# ASSESSMENT OF OCCUPATIONAL AND RESPIRATORY HEALTH IMPLICATIONS AMONG SHEEP BREEDING AND WOOL SHEARING WORKERS IN KARNATAKA, INDIA

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## ABSTRACT

The present study aimed to assess the airborne contaminants and related health hazards among workers involved in activities associated with sheep breeding and wool shearing. The environmental monitoring was done in the breathing zone of workers with personal air sampling method. A total of 487 persons were interviewed for respiratory symptoms. Data were evaluated based on sex, age, sickness, work nature and experience. The average total suspended particulate matter (TSPM) in sheep shearing activity was 269.8 $\mu g/m^3$. The respirable particulate matter (RSPM) observed in persons with sheep shearing and cleaning activity was 236.6 $\mu g/m^3$ and 148 $\mu g/m^3$, respectively. It was observed that the persons in sheep shearing activity were exposed to higher concentration of dust compared to cleaning activities. Medical examination showed that the sheep breeders were found to be at a significantly higher level of respiratory symptoms and had higher risk of respiratory morbidity. In general, the workers involved in sheep-related occupation have significantly higher prevalence of respiratory symptoms and acute occupational symptoms compared to non-sheep related occupations. Acute respiratory symptoms during work hours are also higher in sheep breeders, indicating the relation of the morbidity to the occupation.

**KEY WORDS**

Sheep breeder, Health hazards, Environmental monitoring, Exposure, Risk Assessment

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## INTRODUCTION

The livestock population of India plays an important role in the economy of our country. Use of natural fibres is an area of increasing interest, and opportunities are being developed in new markers (Khedari et al., 2004). Historically, natural fibres have been used extensively due to their attractive properties and benefits: efficient thermal resistivity (Fan et al., 2008), good structural strength (Feughelman, 1997; Wambua et al., 2003), moisture buffering capacity (Watt, 1960), uptake of certain gases (Curling et al., 2012) and the availability and sustainability. Therefore, it can be practiced that processing of such fibres into insulation products is encouraging from a performance, environmental, and a wider economic viewpoint. There are many indications about the environmental benefits and actual health benefits associated with the presence of natural insulation materials (Dewick and Miozzo, 2002; Korjenic et al., 2011).

The workers involved in this sector are at increased risk of contracting certain infectious diseases because of regular contact with domestic livestock, poultry, and their environments. Agricultural infectious diseases affecting the respiratory system are bovine tuberculosis, Q fever due to inhalation of *Coxiella burnetii* (rickettsia) from sheep, cattle, goats and their by-products. Airborne dust collected inside the factory during goat hair and sheep wool processing (Wattiau et al., 2008) contained genome of *Coxiella burnetii*, the Q fever agent, and *C. burnetii* in air respectively. No information is available about the infectivity or viability of air-suspended *C. burnetii* in the studied environment. Although less dangerous than anthrax, Q fever is still a highly prevalent occupational disease that affects persons working with animal hairs in industrial environments and commonly referred to as woolsorters (Wattiau et al., 2009). Prevalence of Leptospira spp. in sheep was reported from two slaughterhouses in the state of São Paulo, Brazil (Da Silva et al., 2012).

The worldwide research that has been carried out on occupational health hazards among farmers are mainly in poultry and piggery sectors. Few studies were carried out among sheep farmers in western countries (Kift et al, 2003; Randon et al., 1999). Ferguson (1996) reported that the annual work-related injury/illness rate for the sheep industry was 24.0 per 100 farms. The worker exposed to airborne contaminants in sheep breeding and its associated jobs are at high risk to develop illness due to their exposure through manual handling (NOHSC, 1990). Organochlorine pesticide residues in blood samples were associated with rural sheep's wool

workers in Bangalore (Dhananjayan et al., 2012). Evidence of Q fever has been identified in workers in sheep abattoirs (Fragar et al., 2001; Wattiau et al., 2011), Gram negative bacteria (Pseudomonas spp) are found in the fleece thereby exposure to endotoxins cannot be ruled out. Presence of toxic heavy metals (As, Cd, Hg, Pb) has been reported in sheep wool originated from Poland, Greece and Syria (Patkowska-Sokoła et al., 2009). Sheep wool was identified as specific allergens for male children by skin patch test (Shetty et al., 2017). In general woolgrowers have relied heavily on chemical application to manage sheep lice and blowflies.

