. Authors are also thankful to Dr. Kalaiselvi Kannan, Associate Professor, PSG College of Arts and Science, Coimbatore, Dr. Karthick MD, Christian Medical College, Vellore, Dr. Hariharan MBBS, AFIH, Dr. Subramaniyam, Regenix Super specialty Laboratory, Chennai, Mr. Vijay kumar, Chennai and Dr. Jaseer Muhamed, Scientist-B, ROHCS for his comments on manuscript.

Conflict of Interest
The authors declare that they have no competing interests.

References
1. https://leatherindia.org/indian-leather-industry/
2. Aljerf L. High-efficiency extraction of bromocresol purple dye and heavy metals as chromium from industrial effluent by adsorption onto a modified surface of zeolite: Kinetics and equilibrium study. *Journal of Environmental Management*. 2018; 225: 120-132.
3. Hashmi GJ, Dastageer G, Sajid MS, Ali Z, Malik MF, Liaqat I. Leather Industry and Environment: Pakistan Scenario. *International Journal of Applied Biology and Forensics*. 2017; 1(2):20-25.
4. Kolomaznik K, Adamek M, Andel I, Uhlirova M. Leather waste-potential threat to human health, and a new technology of its treatment. *Journal of Hazardous Material*. 2008; 160 (2-3):514-520.
5. Mahamudul Hasan MD, Hosain S, Asaduzzaman AM, Haque MA and Roy UK. Prevalence of health diseases among Bangladeshi tannery workers and associated risk factors with workplace investigation. *Journal of Pollution Effects & Control*. 2016, 4:4.
6. Bhatia R, Sharma VK. Occupational dermatoses: An Asian perspective. *Indian Journal of Dermatology, Venereology and Leprology*. 2017; 83: 525-35.
7. Diepgen TL Kanerva L. Skin diseases in Europe. *Eur J Dermatol*. 2006; 16:324- 330.
8. Sahoo AK, Mahajan R. Management of tinea corporis, tinea cruris, and tinea pedis: a comprehensive review. *Indian Dermatology Online Journal*. 2016; 7(2); 77-86
9. Rajagopalan M, Inamadar A, Mittal A, Miskeen AK, Srivivas CR, Sardana K, Godse K, Patel K, Rengasamy M, Rudramurthy S, Dogra S. Expert Consensus on the Management of Dermatophytosis in India (ECTODERM India). *BMC Dermatology*. 2018; 24; 18(1):6.
10. National Institute for Occupational Safety and Health (NIOSH). Online pocket guide to chemical hazards. Appendix C, Centers for Disease Control and Prevention, USA; 2015. Available from: http://www.cdc.gov/ niosh/ programs.html.
11. Alfonso JH, Bauer A, Bensefa-Colas L, Boman A, Bubas M, Constandt L, Crepy MN, Goncalo M, Macan J, Mahler V, et al., Minimum standards on prevention, diagnosis and treatment of occupational and work-related skin diseases in Europe - position
12. Febriana SA, Jungbauer F, Soebono H, Coenraads PJ. Inventory of the chemicals and the exposure of the workers’ skin to these at two leather factories in Indonesia. *International Archives of Occupational Environmental Health*. 2012; 85: 517-526.

13. El-Hassan KE, El-Kordofani YM, Mithani A, Tayseer E, E D, Zuhair A A B, Ali Thoulifkar A I, Gamal O, et al. The Prevalence of Occupational Dermatosis among Workers in Khartoum State’s Tanneries. *American Journal of Dermatology and Venereology*. 2014, 3(5): 81-83.

14. Klimová Z, Hojerová J, Lucová M and Silvia Pažoureková S. Dermal exposure to chemicals - evaluation of skin barrier damage. *Acta Chimica Slovaca*, 2012; 5(1): 70-74.

15. Febriana SA, Soebono H, Coenraads PJ. Occupational skin hazards and prevalence of occupational skin diseases in shoe manufacturing workers in Indonesia. *International Archives of Occupational Environmental Health*. 2014; 87:185-94.

16. Aaron DM. Overview of fungal skin infections. Merck Manual Consumer Version website. www.merckmanuals.com/home/skin-disorders/fungal-skin-infections/ overview-of-fungal-skin-infections. 2017. 15.

17. Gupta CM, Tripathi K, Tiwari S, Rathore Y, Nema S, Dhanvijay AG. Current trends of Clinico mycological profile of Dermatophytosis in Central India. *IOSR-Journal of Dental and Medical Sciences*. 2014; 13(10):23-6.

18. Pihek M, Le Govic Y. Reappraisal of conventional diagnosis for dermatophytes. *Mycopathologia*. 2017; 182(1-2):169-80.

19. Dogra S, Uprety S. The menace of chronic and recurrent dermatophytosis in India: is the problem deeper than we perceive? *Indian Dermatology Online Journal*. 2016; 7(2): 73-76.

20. London L, Kisting S (2002) Ethical concerns in international occupational health and safety. *Occup Med* 17(4):587-600.