Sheep's wool stands out from other fibres. It is the only protein based one utilized by the insulation industry. Its structure is known to be composed of cortical cells, surrounded by cuticular scales (Bonès and Sikorski, 1967). It differs vastly from synthetic fibres, which tend to be a random mixture of silica and other metaloxides (Dunster, 2007). Studies related to occupational health aspects among workers involved in sheep breeding and its associated jobs are not available from India. In order to fully appreciate the possible health risk resulting from the manufacture of sheep wool, potential problem associated with general organic dust are to be investigated. The sheep farming and sheep wool workers constitute a major workforce of rural Karnataka, India. Among the 27 districts, rural inhabitants of 13 districts carry out intense sheep farming. Approximately twelve lakh populations are involved in this occupation. Therefore, the present study was initiated 1) to measure the airborne contaminants during animal handling, shearing and cleaning activities, 2) to quantify the health hazards due to their exposure and identify the hazards associated with the sheep farming, sheep wool shearing & processing and 3) to evolve strategies to minimize the risk associated with it and to develop data and to understand the prevalence of various respiratory symptoms and to create its baseline data for various occupational groups.

## MATERIALS AND METHODS

The study location was selected in Siddlaghatta Taluk, Karnataka State, India. This region has different varieties of sheep such as Bannur, Rambolt and Australian Merino varieties. Ethical clearance was obtained from the institute’s ethical committee. An announcement with the request for participation in the study was made in villages around Siddlaghatta taluk of Karnataka in their local language. Informed consent was obtained from all the 487 people

voluntarily participating in this study. We carried out the entire interview using a questionnaire based interview. The questionnaire was developed based on the British Medical Research Council (BMRC) recommendation for the documentation of respiratory morbidity. The subjects were informed in local language about the need, the scope and the methods of the study. The detailed consort flow of materials and methods are given in *Figure 1*.