21. Shamout Y and Adisesha A. The Nordic Occupational Skin Questionnaire. *Occupational Medicine*. 2016; 66(1): 82. https://doi.org/10.1093/occmed/kqv059

22. Mahon CR and Donald C Lehman DC. Textbook of Diagnostic Microbiology 6th edition.2018. ISBN:9780323613170. Pages?

23. Scognamiglio T, Zinchuk R, Gumpeni P, and Larone DH. Comparison of inhibitory mold agar to Sabouraud Dextrose Agar as a primary medium for isolation of fungi. *Journal of Clinical Microbiology*. 2010; 48(5): 1924-1925.

24. https://sites.google.com/site/isttschool/useful-information/chemicals-used-in-leather-processing

25. http://www.cdc.gov/niosh/programs.html

26. Kalboussi S, Kacem I, Aroui H, ElMaalel O, Maoua M, Brahem A, El Guedri S, Chatti S, Ghariani N, and Mrizak N. Impact of Allergic Contact Dermatitis on the Quality of Life and Work Productivity. *Dermatology Research and Practice*. 2019, 3797536, 8. doi.org/10.1155/2019/3797536.

27. Rastogi SK, Pandey A and Tripathi S. Occupational health risks among the workers employed in leather tanneries at Kanpur. *Indian J Occup Environ Med*. 2008; 12(3): 132-135.

28. Rahman M, Akhtar N, Ahmed BN, Hassan KM, Nahar K, Paul HK, Islam MT, Shahidulla AZM, Islam S. Skin diseases in tannery workers of Hazaribagh, Dhaka, Bangladesh: A cross sectional study. *Bangladesh J. Dermatol. Venerol. Leprol*. 2007; 24(1): 15-20.

29. Islam R, Hossain S and Siddique AB. Occupational health hazards and safety practices among the workers of tannery industry in Bangladesh. *Jahangirnagar University Journal of Biological Sciences*. 2017, 6 (1): 13-22.

30. Were F, Moturi M, Wafuila G. Chromium exposure and related health effects among tannery workers in Kenya. *Journal of Health and Pollution*. 2014; 4:25-35.

31. Shukla A, Kumar S, Ory FG. Occupational health and the environment in an urban slum in India. *Social Science and Medicine*. 1991; 33(5):597-603.

32. Kvitko E. Occupational contact dermatitis in the tanning industry. *Contact Dermatitis*. 2001; 45(4):256.
33. Ory FG, Rahman FU, Katagade V, Shukla A, Burdorf A. Respiratory disorders, skin complaints, and low-back trouble among tannery workers in Kanpur, India. *American Industrial Hygiene Association Journal.* 1997; 58(10):740-746.

34. Schwensen JF, Menné T, Veien NK, Funding AT, Avnstorp C, Østerballe M, Andersen KE, et al. Occupational contact dermatitis in blue-collar workers: results from a multicentre study from the Danish Contact Dermatitis Group (2003-2012). *Contact Dermatitis.* 2014; 71:348-55.

35. Mohanta MK, Saha AK and Hasan MA. Rajshahi: Prevalence and determination of occupational diseases of leather tannery workers. *University Journal of Zoology.* 2012; 31: 79-82.

36. Castellanos-Arévalo DC, Castellanos-Arévalo AP, Camarena-Pozos DA, Colli-Mull JG, Maldonado-Vega M. Evaluation of Microbial Load in Oropharyngeal Mucosa from Tannery Workers. *Safety and Health at Work.* 2015; 6(1): 6.

37. Shahzad K, Akhtar S and Mahmud S. Prevalence and determinants of asthma in adult male leather tannery workers in Karachi, Pakistan: A cross sectional study. *BMC Public Health.* 2006, 6:292.

38. Al-Hossain MM, Ichiro Y, Huadong Xu, Saheduzzaman, Nobutaka OG, Nazmul A, AZim AA, Masashi K. Chromium-mediated hyperpigmentation of skin in male tannery workers in Bangladesh. *Chemosphere.* 2019; 229. 611-617.

39. Zareen S, Rehman HU, Zaman H, Ali T, Rashid L, Jamal B, Saeed FK. Occupational allergic contact dermatitis in tannery workers of Peshawar KP Pakistan: an under estimate health issue. *Journal of Entomology and Zoology Studies.* 2016; 4(5): 310-312.

40. Schmidt K, Kersten N and Pohrt U. The use of protective gloves in occupational skin disease prevention: feasibility and customer acceptance in physiotherapy. *Int J Physiother.* 2016; 3(4), 401-408.

41. Raidas RB. Occupational health hazards in tanneries. Directorate general factory advice service & labour institutes, Mumbai, India. Indoshnews. 2007; 2: 4-7.

42. Jerajani H, Janaki C, Kumar S, Phiske M. Comparative assessment of the efficacy and safety of Sertaconazole (2%) cream versus terbinafine cream (1%) versus Luliconazole (1%) cream in patients with Dermatophytoses: a pilot study. *Indian J Dermatol.* 2013; 58(1):34-8.

43. Park JS, Park EK, Kim HK, Choi GS. Prevalence and Risk Factors of Occupational Skin Disease in Korean Workers from the 2014 Korean Working Conditions Survey. *Yonsei Med J.* 2020; 61(1):64-72. doi: 10.3349/ymj.2020.61.1.64.