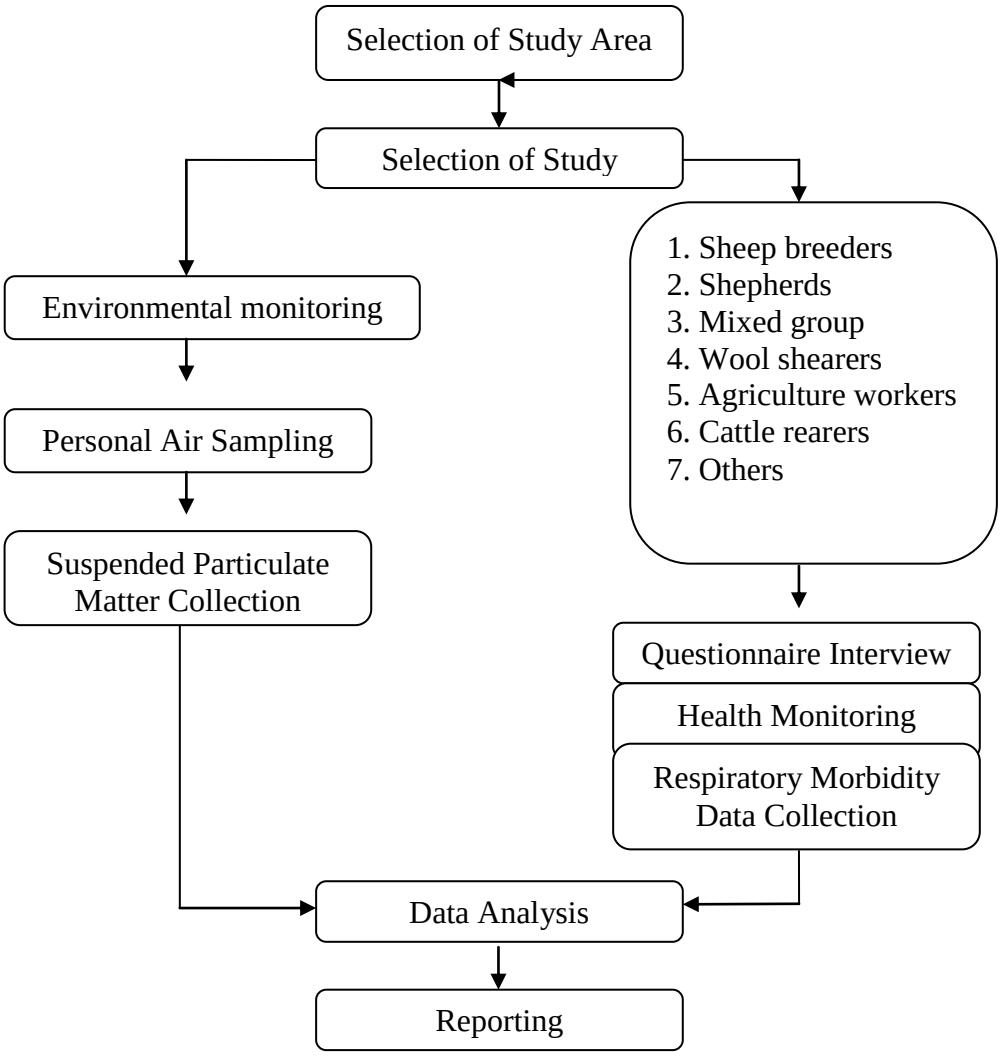


*Figure 1. Consort flow of materials and methods*

The demographic details of all the study participants are given in *Table I.* The study population was divided into seven occupational groups (1.Sheep breeders, 2.Shepherds, 3.Mixed group, 4.Wool shearers, 5.Agricultural workers, 6.Cattle shearers and 7.Others) based on their occupational history. This segregation of groups was done for a better under-

**Table I**. **Demographic characteristics of the study population**

| **Variables** | **Sheep breeding and related occupation* (n=322)** | **Non-sheep related occupation* (n=165)** |
|---|---|---|
| Sex | | |
| Male | 227 (70.5) | 84 (50.9) |
| Female | 95 (29.5) | 81 (49.1) |
| Age range (mean ± SD) | 45.6 ± 17.9 | 42.3 ± 18.4 |
| Exposure (yrs) | 30.7 ± 11.2 | - |
| Education | | |
| Illiterate | 136 (42.2) | 70 (42.4) |
| Primary | 119 (37.0) | 52 (31.5) |
| Secondary | 51 (15.8) | 37 (22.4) |
| Graduate | 16 (5.0) | 6 (3.6) |
| Marital status | | |
| Married | 271 (84.2) | 140 (84.8) |
| Single | 51 (15.8) | 25 (15.2) |
| Smoking habits | | |
| Smoker | 82 (25.5) | 34 (20.6) |
| Ex-smoker | 15 (4.7) | 5 (3.0) |
| Non smoker | 225 (69.9) | 126 (76.4) |
| Alcohol intake | | |
| Alcoholic | 52 (16.1) | 19 (11.5) |
| Ex-alcoholic | 9 (2.8) | 2 (1.2) |
| Non alcoholic | 261 (81.1) | 144 (87.3) |
| Tobacco chewing | | |
| Chewer | 138 (42.9) | 55 (33.3) |
| Ex-chewer | 4 (1.2) | 5 (3.0) |
| Non chewer | 180 (55.9) | 105 (63.6) |
| Food habit | | |
| Vegetarian | 3 (0.9) | 3 (1.8) |
| Non vegetarian | 319 (99.1) | 162 (98.2) |
| Drinking water | | |
| Tube well | 322 (100.0) | 165 (100.0) |
| Open well | - | - |
| Cooking fuel use | | |
| Wood | 274 (85.1) | 149 (90.3) |
| Dung | - | 1 (0.6) |
| Kerosene | 8 (2.5) | 3 (1.8) |
| Gas | 35 (10.9) | 12 (7.3) |
| No answer | 5 (1.5) | - |

* Values in the parenthesis indicate the percentage

standing of relation of respiratory morbidity to occupation. Based on the BMRC questionnaire, the symptomatology used categories as *Chronic cough* of those who usually

coughed at least 4 times a day, at least on 4 days a week for at least three months a year. *Chronic bronchitis* symptoms were found in those individuals who usually brought up phlegm from the chest as frequently as twice a day, 4 days a week and 3 months on the trot in a year. *Chest tightness* corresponded to the complaints of feeling of tightness and difficulty in breathing. *Wheezing after work* was meant as the development of asthma-like symptoms immediately after work. *Organic Dust Toxic Syndrome (ODTS)* was understood when the subject complained about fever, aching and tiredness after work (flu-like symptoms). Environmental monitoring was carried out in sheep farming locations where workers were continuously engaged in sheep shearing activity to estimate the dust levels by gravimetric method. Pre-calibrated personal air samplers (PCXR4 SKC Inc. USA fitted with cyclones) were employed to collect air samples at the flow rate of 2 l/min. Air sampling was done in the breathing zone of the worker during his job. These samplers were tucked to the waist of the subjects and the filter cassette was clamped to the collar of the shirt. Workplace temperature and relative humidity were recorded using 3M™ Environmental Monitors (EVM-7).

The data was entered into Microsoft Excel and transferred to SPSS student version software 16 for preparation of tables and graphs. Spearman's correlation coefficient was used to test the relationship between number of sheep shearing and total dust generated. $X^2$ test was performed to analyse variation in respiratory morbidity between workers of sheep related occupation and non-sheep related occupational groups.

## RESULTS

Environmental monitoring study was conducted in different places of sheep shearing, wool cleaning and sheds. The meteorological data showed the mean indoor temperature while shearing activity ranged between 13.90 and 32.3 ºC with a mean value of 22.59 ± 3.33ºC. The relative humidity in the sheds was 47.17 ± 16.7%. The ambient monitoring result showed that the mean concentration of total suspended particulate matter (TSPM) was 269.8 $\mu g/m^3$ during sheep shearing activity with a range of 74 - 609 $\mu g/m^3$, whereas the respirable particulate matter (RSPM) was 236.6 $\mu g/m^3$ with a range of 49 - 726 $\mu g/m^3$. The RSPM during the cleaning activity of the sheds was 148 $\mu g/m^3$ with a range of 38 - 300 $\mu g/m^3$ *(Table II)*.

**Table II. Total and respirable dust exposure among different categories of people engaged in sheep shearing and cleaning activity**

| Statistics | Sheep shearing | | Cleaning activity |
|---|---|---|---|
| | (TSPM) (μg/m$^3$) | (RSPM) (μg/m$^3$) | (RSPM) (μg/m$^3$) |
| N | 12 | 25 | 3 |
| Mean | 269.8 | 236.6 | 148 |
| SD | 145.1 | 183.2 | 135.8 |
| Range | 74 – 609 | 49 – 726 | 38 - 300 |

**Table III. Comparison of dust concentration reported in various studies**

| **Occupational group** | **TSPM (μg/m$^3$)** | **RSPM (μg/m$^3$)** | **References** |
|---|---|---|---|
| Sheep shearing | 269.8 (74-609) | 236.6 (49 – 726) | Present study |
| Sheep cleaning activity | - | 148 (38-300) | Present study |
| Mixed activity | - | 490 (170-1070) | Kift et al., 2005 |
| Wool mill | 3930 (2530-6120) | - | Simpson et al., 1999 |
| Cattle feed-lots | 654 (54-1268) | - | Algeo et al., 1972 |
| Maximum concentration levels listed for Occupational Health | 4 mg.m-3 (grain dust); 10 mg.m-3 (nuisance dust) | 3 mg.m-3 (grain dust) | ACGIH |
| | 4 mg.m-3 (grain dust) | - | NIOSH |
| | 10 mg.m-3 (grain dust); 15 mg.m-3 (nuisance dust) | 5 mg.m-3 | OSHA |
| | - | 0.15 mg.m-3 24 hrs (for Suspended Particulate Matter) | US Federal Ambient Standard |

ACGIH: American Conference of Governmental Industrial Hygienists; NIOSH: The National Institute for Occupational Safety and Health; OSHA: Occupational Safety and Health Administration.

All the subjects were categorized based on sex, occupation, smoking habits and respiratory complaints. Workers involved in sheep breeding activity reported higher percentage of respiratory complains followed by agriculture workers, shearing activities and mixed activity *(Table III and IV)*. Symptoms in breeders were significantly higher than shepherd, agricultural workers and other occupations ($p < 0.05$). Prevalence of diseases among various occupational groups is reported in *Table V*. Of the various complains reported by workers, sheep breeder had high prevalence of respiratory disorders compared to agriculture workers. In general, the workers involved in sheep related occupation had significantly ($p < 0.05$) higher prevalence of respiratory symptoms and acute occupational symptoms compared to non-sheep related occupation (*Table VI).*

**Table IV. Comparison of respiratory complaints between sheep breeding and related occupation and non-sheep related occupation**

| Symptoms | Sheep breeding and related occupation (n=322) | Non-sheep related occupation (n=165) | $\chi^2$ -value | P value |
|---|---|---|---|---|
| Burning of eyes | 145 (45.0) | 73 (44.2) | 0.027 | 0.868 |
| Occasional cough | 185 (57.5) | 82 (49.7) | 2.650 | 0.104 |
| Headache | 158 (49.1) | 71 (43.0) | 1.597 | 0.206 |
| Nausea | 53 (16.5) | 24 (14.5) | 0.30 | 0.584 |
| Sneezing | 35 (10.9) | 17 (10.3) | 0.037 | 0.848 |
| Skin symptoms | 55 (17.1) | 19 (11.5) | 2.622 | 0.105 |
| Watering of eyes | 101 (31.4) | 59 (35.8) | 0.954 | 0.329 |
| Occasional chest pain | 124 (38.5) | 65 (39.4) | 0.036 | 0.849 |
| Dizziness | 56 (17.4) | 35 (21.2) | 1.048 | 0.306 |
| Irritation of throat | 54 (16.8) | 29 (17.6) | 0.05 | 0.823 |
| Vertigo | 8 (2.5) | 4 (2.4) | 0.002 | 0.968 |
| Hearing problem | 47 (14.6) | 16 (9.7) | 2.33 | 0.127 |
| Backache | 183 (56.8) | 90 (54.5) | 0.23 | 0.630 |
| Joint pain | 184 (57.1) | 99 (60.0) | 0.37 | 0.545 |

**Table V. Prevalence of respiratory symptoms among subjects of various occupational groups**

| Occupational Group (N= 487) | Chronic cough | Chronic bronchitis-like symptoms | Chest tightness after work | ODTS | Wheezing after work |
|---|---|---|---|---|---|
| Sheep breeders (153) | 63 (41.2) | 49 (32) | 42 (27.5) | 28 (18.3) | 9 (5.9) |
| Shepherds (92) | 22 (23.9) | 11 (12) | 6 (6.5) | 10 (10.9) | 2 (2.2) |
| Mixed group (76) | 24 (31.6) | 18 (23.7) | 17 (22.4) | 16 (21.1) | 4 (5.3) |
| Wool shearers (3) | 1 (33.3) | 1 (33.3) | 1 (33.3) | 1 (33.3) | Nil |
| Agriculture workers (96) | 28 (29.2) | 21 (21.9) | 9 (9.4) | 8 (8.3) | 3 (3.1) |
| Cattle shearers (16) | 5 (31.3) | 2 (12.5) | 3 (18.8) | 2 (12.5) | Nil |
| Others (51) | 11 (21.6) | 10 (19.6) | 8 (15.7) | 6 (11.8) | 3 (5.9) |

Figures in parenthesis indicate the percentages

**Table VI. Comparison of respiratory and acute occupation related morbidity between those involved and not involved in sheep related occupations**

| Finding | Sheep related occupation (n=324) | Non-sheep-related occupation (n=163) | $\chi^2$ -value | *p* value |
|---|---|---|---|---|
| At least one respiratory symptom | 156 | 60 | 4.871 | 0.020 |
| At least one acute occupational symptom | 94 | 28 | 9.068 | 0.005 |

## DISCUSSION

RSPM and TSPM levels detected in this study were well below the concentration of reported in various other studies (Algeo et al., 1972; Kift et al., 2005; Simpson et al., 2009). Particulate matter concentration detected in the present study was higher than the US federal Ambient Total Suspended Particulate standards prescribed for 24 hrs. However it was less than the ACGIH, NIOSH and OSHA standards *(Table III).* Although the levels reported appeared to be less, these bio-aerosols may contain many harmful contaminants. Bio-aerosols

include bacteria, fungi, fungal and bacterial spores, viruses, mammalian cell debris, products of microorganisms, pollens, and aeroallergens. The concentrations of pathogens in aerosols and feed-lot dust would be dependent on the concentrations in the cattle faeces and feed-lot soils, and how well the organisms survive. Studies have determined airborne fungi levels in cattle houses that might present occupational risk of respiratory diseases (Adhikari et al., 2004; Ajoudanifar et al., 2011). However, the risk of contaminant by inhalation can be considerably decreased by taking simple precautions including: use of air extractors, using personal protective equipment, and modest enhancements to ventilate the rooms.

According to the Control of Substances Hazardous to Health Regulations 2002, dust falls under the definition of a substance hazardous to health if inhalable and present at 10 $mg/m^3$ for 8 hours, or if respirable and present at 4 $mg/m^3$ for 8 hours. For wool, there exists only a long-term exposure limit of 10 $mg/m^3$ (Health and Safety Executive, 2011). The Trades Union Congress proposes to significantly lower the limits to 2.5 $mg/m^3$ for all inhalable dust and to 1 $mg/m^3$ for respirable dust, based on an exposure of 8 hours per day (TUC, 2011). The most contributing factor to these risks exclude particle shape, and have been identified to be: chemical additives; endotoxins present on the particle surface; microorganisms such as spores of fungi, actinomycetes and bacteria (Fishwick et al., 2001; Järvholm, 2000). There are no studies, found on the exposure values related to dust resulting from processing sheep wool, all studies to date have reported on findings from the textile industry instead. Exposure to endotoxins at wool mills was found to be more than 4 fold less than at cotton mills, and contamination decreased with increasing amount of fibres processed (Simpson et al., 1999). It was observed that the shearers were exposed to higher concentration of dust compared to the cleaners.

It implies that workers involved in sheep breeding are at a much higher risk for respiratory illnesses. Reported health hazards of natural wool dust includes irritation to the airways and eyes (Jarvholm 2000), chronic cough, phlegm and bronchitis (Health and Safety Executive, 2004) and nasal catarrh and sinusitis, breathlessness and wheeze (Zuskin et al., 1995). Symptoms reported in the present paper are similar to the earlier study findings and adequate care and maintaining of hygienic conditions is necessary.

The most significant differences were noted for work-related chest tightness in breeders. The levels of symptoms appear to follow a trend of highest in breeders, lesser in mixed group and least in other groups. This may be related to dose-related exposure, which needs further evaluation. Acute symptoms arising during work including chest tightness during or immediately after work, work-related wheezing and symptoms of Organic dust toxic syndrome have been studied. These are complaints related to occupational exposures and hence are very important.

## LIMITATION OF THE STUDY

In this study personal exposure samples were only collected. Correlations between dust particles and number of sheep shearing was done, but not with the health complaints of the individuals. On the other hand, the strength of this study is that for the first time, personal exposures to RSPM have been measured simultaneously among the sheep shearers, sheep cleaner and other workers in this region in India. RSPM levels reported in other studies have been compared with the present study. Therefore, we measured RSPM in personal exposures and medical history has allowed us to assess the correlation of environmental concentrations with the respiratory symptoms for those subjects in the sheep wool related occupation. The number of wool shearers is very few because it is a specialized job which is done by few people for a group of villages, so interpretation of their data will have to be done on individual basis. The environmental sampling and monitoring of sheep-house air (endotoxin) will also add to the understanding of the high rate of symptoms among the breeders.

## CONCLUSION

The environmental study findings showed that exposure to airborne total respirable particulate matter and respirable particulate matter was high in sheep shearers during their job. It also correlated with the finding that the total dust generated was proportionately increasing with the number of sheep handled for shearing. Hence these groups are prone to more respiratory problems. The medical history of workers supports that the respiratory symptoms among sheep breeders were significantly higher when compared to other occupational groups in a rural population, and hence they have higher risk of respiratory morbidity. Though each occupational group suffers from varying degrees of respiratory mor-

bidity, the breeders have significantly higher morbidity as compared to all other groups in this study. To further support this, acute respiratory symptoms during work hours are also higher in sheep breeders, which show the relation of the morbidity to the occupation. Additionally it was observed that those involved in sheep related occupation were found to have a significantly higher respiratory morbidity when compared to occupations not involving sheep. This shows that sheep related occupation has higher risk for occupational respiratory morbidity. Other hazards associated with the industry include those associated with noise, farm chemicals and zoonotic disease.

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